Annual Report

October 9, 2017

National Pollutant Discharge Elimination System
Municipal Separate Storm Sewer System
Permit No. 11-DP-3313 MD0068276
Permit Term
October 2015 to October 2020

Submitted to:
Sediment, Stormwater, and Dam Safety Program
Water and Science Administration
Maryland Department of the Environment
1800 Washington Boulevard
Baltimore, MD 21230

Submitted by:
Maryland Department of Transportation
State Highway Administration
Office Of Environmental Design
707 North Calvert Street, C-303
Baltimore, MD 21202

MARYLAND DEPARTMENT OF TRANSPORTATION™
STATE HIGHWAY ADMINISTRATION

MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

Larry Hogan
Governor
Boyd K. Rutherford
Lt. Governor
Pete K. Rahn
Secretary
Gregory Slater
Administrator

October 9, 2017

Mr. Raymond Bahr
Sediment, Stormwater & Dam Safety Program
Maryland Department of the Environment
1800 Washington Boulevard, Suite 440
Baltimore MD 21230

Dear Mr. Bahr:

The Maryland Department of Transportation State Highway Administration (MDOT SHA) Office of Environmental Design (OED) is pleased to submit this second annual report addressing conditions under the MDOT SHA NPDES MS4 permit (11-DP-33133 MD 0068276) which took effect on October 9, 2015.

The report covers compliance efforts from July 1, 2016 to June 30, 2017, and includes an overview of MDOT SHA's MS4 Program, addresses MDE comments on the first annual report, and discusses how MDOT SHA has progressed in implementing water quality improvements.

This submission includes one hard copy, a compact disc containing an electronic version with accompanying digital geodatabase, and an external hard drive containing additional data related to Appendix C.

If you have any questions or need additional information regarding this delivery, please contact Ms. Karen Coffman at 410-545-8407 (or via email at kcoffman@sha.state.md.us) or me at 410-545-8640 (or via email at sram@sha.state.md.us).

Sincerely,

FR
Sonal Ram, Director
Office of Environmental Design

Enclosures: MDOT SHA MS4 Annual Report, 10/9/2017

CC: Mr. Robert Shreeve, MDOT SHA OED
Ms. Karen Coffman, MDOT SHA OED
Mr. Brian Cooper, MDE WSA Sediment, Stormwater, and Dam Safety Program

National Pollutant Discharge Elimination System
Municipal Separate Storm Sewer System
Permit No. 11-DP-3313 MD0068276
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Second Annual Report

October 9, 2017

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Table of Contents

Table of Contents i
List of Tables iii
List of Figures v
List of Acronyms vii

1. Standard Permit Conditions and Responses 1-1
Introduction 1-1
A. Permit Administration 1-5
B. Legal Authority 1-5
C. Source Identification 1-5
C.1 Storm Drain System 1-5
C.2 Industrial and Commercial Sources 1-7
C.3 Urban Best Management Practices (BMPs) 1-7
C.4 Impervious Surfaces 1-7
C.5 Monitoring Locations 1-8
C.6 Water Quality Improvement Projects 1-12
D. Management Programs 1-12
D.1 Stormwater Management 1-12
D.2 Erosion and Sediment Control 1-25
D.3 Illicit Discharge Detection and Elimination 1-30
D.4 Trash and Litter 1-34
D.5 Public Education 1-55
E. Restoration Plans and Total Maximum Daily Loads (TMDLs) 1-63
E.1 Watershed Assessments 1-66
E.2 Restoration Plans 1-68
E.3 Public Participation 1-73
E.4 TMDL Compliance 1-75
F. Assessment of Controls 1-97
F.1 Watershed Restoration Assessment 1-97
F.2 Stormwater Management Assessment 1-100
G. Program Funding 1-102

Part Two – Drainage and Stormwater Asset Program 2-1
A. Planning 2-2
B. Engineering 2-8
C. Construction 2-12
D. Operations 2-15
E. Future Focus 2-16
F. Summary 2-20

Appendix A Restoration Accounting Methodology A-1
Appendix B Existing Stormwater Control Structures WQ Treatment Determination B-1
Appendix C MDOT SHA Plan Review Division – Annual Report C-1
Appendix D MDOT SHA IDDE Tracking – Business Flow Diagram D-1
Appendix E MDOT SHA Litter Program Attachments E-1
- MDOT SHA Litter Report – FY 2017 ..... E-2
- "Don't Trash Maryland" by Greg Slater – Baltimore Sun 5/24/17 ..... E-12
- 2017 Market Research Study – Pre-Campaign Summary Report E-14

- Litter Education Campaign Communication Plan E-48

Appendix F Research Activity F-1
- Assessment of Stream Restoration Projects in Maryland F-2
- Meeting Local TMDLs for PCBs F-68
- Inlet Cleaning Pollutant Characterization Study F-85
- Assessment of Bioswale Performance F-93
- Use of Compost to Establish Permanent Vegetation F-159
- Turfgrass – Experimental Field Trials F-171

Appendix G MDOT SHA 2016 Impervious Restoration and Coordinated TMDL Implementation Plan – Revised Pages G-1

Appendix H MDOT SHA Automated Modeling Protocol – Revised (October 2017) H-1

Appendix I Comprehensive List of Restoration Practices by Contract I-1

Appendix J Little Catoctin Creek Watershed Monitoring Implementation Document J-1

Appendix K Stormwater Management Assessment Monitoring Plan for Environmental Site Design (ESD) at Interstate 70 ..... K-1

Appendix L Grass Swale Process Addendum L-1

Appendix M Geospatial Database and Data Dictionary M-1

CD Digital Copies of the Annual Report and Appendices, Geospatial Database, and Data Dictionary

List of Tables

Table 1-1: Storm Drain System Source ID Update Schedule 1-7

Table 1-2: MDOT SHA Impervious Surface Baseline Dates by County 1-8

Table 1-3: Stormwater Management Review and Approval 1-14

Table 1-4: MDOT SHA BMPs for Maintenance Work Orders 1-18

Table 1-5: MDOT SHA BMP Remediation Progress 1-22

Table 1-6: Priority MDOT SHA BMPs for Major Remediation or Retrofits 1-24

Table 1-7: Priority MDOT SHA BMP Major Remediation and Retrofit Progress 1-25

Table 1-8: Erosion and Sediment Control Permits and Disturbance Acreage 1-27

Table 1-9: MDOT SHA ESC Training 1-29

Table 1-10: Field Screening Summary 1-30

Table 1-11: Illicit Discharge Requiring Follow-up 1-34

Table 1-12: Maintenance/Contracted/Inmate Right-of-Way Trash/Litter Removal 1-35

Table 1-13: Adopt-A-Highway Program Right-of-Way Trash/Litter Removal 1-36

Table 1-14: Sponsor-A-Highway Program 1-36

Table 1-15: Industrial NPDES Permit Status 1-42

Table 1-16: 12-SW Impervious Accounting Included in MS4 Baseline 1-43

Table 1-17: Capital Expenditures for Pollution Prevention BMPs 1-45

Table 1-18: Number of inlets cleaned and tons collected in FY2017 1-47

Table 1-19: Pesticide Applicator Training 1-48

Table 1-20: Herbicides Applied to MDOT SHA Property 1-49

Table 1-21: MDOT SHA Deicing Materials 1-50

Table 1-22: Recent Salt Usage Statewide 1-51

Table 1-23: MDOT SHA Snow College Training 1-52

Table 1-24: SWPPP Training by Shop 1-54

Table 1-25: MDOT SHA Baseline Impervious Surface by County (Acres) 1-70

Table 1-26: TMDL Implementation Plans Submitted since 2016 Annual Report 1-72

Table 1-27: Impervious Restoration Credit by BMP Type for Timeframe between Baseline Year* through FY17 1-77

Table 1-28: Local TMDL Pollutant Reduction Progress Through June 30, 2017 1-80

Table 1-29: Percentage of Impervious Treatment (Goal vs Achieved) 1-87

Table 1-30: Fund 82 Allocations (Capital Funds) 1-89

Table 1-31: FY 2011 to 2017 Itemized Costs for Completed Projects 1-91

Table 1-32: MS4 Funding Budget and Expenditures 1-103

List of Figures

Figure 1-1: Municipal Separate Storm Sewer System (MS4) Jurisdictions 1-3

Figure 1-2: 2017 Organizational Chart for MDOT SHA NPDES MS4 Permit Administration 1-4

Figure 1-3: HHD Research Web App 1-6

Figure 1-4: Demonstration of Video Pipe Inspection Equipment 1-6

Figure 1-5: Watershed Restoration Assessment Monitoring Locations 1-10

Figure 1-6: Stormwater Management Assessment Monitoring Locations 1-11

Figure 1-7: Internal Process for SWM As-Built Coordination 1-15

Figure 1-8: Quality Assurance Toolkit - Use for As-Built Tracking 1-16

Figure 1-9: MDOT SHA Yellow Card Certification 1-29

Figure 1-10: MDOT SHA Illegal Dumping and Illicit Discharge Flyer 1-33

Figure 1-11: MDOT SHA Adopt-A-Highway Sign 1-35

Figure 1-12: MDOT SHA Sponsor-A-Highway Sign 1-36

Figure 1-13: Example of MDOT SHA's Use of Social Media in Promoting Litter Education 1-37

Figure 1-14: MDOT SHA Earth Day Service Project 1-38

Figure 1-15: MDOT SHA's 2016 PARK(ing) Day Display 1-39

Figure 1-16: MDOT SHA Performance Measure 8.1 – Percent of Half-Mile Segments 1-40

Figure 1-17: MDOT SHA Nighttime Street Sweeping Operation 1-45

Figure 1-18: MDOT SHA Vacuum Truck Used to Clean Inlets 1-46

Figure 1-19: Inlet Before and After Cleaning 1-47

Figure 1-20: Comparison of Salt Usage Normalized by Snow Depth Statewide 1-52

Figure 1-21: Screen Capture of CCMS 1-56

Figure 1-22: Screen Capture of MDOT SHA's Park and Ride Facility Locator Interactive Map 1-59

Figure 1-23: MDOT SHA HOV Lane 1-59

Figure 1-24: MDOT MVA Administrator Paul Comfort (left) and SHA Administrator Gregory Slater (right) Participating in Bike to Work Day 2017 1-60

Figure 1-25: Pet Waste Disposal Station at the I-70 Eastbound Rest Area 1-61

Figure 1-26: September 2016 MDOT SHA Chesapeake Bay Field Trip 1-61

Figure 1-27: WPD Team Leader Ryan Doran, Presenting at the February 2017 ASHE Technical Meeting 1-62

Figure 1-28: MDOT SHA Baseline Treated and Untreated Impervious Surfaces by County 1-71

Figure 1-29: Washington Post Public Notice 1-74

Figure 1-30: MDOT SHA TMDL Implementation Plan Webpage 1-75

Figure 1-31: Impervious Restoration Completed by BMP Type (Baseline Year – 2017) 1-78

Figure 1-32: Achieved Sediment Reduction Loads 1-85

Figure 1-33: Achieved Phosphorus Reduction Loads 1-86

Figure 1-34: MDOT SHA Impervious Restoration Achieved Compared to Goal 1-87

Figure 1-35: Cumulative Impervious Restoration Progress 1-88

Figure 1-36: Storm flow at U.S. Geological Survey Site 01636845 (Little Catoctin Creek Near Rosemont, MD; Upstream) 1-99

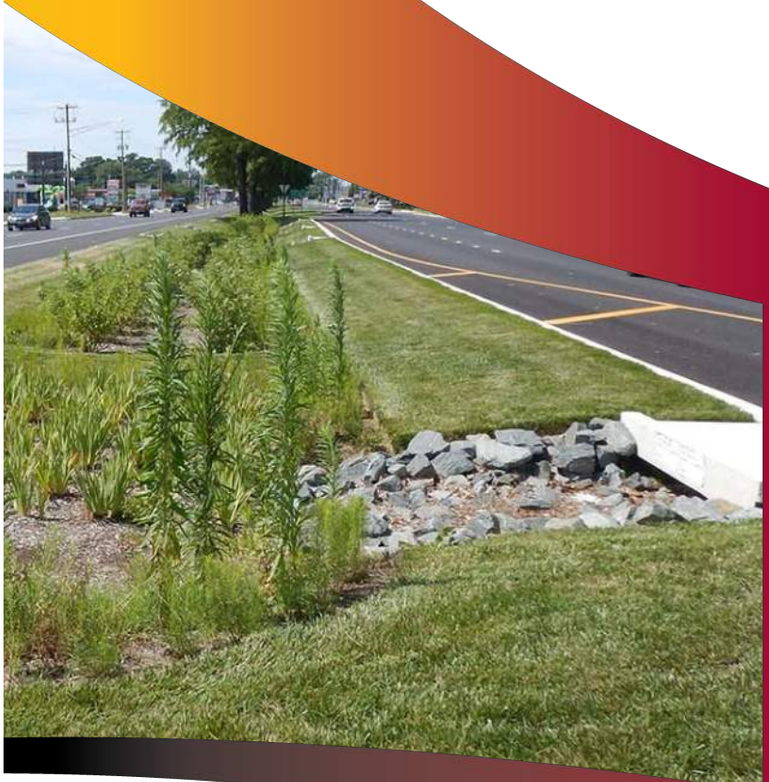
Figure 1-37: Exposed Bank at Section P-4 of the Physical Monitoring Locations 1-100

Figure 1-38: MDOT SHA and HO County ESD Facilities and Monitoring Sites 1-101

List of Acronyms

BMP	Best Management Practice
CFR	Code of Federal Regulations
COMAR	Code of Maryland Regulations
CWA	Clean Water Act
CCMS	Customer Care Management System
ECD	Environmental Compliance Division
ECU	Environmental Crimes Unit
EPA	Environmental Protection Agency
ESC	Erosion and Sediment Control
ESD	Environmental Site Design
FY	Fiscal Year
GIS	Geographic Information System
HEC-2	Hydrologic Engineering Centers – Water Surface Profiles
HEC-RAS	Hydrologic Engineering Centers River Analysis System
HHD	Highway Hydraulics Division
HSPF	Hydrologic Simulation Program - Fortran
IDDE	Illicit Discharge Detection and Elimination
lbs	Pounds
MBSS	Maryland Biological Stream Survey
MD	Maryland
MDE	Maryland Department of the Environment
MDOT	Maryland Department of Transportation
MES	Maryland Environmental Service
MEP	Maximum Extent Practicable
MS4	Municipal Separate Storm Sewer System
N	Nitrogen
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
OAG	Office of the Attorney General
OED	Office of Environmental Design
OHD	Office of Highway Development
P	Phosphorus
PCB	Polychlorinated Biphenyls
PRD	Plan Review Division
RBP	Rapid Bioassessment Protocol
S	Sediment
SHA	State Highway Administration
SOIRP	Storm Drain and Outfall Inspection and Remediation Program
SWM	Stormwater Management
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorous
TPH	Petroleum Hydrocarbons
TSS	Total Suspended Solids
WLA	Waste Load Allocation
WSA	Water and Science Administration
WPD	Water Programs Division
WQv	Water Quality Volume

Part One



Standard Permit Conditions and Responses

PART ONE

1. Standard Permit Conditions and Responses

Introduction

The Maryland Department of Transportation State Highway Administration (MDOT SHA) is committed to continuing the National Pollution Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Program efforts, and is pleased to partner with the Maryland Department of the Environment (MDE) Water and Science Administration (WSA), the Environmental Protection Agency (EPA), and other NPDES jurisdictions in order to achieve the program goals.

The original MDOT SHA NPDES Phase I permit, MS-SH-99-011, was issued on January 8, 1999 and expired in 2004. This permit guided MDOT SHA through establishing an NPDES MS4 program.

The Phase II State and Federal Small MS4 General Permit (GP), 05-SF-5501, MDR 055501, was issued November 12, 2004 and expired November 12, 2009. MDOT SHA submitted an NOI for coverage under the Phase II MS4 GP and received authorization for coverage May 25, 2005. Under the authority of this Phase II permit, MDOT SHA extended the same MS4 program elements established under the Phase I permit to the MDOT SHA storm drain systems in Phase II areas.

The next Phase I permit (99-DP-3313, MD0068276, issued October 21, 2005 and expired on October 21, 2010) focused on improving water quality benefits, developing an impervious accounting database and developing a watershed-based outlook for stormwater management and MS4 program elements. MDOT SHA submitted a re-application for the Phase I permit on October 21, 2009 and a new permit was issued to MDOT SHA on October 9, 2015. This current permit covers MDOT SHA storm sewer systems in both the originally designated Phase I and Phase II jurisdictions. This report covers compliance with the permit that was issued in 2015. MDOT SHA has provided the permit general information in the Permit Information table (PER) as specified in the May 2017 MDE Geodatabase Guideline format.

Report Format and Deliverables

This second annual report covers Fiscal Year 17 (FY17) from July 1, 2016 through June 30, 2017, in accordance with the current permit reporting requirements listed in Part V.A.1.

Geographically, this report covers MDOT SHA compliance for storm drain systems owned or operated by MDOT SHA located within the NPDES counties of Anne Arundel, Baltimore, Carroll, Cecil, Charles, Frederick, Harford, Howard, Montgomery, Prince George's, and Washington as depicted in green on the map in Figure 1-1 on the following page. The Cities of Salisbury, Cambridge, and Cumberland have been removed from our reporting - Allegany and Wicomico Counties will be added to MDOT SHA's next MS4 permit coverage, therefore Cumberland and Salisbury will be included in those areas for the next permit term. Since Dorchester has been removed from MS4 status, Cambridge is not anticipated to be included in the next MS4 permit coverage.

Part One of this report lists permit conditions and explains MDOT SHA activities over the reporting period to comply with each one. Wherever possible, future activities and schedules for completion are provided. Part Two of this report discusses the MDOT SHA Stormwater and Drainage Asset Management Program in depth. Appendices are included at the end of the report that contain information on data, public outreach, research, MDOT SHA's revised Restoration Modeling Protocol, and the monitoring plan for the stormwater management assessment condition (Part IV.F.2 of the permit).

A CD is included that contains portable document format (PDF) files of the report, database tables, and GIS spatial data.

MDE Comments on MDOT SHA 2016 MS4 Report and One-Year Submittals

MDE supplied comments dated April 26, 2017 relating to the results of MDE review of the MDOT SHA 2016 MS4 annual report, data submittal, impervious accounting, and the MDOT SHA 2016 Impervious Restoration and Coordinated TMDL Implementation Plan. The MDE comments were divided into three attachments:

I: MDE Assessment and Recommendations,

II: Impervious Area Assessment Report, and

III MDOT SHA Stormwater Waste Load Allocation (WLA) Implementation Plan Comments for Nutrients, PCBs, Trash, Sediment, and Bacteria.

MDE's Impervious Area Assessment Report (MDE Attachment II) outlined specific information required to be submitted to MDE by July 31st, 2017 to finalize its assessment and approval of the MDOT SHA baseline impervious accounting. On 7/31/2017, MDOT SHA delivered to MDE a complete reassessment of the baseline impervious accounting, 20 percent restoration goal, and detailed responses to the specific comments included in MDE Attachment II. The 7/31/2017 submission included attachments, a compact disc, and an external hard drive as described below:

- A compact disc containing revised submission of the October 2016 MS4 Geodatabase with updated baseline BMPs along with a new copy of the MDOT SHA revised impervious surface layer

- *Baseline Impervious Accounting Calculation Methodology* – A document detailing the technical process of calculating impervious area credit using the MDE MS4 geodatabase format, providing a clear basis of understanding for how the impervious acre credit value is calculated for baseline treatment across each of the BMP types.

- *Existing Stormwater Control Structures Water Quality Treatment Determination* - A document presenting MDOT SHA's process for researching and documenting the amount of stormwater treatment provided by each existing MDOT SHA stormwater control structure for credit in support of MDOT SHA baseline treatment calculations (Appendix B for this report)

- Revised pages to the MDOT SHA 2016 Impervious Restoration and Coordinated TMDL Implementation Plan, Part II, reflecting the revised impervious baseline and 20 percent restoration goal.

- Example pre-1985 stormwater control computations

- An external hard drive containing 95 GB of stormwater treatment documents

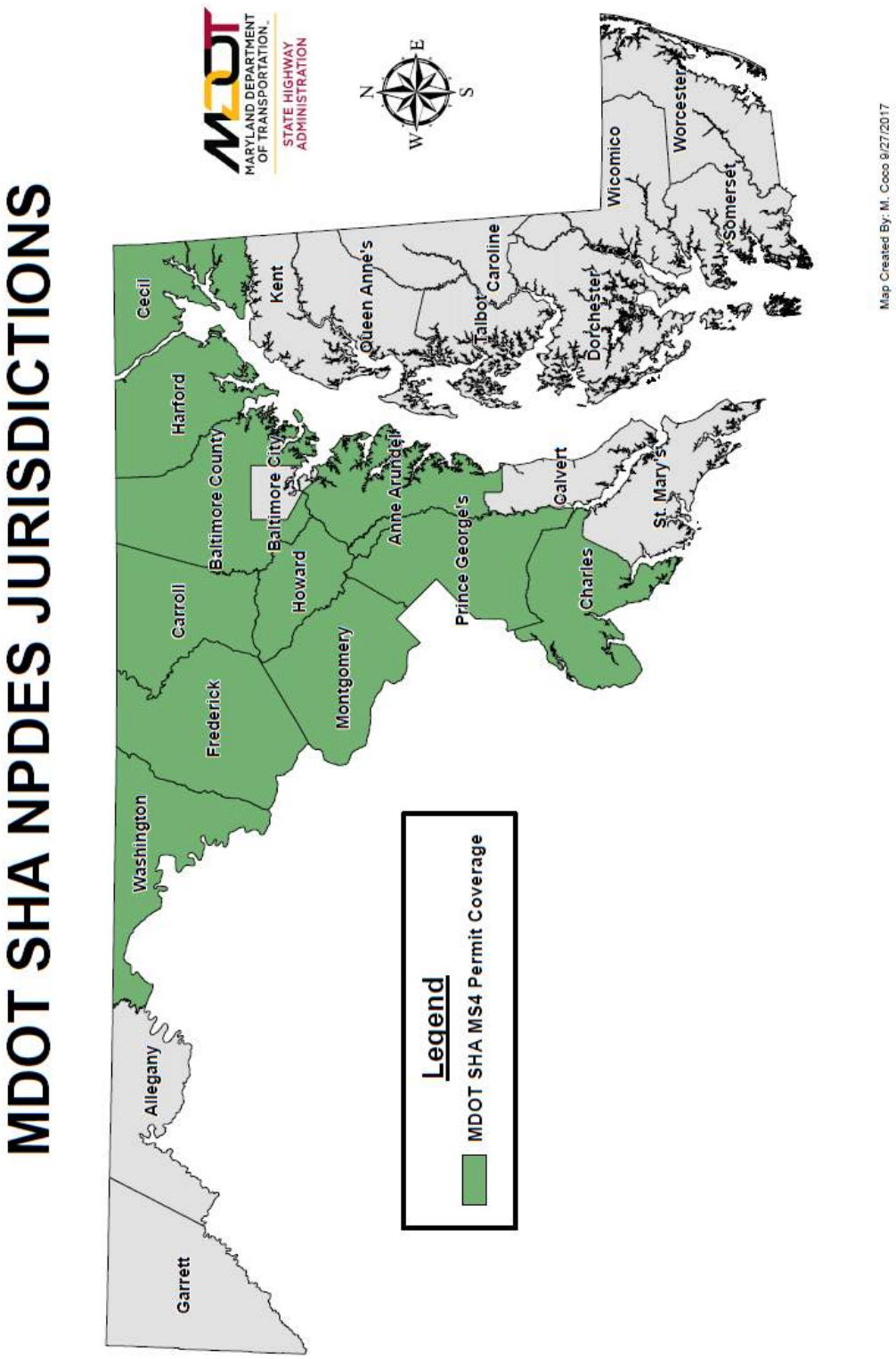


Figure 1-1: Municipal Separate Storm Sewer System (MS4) Jurisdictions

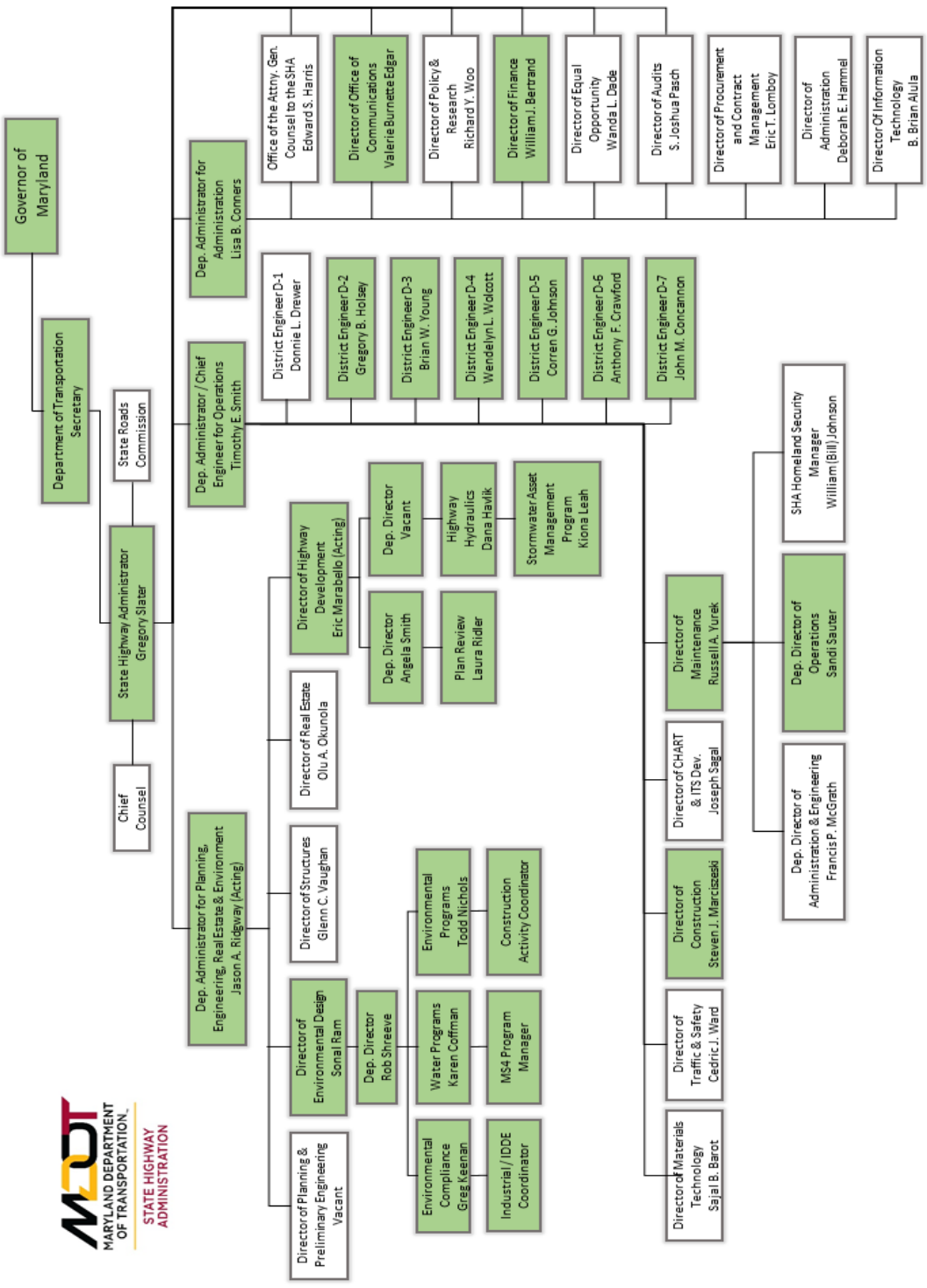


Figure 1-2: 2017 Organizational Chart for MDOT SHA NPDES MS4 Permit Administration

A. Permit Administration

Administration coordinator for the NPDES Program is listed below and an organizational chart detailing personnel responsible for major program components is included on page 1-3 as Figure 1-2.

Mr. Robert Shreeve
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Office of Environmental Design
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The MDOT SHA Program Manager for the MS4 permit is:

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Division Chief
Water Programs Division
Office of Environmental Design
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KCoffman@sha.state.md.us

B. Legal Authority

A description of the legal authority maintained by MDOT SHA was included in the first annual report dated October 9, 2016 and remains unchanged.

C. Source Identification

According to the permit language, sources of pollutants in stormwater runoff should continue to be identified and linked to specific water quality impacts on a watershed basis. The collected data as a result of source identification should be used by MDOT SHA and surrounding NPDES counties for watershed restoration planning.

Requirements under this condition include submitting MDOT SHA stormwater infrastructure data within the permit area in geographic information system (GIS) format on an annual basis:

1. *Storm drain system: Delineate all infrastructure, major outfalls, inlets, and associated drainage areas;*
2. *Industrial and commercial sources: Identify industrial and commercial land uses and sites that have the potential to contribute significant pollutants to SHA storm drain systems;*
3. *Urban best management practices (BMPs): Collect stormwater management facility data including outfall locations and delineated drainage areas;*
4. *Impervious surfaces: Delineate SHA-owned and private land owned (if within SHA BMP drainage area) controlled and uncontrolled impervious areas based on, at a minimum, Maryland's hierarchical eight-digit sub-basins;*
5. *Monitoring locations: Locations established for chemical, biological, and physical monitoring of watershed restoration efforts and the 2000 Maryland Stormwater Design Manual; and*
6. *Water quality improvement projects: Projects proposed, under construction, and completed with associated drainage areas delineated, when applicable.*

C.1 Storm Drain System

MDOT SHA completed the inventory of drainage infrastructure, major outfalls, stormwater management facilities, and associated drainage areas in 2008. MDOT SHA developed a spatial Geographic Information System (GIS) database, and has been performing regular updates of the drainage infrastructure including new or altered storm drain systems and new or retrofitted SWM facilities. Throughout the past several years, significant effort and resources were allocated to complete updates of the SWM inventory, inspections, and the associated drainage infrastructure to properly establish baseline MDOT SHA owned impervious treatment. SHA continues to populate the missing database fields to add outfall drainage areas and other records such as City, State, and zip codes. Significant research has been conducted in the past year to determine constructed (as-built) dates for drainage outfalls and SWM BMPs. MDOT SHA has provided the outfall structure information in the Outfall feature class (OUT) and the Outfall Drainage Area feature class (ODA) as specified in the May 2017 MDE Geodatabase Guideline format.

Part Two of this report focuses on components of the MDOT SHA SWM and Drainage Asset Program. This includes inventory, inspections

(both within and outside permitted areas), functional rating, assessment for remedial activities, project planning, design and implementation of remedial and retrofit projects.

HHD Web Research Application

A new tool available to all MDOT SHA business units has been implemented in 2017. The HHD Web Research Application integrates many GIS database layers into a single map viewer showing additional environmental features, planning projects, and public flooding information to enhance planning efforts. All MDOT SHA outfalls within MS4 counties have been identified and captured in the spatial database. Efforts beyond the MS4 counties continue to identify outfalls within MDOT SHA ROW. The stormwater and drainage assets database (screenshot included in Figure 1-3 below) is an excellent resource during drainage investigations, when addressing public flooding issues, or during assessment of outfall channel stability. It is an essential tool for initiating drainage improvement projects-, stormwater retrofits, major remediation, and outfall stabilization planning, as well as rapidly addressing any emergency repairs.

Figure 1-3: HHD Research Web App

Video Pipe Inspection (VPI) Program

MDOT SHA expanded the drainage system inspection program by adding video inspections to allow for precise assessment of system functionality. The VPI consists of nine cameras operating Granite XP software. Granite XP is installed on individual laptops assigned to each camera, and allows for the data input and management of individual inspections.

MDOT SHA performed an evaluation of current video inspection procedures across its districts to identify the specific needs of the VPI Program, and develop a plan to address these needs as they relate to drainage asset management. In the past year, the existing process was identified and documented, and a plan for the revised process (including data collection, management, and storage) has been devised. Additionally, the Granite XP software on one laptop in District 3 was configured for the data input fields to match the language that MDOT SHA currently uses for hydraulic and asset management purposes.

Prior to a statewide rollout, MDOT SHA will be implementing a pilot program to better evaluate the strengths and weaknesses of the revised process and Granite XP configurations.

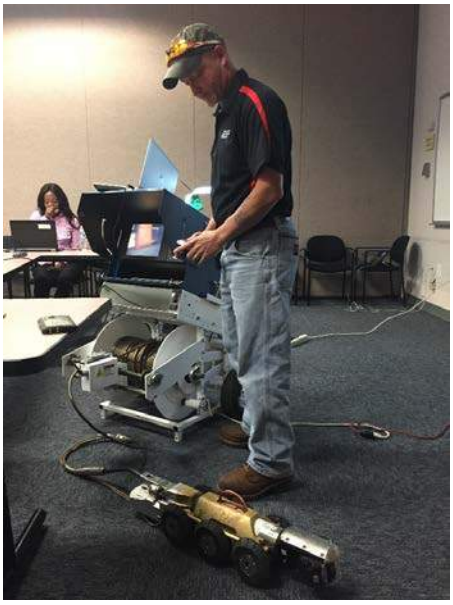


Figure 1-4: Demonstration of Video Pipe Inspection Equipment

Database and System Upgrades

MDOT SHA is also updating the current data structure to new hardware and software that will enable the system to more efficiently operate and facilitate future upgrades. The new structure includes improved hardware to be installed in late 2017 and an upgrade of the current database

platform to support new technology for mobile operations. MDOT SHA is developing a new stormwater BMP inspection and inventory field tool based on enterprise GIS technologies to improve the efficiency and accuracy of the inspection data management.

There are new data standards for the NPDES MS4 Stormwater Program Geodatabase as described in the MDE NPDES Geodatabase Design and User's Guide originally published March 2015, and revised and republished as the May 2017 MDE Geodatabase Guidance.

The schedule for future updates to the storm drain system inventory is shown in Table 1-1. Stormwater facility inspections and outfall illicit discharge field screenings are performed for each county according to the same schedule.

Table 1-1: Storm Drain System Source ID Update Schedule

Jurisdiction	Date Last Inspections Initiated	Next Inspection & Source ID Completed By
Prince George's County	August 2014	August 2017
Anne Arundel County	August 2015	September 2018
Harford County	September 2015	October 2018
Baltimore County	March 2016	April 2019
Charles County	March 2016	April 2019
Frederick County	March 2016	April 2019
Howard County	March 2016	April 2019
Washington County	August 2016	August 2019
Carroll County	August 2016	August 2019
Montgomery County	January 2017	January 2020
Cecil County	April 2017	April 2020

C.2 Industrial and Commercial Sources

During the reporting period, a GIS layer was developed to identify industrial sites within MDOT SHA right-of-way that have the potential to contribute pollutants to MDOT SHA storm drain systems. There are no commercial sites on MDOT SHA properties. This GIS layer is included in the MDOT SHA Supplemental 2017 Geodatabase, submitted with this annual report. The layer includes MDOT SHA 12-SW permitted industrial sites. The inventory of these industrial sites will be updated when new 12-SW permits are acquired for MDOT SHA facilities.

Section D.3.b of this annual report discusses how these potential sources will be inspected in accordance with MDOT SHA's current 12-SW inspection program.

C.3 Urban Best Management Practices (BMPs)

The drainage and stormwater assets inventory data is updated according to the schedule presented in Table 1-1 and includes inventory and inspection of stormwater control structures, associated outfalls, and drainage areas. MDOT SHA has provided the urban BMP information in the in the BMP Point of Investigation feature class (BMPPOI) and the BMP table (BMP)as specified in the May 2017 MDE Geodatabase Guideline format.

C.4 Impervious Surfaces

MDOT SHA performed a reevaluation of its impervious accounting to fall in line with the 2014 MDE Accounting Guidance and expectations for a baseline year of 2002. The previous baseline had been established as 2010 to coincide with the expiration of the last MDOT SHA MS4 permit (10/21/2010). Revised impervious surfaces were

developed using available photogrammetry data that was closest to 2002 for each MS4 jurisdiction and the resulting baseline years range from 2002 to 2005. Table 1-2 shows the MDOT SHA impervious surface baseline year by MS4 jurisdiction. This GIS layer is included in the MDOT SHA Supplemental 2017 Geodatabase, submitted with this Annual Report.

Table 1-2: MDOT SHA Impervious Surface Baseline Dates by County

County	Baseline Date
Anne Arundel	12/31/2005
Baltimore	12/31/2005
Carroll	12/31/2005
Cecil	12/31/2005
Charles	12/31/2004
Frederick	12/31/2005
Harford	12/31/2004
Howard	12/31/2002
Montgomery	12/31/2004
Prince George's	12/31/2005
Washington	12/31/2005

Information about the impervious accounting reevaluation and resulting baseline was provided in MDOT SHA's 7/31/2017 submission to MDE: MDOT SHA Response to MDE Impervious Area Assessment Report Comments (MDE Attachment II). Discussion of the revised impervious accounting and additional information can be found within Section E.2.b and within Appendices A and B of this report.

Also, pertinent pages relating to the impervious baseline were revised in Part II of the MDOT SHA Impervious Restoration and Coordinated TMDL Implementation Plan, October 8, 2016 to reflect latest accounting methods. These revised pages were delivered to MDE on 7/31/2017.

C.5 Monitoring Locations

Monitoring site locations for current studies to meet the Section IV.F Assessment of Controls permit conditions F.1, Watershed Assessment, and F.2, Stormwater Management Assessment, are provided in the Chemical Monitoring (CHE) and Biological Monitoring (BIO) tables as specified in the May 2017 MDE Geodatabase Guideline format. MDOT SHA has also provided the monitoring site location information in the Monitoring Site feature class (MSI) and the Monitoring Drainage Area feature class (MDA). Discussion on progress for each of these studies and analysis of data obtained over the report period are included in Section F of this report while discussion of the monitoring locations is provided below.

Watershed Restoration Assessment Monitoring Locations

The study reach for Little Catoctin Creek project is 3,100 feet long. The approved monitoring plan was appended to the MDOT SHA 2016 annual report. During the reporting period, chemical, biological, and physical monitoring was performed as specified in the monitoring methodology in the monitoring plan. These monitoring locations can be found in Figure 1-5, and include two locations for discrete, manual chemical sampling (01636845 AND 01636846); seven biological sampling locations (PRFR-201-X, PRFR-202-X, PRFR-203-X, PRFR-204-X, PRFR-205-X, PRFR-206-X, PRFR-107-X); and five physical monitoring locations (P-1, P-2, P-3, P-4, and P-5). Chemical monitoring site 01636846 is instrumented with an acoustic doppler velocity meter (ADVM) for continuous flow measurements.

Optional Monitoring Efforts

As discussed in the 2016 monitoring plan, MDOT SHA recognizes that this overall monitoring effort creates opportunity to collect important information beyond the requirements of the NPDES/MS4 permit, and would be implementing additional monitoring efforts as funding allows.

- Floodplain Monitoring and Assessment: 125 floodplain tiles were installed at 7 floodplain monitoring transects to quantify floodplain sediment accretion throughout the study reach. These transects are not included in the monitoring site data delivered with this report.

- Groundwater: Three groundwater monitoring transects were included in the 2016 monitoring

plan as optional and MDOT SHA has decided not to implement this monitoring due to cost.

MDOT SHA is in the process of monitoring the physical, chemical and biological features of the Little Catoctin Creek for five years. A report documenting the findings from the first year of monitoring for the pre-restoration baseline, is appended as Appendix J, and is discussed further in Section F.1 of this annual report.

Stormwater Management Assessment Monitoring Locations

MDOT SHA has proposed to monitor the impacts of environmental site design (ESD) practices on the Litter Patuxent River main stem near I-70 and Marriottsville Road in Howard County, Maryland. On August 30, 2017, MDE granted MDOT SHA formal approval of the MDOT SHA March 2017 monitoring plan to conduct ESD monitoring at this site contingent upon MDOT SHA submitting a revised monitoring plan to MDE. MDOT SHA's revised monitoring plan, dated October 2017, is included in Appendix K and discussed in Section F.2 of this report.

Monitoring locations for the Little Patuxent River near I-70 and Marriottsville Road in Howard County are shown in Figure 1-6 and include two physical monitoring locations, and three flow station locations. These flow stations are optional sites that will only monitor discharge stage for the site. A physical monitoring site was dropped in this 2017 version of the plan because MDOT SHA right-of-way (ROW) was investigated and the third physical section (southernmost) was eliminated because it was located outside the ROW.

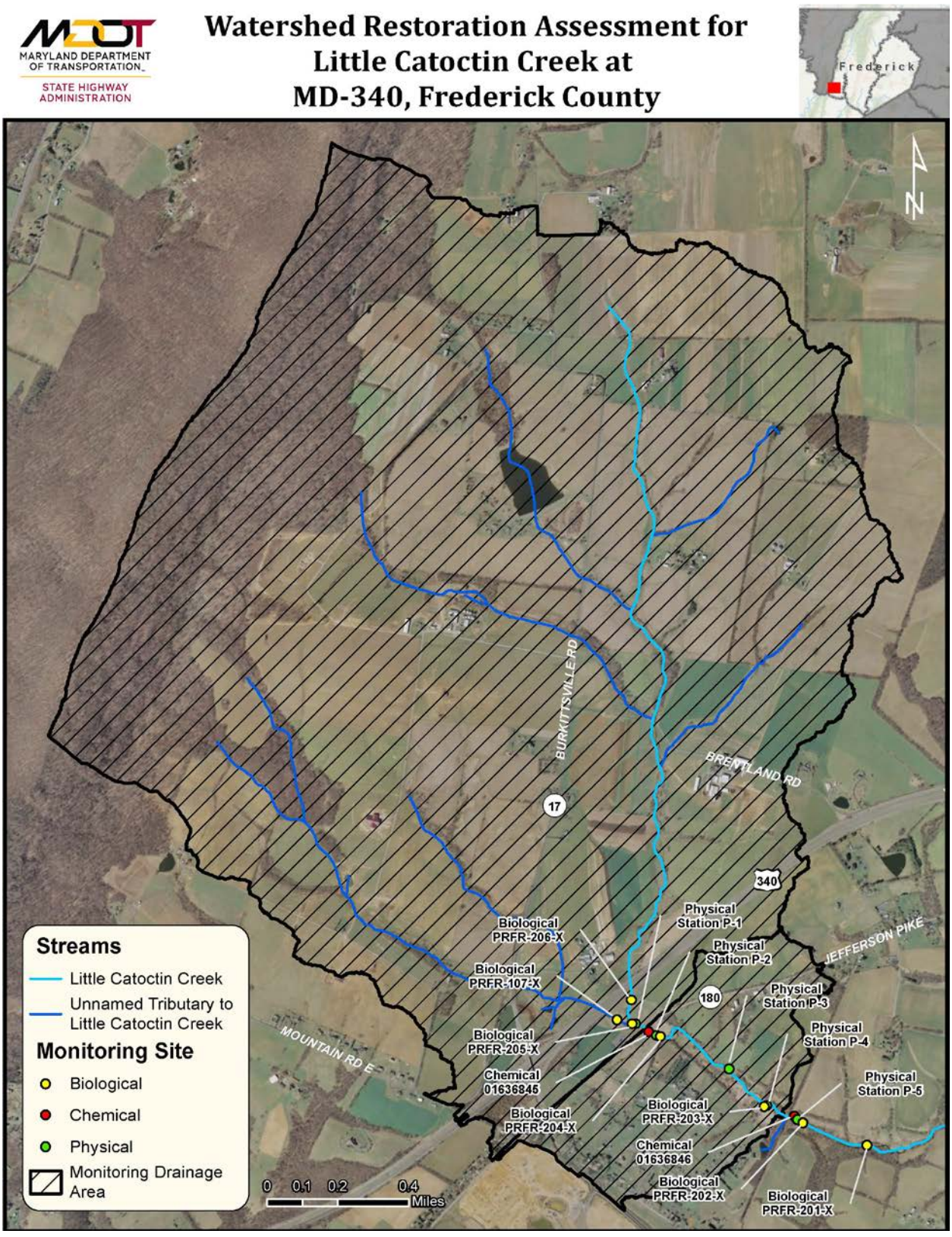


Figure 1-5: Watershed Restoration Assessment Monitoring Locations

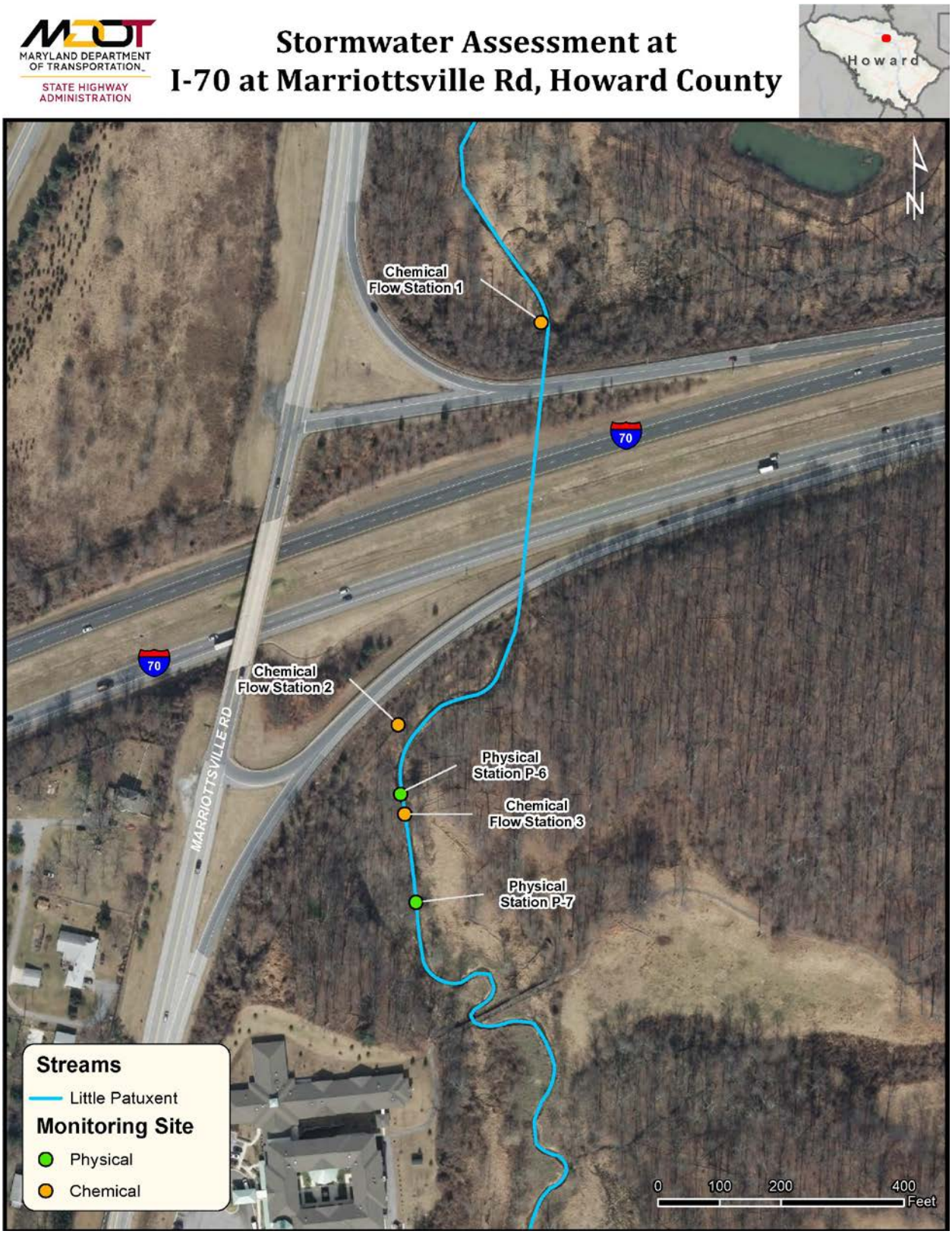


Figure 1-6: Stormwater Management Assessment Monitoring Locations

C.6 Water Quality Improvement Projects

MDOT SHA has provided water quality improvement project information for completed projects through FY17 (restoration BMPs) using the following feature classes and tables as specified in the May 2017 MDE Geodatabase Guideline format:

- Restoration BMP feature class (RST)
- Alternate BMP Polygon feature class (APY)
- Alternate BMP Line feature class (ALN)
- Stream Restoration Protocols table (SRP)

The submitted data includes only completed projects at this time and does not include projects with a status of planning or under construction.

Further discussion on progress meeting restoration goals is included in Section E.4.

For more information on SHA's proposed and under construction water quality improvement projects, please refer to Tables 2-2a – 2-2g in the MDOT SHA Impervious Restoration and Coordinated TMDL Implementation Plan that was delivered to MDE on October 8, 2016. These tables provide a comprehensive list of annual operations practices and completed, planned, and under construction impervious restoration practices broken down by fiscal year. These tables will be updated in the revised implementation plan to be delivered with the next annual report. Additionally, proposed practices to meet various pollutant reductions for each impaired watershed with MDOT SHA assigned WLAs are shown in Section IV of the MDOT SHA 2016 Implementation Plan.

D. Management Programs

A management program is required to limit the discharge of stormwater pollutants to the maximum extent practicable (MEP). The idea is to eliminate pollutants before they enter the waterways. This program includes provisions for stormwater management, erosion and sediment control, IDDE, trash and litter reduction, property management and maintenance, and public education concerning stormwater and pollutant minimization.

D.1 Stormwater Management

The continuance of an effective stormwater management program is the emphasis of this permit condition. Requirements under this condition include:

a) Implement the stormwater management design principles, methods, and practices found in the 2000 Maryland Stormwater Design Manual;

b) Maintain programmatic and implementation information including but not limited to number of plans received, number of projects received, number of exemptions issued and number and type of waivers received and issued;

c) Maintain construction inspection information according to COMAR 26.17.02 for all ESD treatment practices and structural stormwater management facilities; and

d) Conduct preventative maintenance inspections according to COMAR 26.17.02 of all ESD treatment systems and structural stormwater management facilities at least on a triennial basis.

D.1.a Implement 2000 SW Design Manual and Regulations

MDOT SHA continues to comply with Maryland State and federal laws and regulations regarding SWM as well as MDE permit requirements. MDOT SHA also continues to implement the practices established in the *2000 Maryland Stormwater Design Manual* and the MDOT SHA Sediment and Stormwater Guidelines and Procedures (November 24, 2015) for all projects. MDOT SHA remains in compliance with the Stormwater Management Act of 2007, including the revised Chapter 5 of the *2000 Maryland Stormwater Design Manual*, by implementing environmental site design (ESD) to the maximum extent practicable (MEP) for all new and redevelopment projects.

The MDOT SHA Plan Review Division (PRD) tracks MDOT SHA's progress towards satisfying the requirements of the Stormwater Management

Act of 2007 (the Act) and identifies and reports problems and modifications needed to implement ESD to the MEP in its quarterly reports to MDE. During the previous reporting period PRD worked collaboratively with MDE to prepare draft Technical Procedures which were submitted to MDE for review in February 2016. The Technical Procedures have been revised based on meetings with MDE during this reporting period and are submitted electronically for approval with this annual report.

As part of their reporting, PRD also makes required modifications to the plan review and approval processes to comply with the Act. During the reporting period, MDE transferred many of the remaining MDOT SHA projects under review at MDE to PRD for review and approval. MDE also initiated a COMAR change to remove the 20-acre Grading Unit requirement. As a result of these changes PRD made several modifications to the Guidelines and Administrative Procedures. PRD also updated Table 2 in the Guidelines to reflect current county stormwater management requirements.

D.1.b Maintain Programmatic and Implementation Information

MDOT SHA and MDE signed a Memorandum of Understanding (MOU), dated July 8, 2014, designating MDOT SHA as an approving authority for both erosion and sediment control and stormwater management for all MDOT SHA projects. This authority was given by a letter of authorization from MDE on February 24, 2015. MDOT SHA's approval authority lies with the PRD under the Office of Highway Development (OHD). PRD's sole responsibility is to review and approve MDOT SHA stormwater management and erosion and sediment control plans. PRD is separate and distinct from the OHD design divisions. In addition, the OHD design divisions are supervised by a different Deputy Director than PRD. PRD maintains a database to track stormwater management submittals, reviews, and approval progress on all MDOT SHA projects.

During FY 2017, PRD received 1,247 submissions on 356 projects, provided 688 comment memoranda, approved 204 concept design stage submittals, approved 141 site development stage submittals, and issued 121 final approvals statewide. Within the MS4 controlled areas, MDOT SHA PRD received 753 plan submittals for 227 projects, issued 412 comment memoranda, approved 130 concept plans, 95 site development plans, and 87 final plans. Table 1-3 summarizes these quantities below. It is important to note that projects and plans included in these values were required to have been received by, or have had approvals or comments issued on dates within the permit term in order to be included in the total values.

ESD must be implemented to the MEP. However, there are situations that warrant relaxing stormwater management requirements due to site specific circumstances. For those situations, waivers or variances may be applicable. During the reporting period, PRD granted 179 SWM quantity or quality control waivers and granted 50 variance requests for SWM quantity control within Maryland. Within the MS4 controlled areas, PRD issued 152 SWM waivers and 44 variances. To satisfy the requirements of SHA's delegated review and approval authority, PRD submitted its FY 2016 Report to MDE on October 7, 2016, covering the partial fiscal year from February 2, 2016 through June 30, 2016. As previously noted, PRD's FY 2017 Report is appended as Appendix C to this annual report. MDOT SHA has provided the stormwater management program information in the SWM table (SWM) as specified in the May 2017 MDE Geodatabase Guideline format. A summary by MS4 Jurisdiction is presented below in Table 1-3.

Table 1-3: Stormwater Management Review and Approval

Jurisdiction	Number of Projects	Review Submissions	Comment Memoranda	Concept Design Submittal Approvals	Site Development Stage Approvals	Final Approvals	Granted SWM Waivers	Granted SWM Variances
Anne Arundel	30	92	52	18	11	9	22	3
Baltimore	41	154	82	30	19	17	38	13
Carroll	15	44	28	6	4	6	7	9
Cecil	8	29	15	5	4	3	1	3
Charles	7	18	9	2	4	3	2	0
Frederick	29	113	57	17	15	15	18	12
Harford	12	43	24	8	5	3	0	2
Howard	8	28	19	6	1	2	1	0
Montgomery	33	103	58	14	14	14	16	1
Prince George's	32	87	48	31	13	11	47	1
Washington	12	42	20	11	5	4	0	0
MS4 Totals	**227**	**753**	**412**	**130**	**95**	**87**	**152**	**44**
Outside MS4	129	494	276	74	46	34	27	6
Statewide Total	**356**	**1247**	**688**	**204**	**141**	**121**	**179**	**50**

Notes:

1. Projects included in the total number above include any project that had activity during the permit term. Activity can include submittal of any plan type, waiver or variance request, or the receipt of comments or approvals.
2. Granted SWM Waivers or Variances include only those requests associated with final design plans that have been approved during the reporting term.
3. Plan review and related activity associated with "Areawide" projects, or those spanning multiple counties or jurisdictions, have been assigned to the "Outside MS4" category.

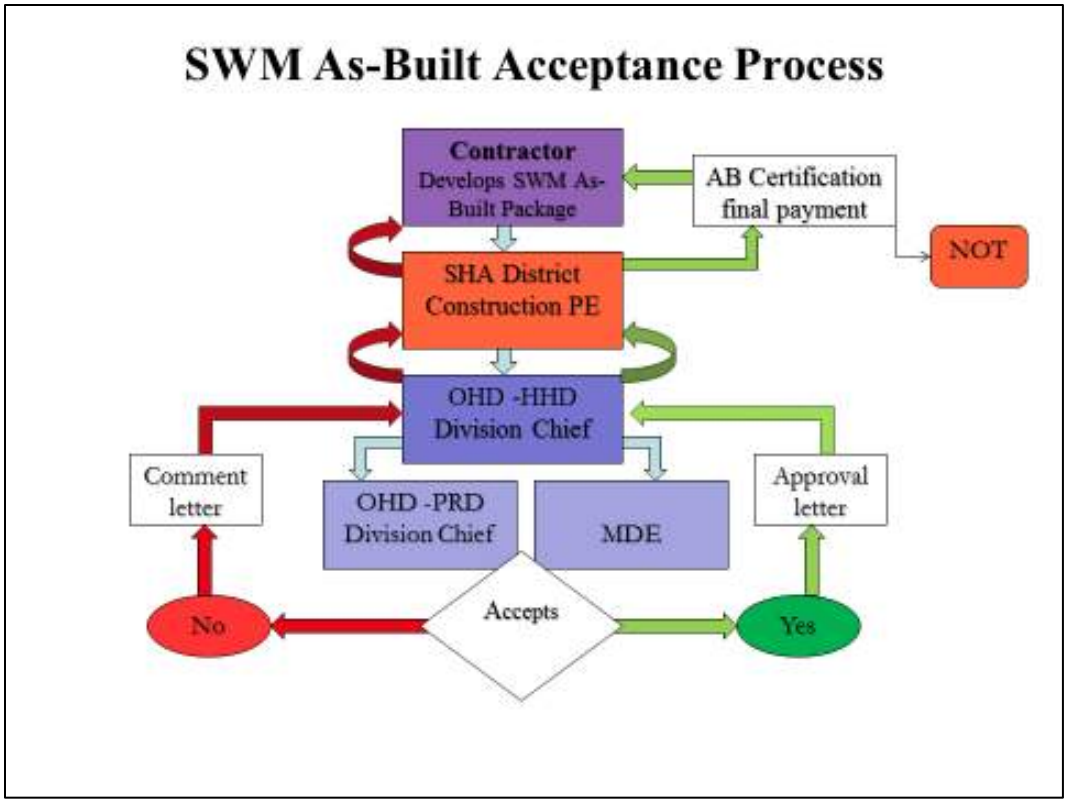


Figure 1-7: Internal Process for SWM As-Built Coordination

D.1.c Maintain Construction Inspection Information

COMAR 26.17.02.10 details regulations for inspections to be conducted for MDOT SHA maintains and continues to improve the SWM facility as-built (AB) certification process in order to comply with the SWM approval and COMAR requirements. See Figure 1-7 for AB certification process flow chart. The AB certification process assures verification of proper construction of SWM facilities so they meet design intent. Throughout the facility construction process, the Contractor's SWM as-built inspector coordinates with both the Office of Construction and the Contractor to perform required inspections necessary to complete the as-built tabulations and construction checklists included on the SWM design plans. The MDOT SHA issued SWM Facility AB Certification Special Provision included in the Contract Documents lists the allowed tolerances the construction AB inspector uses as a guide for certification that the SWM facility was constructed according to the approved design.

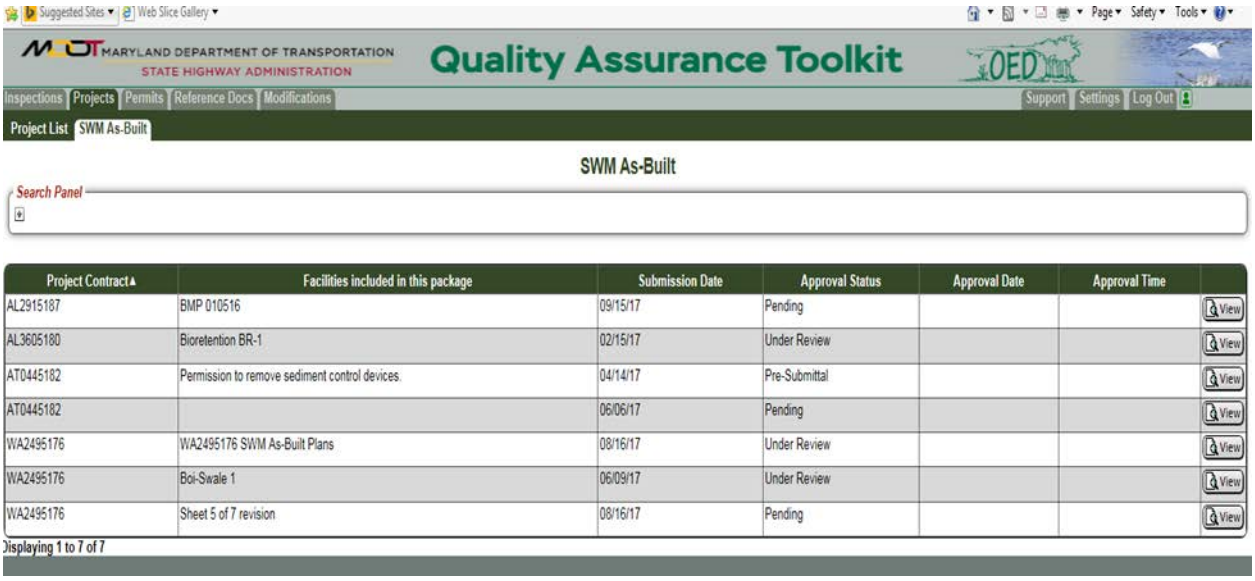
The SWM AB certification is a separate pay/bid item in the contract documents for each project; this provides the contractor additional incentive to comply with regulatory requirements.

The HHD coordinates with MDE-PRD and MDOT SHA-PRD on the review and acceptance of the SWM As- Built certified plans. MDE reviews SWM AB certified plans for projects that have received MDE Small Pond Approval. PRD issues final acceptance for structural components on all SWM AB certified plans and final approval is issued once vegetation is established and accepted by MDOT SHA Landscape Operation Division (LOD). The construction project cannot be closed out and accepted for maintenance until the SWM AB plans have been found acceptable by MDE/PRD. When SWM facilities do not meet design parameters within allowed tolerances as determined by either MDOT SHA or MDE, the Contractor is responsible for corrective construction or reconstruction, the re-inspection of the facility, and resubmission of the SWM AB

package to MDOT SHA. Copies of the final approved SWM AB plans and certifications, as well as photo documentation of the facility construction, are retained by MDOT SHA and integrated into the Drainage and Stormwater Assets GIS database where they are used for future functionality inspections.

During the reporting period, MDOT SHA initiated new streamlined procedures for the AB approval process. The use of the Quality Assurance Toolkit for electronic submission and approval of as-built packages was begun. This program is similar to the modification request process now followed by contractors for erosion and sediment control. This new process will allow contractors to submit the completed AB information and inspections electronically for review, comment, and final approval. Figure 1-8 shows an example of the software to be used.

MDOT SHA is also in the process of creating new AB standards and specifications for the remedial work order construction process. These activities, undertaken to bring SWM facilities back to functioning as originally designed, require inspection information as the remediation work is completed. These inspections will be performed by the Contractor's AB inspectors as they are for typical construction or retrofit projects, however, they will be less extensive in nature. These completed inspection forms and included photographs will follow the needed information outlined in Chapter 3 of the "*Maryland State Highway Administration Stormwater NPDES Program Standard Procedures – Best Management Practice Assessment Guidelines for Maintenance and Remediation"* for inspection reports on various facility types. This data will be added to the Drainage and Stormwater Assets GIS database for future use. MDOT SHA anticipates that these specifications will be completed before the end of the 2017 calendar year, so that the new standard procedures can be implemented in upcoming 2018 contracts.



Project Contract	Facilities included in this package	Submission Date	Approval Status	Approval Date	Approval Time	
AL2915187	BMP 010516	09/15/17	Pending			View
AL3605180	Bioretention BR-1	02/15/17	Under Review			View
AT0445182	Permission to remove sediment control devices.	04/14/17	Pre-Submittal			View
AT0445182		06/06/17	Pending			View
WA2495176	WA2495176 SWM As-Built Plans	08/16/17	Under Review			View
WA2495176	Boi-Swale 1	06/09/17	Under Review			View
WA2495176	Sheet 5 of 7 revision	08/16/17	Pending			View

Displaying 1 to 7 of 7

Figure 1-8: Quality Assurance Toolkit - Use for As-Built Tracking

D.1.d Preventative Maintenance

MDOT SHA owns, operates, and maintains an extensive roadway network with significant drainage and stormwater management systems. The MDOT SHA Stormwater and Drainage Asset Management Program was established to operate and remediate permanent drainage and stormwater assets that convey and treat highway runoff. The program's goal is to provide preventive and remedial solutions for drainage and stormwater infrastructure within MDOT SHA right-of-way. As of June 30, 2017, MDOT SHA manages nearly 4,900 permanent stormwater management facilities

and ESD practices, nearly 171,000 hydraulic structures, and almost 140,000 conveyance features (nearly 9 million linear feet) statewide. This includes over 4,100 permanent stormwater management facilities and ESD practices, nearly 124,000 hydraulic structures and almost 100,000 conveyances (nearly 7 million linear feet) within the MS4 jurisdictions. The GIS inventory database is being continuously updated to include newly constructed SWM facilities and the delineation of accurate drainage areas. In upcoming years, a rapid increase in the size of the SWM inventory is expected due to ongoing watershed restoration efforts and their associated SWM structures. As a part of this expansion, there are nearly 400 grass swales currently listed as proposed in the GIS database. These facilities are anticipated to be constructed in the coming years, and are not included in the totals listed above.

During the reporting period, MDOT SHA made significant improvements to processes to locate, inspect, evaluate, and remediate these assets to sustain their functionality, improve water quality and stability, protect sensitive water resources, and provide an aesthetic and safe transportation system. MDOT SHA increased the staff size focused on this program component and implemented increased system efficiencies. Inspections are conducted on a cyclical basis as part of the NPDES source identification and update effort (see Section C). Maintenance and remediation efforts are tracked and initiated after the inspection data has been evaluated and ranked according to MDOT SHA rating criteria.

MDE requires all practices be inspected every three years and maintained as appropriate to ensure they function as designed. Based on MDE's guidance, MDOT SHA's impervious surface area assessment includes BMPs providing runoff treatment, therefore data associated with these practices is evaluated to ensure they meet requirements for inspection, maintenance and functionality. MDOT SHA has a maintenance program focused on performing facility remediation within three years after a failed inspection. Detailed information on these procedures are included in Part 2 of this report.

During the reporting period, MDOT SHA conducted preventative maintenance stormwater BMP inspections in accordance with our published Standard Operating Procedures manual. Increased outreach and education efforts by MDOT SHA resulted in improved coordination of preventative maintenance efforts. Additional maintenance manuals were distributed to ensure continued higher maintenance standards in the future. MDOT SHA performed BMP inspections in MS4 areas to ensure all baseline facilities are eligible for credit in the impervious surface area assessment and comply with the triennial inspection requirement. The following counties were the focus of MDOT SHA's BMP inspection efforts during the reporting period:

- Anne Arundel County
- Baltimore County
- Carroll County
- Cecil County
- Frederick County
- Howard County
- Montgomery County
- Prince George's County

During this reporting period, baseline BMP inspections were performed for 10 stream restoration sites and about 250 SWM facilities. MDOT SHA performed restoration BMP inspections for 381 tree planting sites, 12 stream restoration sites, 3 impervious area removal sites and 56 SWM facilities. MDOT SHA has provided the inspection program information in the following tables, as specified in the May 2017 MDE Geodatabase Guideline format:

- BMP Inspections table (BIN)
- Alternative BMP Line Inspections table (LIN)
- Alternative BMP Poly Inspections table (YIN)
- Restoration BMP Inspections table (RIN)

In addition to these BMP inspections, MDOT SHA evaluated the MS4 BMP inventory to identify any

facilities requiring remediation (MDOT SHA action rating of III) originating from inspections and engineer reviews longer than three years ago. As a subset of the overall maintenance program, MDOT SHA has prioritized completing the maintenance for the 141 BMPs shown in Table 1-4. MDOT SHA is committed to re-establishing the intended design functionality of these BMPs through this maintenance effort and is currently claiming credit for these BMPs in the impervious surface area assessment. Following MDOT SHA analysis, Table 1-4 has been appended to include additional BMPs that have recently exceeded the three-year timeframe since inspection and engineering reviews. The table also includes newly established commitment dates for completion of maintenance work orders.

Table 1-4 notes BMP modifications that impact protected resources such as wetlands, that require a Joint Permit Application (JPA) be submitted and approved, or a small pond / 378 review. Table 1-4 notes several facilities with footnotes detailing the reason for delay in work order completion commitment dates. MDOT SHA will continue to report on progress meeting these commitments in the FY18 MS4 Annual Report.

Table 1-4: MDOT SHA BMPs for Maintenance Work Orders

SWM Facility Number	Facility Type	MDOT SHA Action Rating	Work Order Completion Commitment	Remediation Comments
030227	Infiltration trench	III	11/30/2017**	Under construction
030228	Infiltration trench	III	11/30/2017**	Under construction
030242	Infiltration trench	III	11/30/2017**	Under construction
030244	Infiltration trench	III	11/30/2017**	Under construction
FY2018 Commitments				
020003	Infiltration basin	III	6/30/2018	
020013	Wet pond	III	6/30/2018	
020036	Infiltration trench	III	6/30/2018	
020083	Infiltration trench	III	6/30/2018	
020110	Wet pond	III	6/30/2018	
020112	Bioretention	III	6/30/2018	
020115	Wet extended detention pond	III	6/30/2018	
020124	Wet pond	III	6/30/2018	
020143	Infiltration trench	III	6/30/2018	
020162	Wet pond	III	6/30/2018	
020165	Wet pond	III	6/30/2018	
020173	Infiltration trench	III	6/30/2018	
020196	Infiltration trench	III	6/30/2018	
020210	Dry Swale	III	6/30/2018	
020217	Infiltration trench	III	6/30/2018	
020218	Infiltration trench	III	6/30/2018	
020240	Dry pond	III	6/30/2018	
020241	Infiltration trench	III	6/30/2018	
020242	Infiltration trench	III	6/30/2018	
020243	Infiltration trench	III	6/30/2018	
020248	Wet pond	III	6/30/2018	

Table 1-4: MDOT SHA BMPs for Maintenance Work Orders

SWM Facility Number	Facility Type	MDOT SHA Action Rating	Work Order Completion Commitment	Remediation Comments
020250	Wet pond	III	6/30/2018	
020307	Infiltration trench	III	6/30/2018	
020354	Infiltration trench	III	6/30/2018	
020357	Infiltration trench	III	6/30/2018	
020360	Infiltration trench	III	6/30/2018	
020398	Infiltration trench	III	6/30/2018	
020436	Wet pond	III	6/30/2018	
020479	Micropool extended detention pond	III	6/30/2018	
020487	Wet pond	III	6/30/2018	
020528	Infiltration trench	III	6/30/2018	
020554	Infiltration trench	III	6/30/2018	
020807	Infiltration trench	III	6/30/2018	
020809	Wet pond	III	6/30/2018	
020812	Infiltration trench	III	6/30/2018	
020849	Infiltration trench	III	6/30/2018	
020893	Infiltration trench	III	6/30/2018	
030287	Dry pond	III	6/30/2018	
030335	Dry swale	III	6/30/2018	
080081	Infiltration basin	III	6/30/2018	
080091	Dry Pond	III	6/30/2018	
100065	Micropool extended detention pond	III	6/30/2018	
100126	Grass Swale	III	6/30/2018	
100127	Dry Swale	III	6/30/2018	
130074	Micropool extended detention pond	III	6/30/2018	
130136	Infiltration trench	III	6/30/2018	
130198	Micropool extended detention pond	III	6/30/2018	
130204	Infiltration basin	III	6/30/2018	
130225	Shallow marsh	III	6/30/2018	
130228	Wet pond	III	6/30/2018	
130230	Micropool extended detention pond	III	6/30/2018	
130267	Micropool extended detention pond	III	6/30/2018	
130268	Micropool extended detention pond	III	6/30/2018	
130293	Micropool extended detention pond	III	6/30/2018	

Table 1-4: MDOT SHA BMPs for Maintenance Work Orders

SWM Facility Number	Facility Type	MDOT SHA Action Rating	Work Order Completion Commitment	Remediation Comments
130294	Micropool extended detention pond	III	6/30/2018	
130323	Infiltration basin	III	6/30/2018	
130346	Micropool extended detention pond	III	6/30/2018	
130349	Wet pond	III	6/30/2018	
130358	Infiltration trench	III	6/30/2018	
130365	Infiltration trench	III	6/30/2018	
130369	Shallow marsh	III	6/30/2018	
130388	Grass Swale	III	6/30/2018	
130393	Grass Swale	III	6/30/2018	
130394	Grass Swale	III	6/30/2018	
130417	Grass Swale	III	6/30/2018	
210003	Dry Swale	III	6/30/2018	
210014	Infiltration trench	III	6/30/2018	
210233	Dry Pond	III	6/30/2018	
020178	Infiltration trench	III	6/30/2018	
080034	Infiltration trench	III	6/30/2018	
100034	Wet pond	III	6/30/2018	
100128	Dry swale	III	6/30/2018	
130161	Infiltration trench	III	6/30/2018	
130167	Dry pond	III	6/30/2018	
130175	Infiltration Basin	III	6/30/2018	
130178	Infiltration basin	III	6/30/2018	
130208	Infiltration trench	III	6/30/2018	
130292	Micropool extended detention pond	III	6/30/2018	
130308	Infiltration trench	III	6/30/2018	
130325	Shallow marsh	III	6/30/2018	
130357	Infiltration trench	III	6/30/2018	
130366	Infiltration trench	III	6/30/2018	
130370	Infiltration trench	III	6/30/2018	
130377	Infiltration basin	III	6/30/2018	
130390	Grass Swale	III	6/30/2018	
FY2019 Commitments				
020490	Infiltration trench	III	6/30/2019	
030050	Infiltration basin	III	6/30/2019*	Requires JPA
030256	Infiltration trench	III	6/30/2019	
030258	Infiltration trench	III	6/30/2019	

Table 1-4: MDOT SHA BMPs for Maintenance Work Orders

SWM Facility Number	Facility Type	MDOT SHA Action Rating	Work Order Completion Commitment	Remediation Comments
080057	Infiltration basin	III	6/30/2019	
130181	ED or Wet pond	III	6/30/2019	
130199	Wet pond	III	6/30/2019	
130291	Micropool extended detention pond	III	6/30/2019*	PRD review for small pond / 378
130378	Infiltration basin	III	6/30/2019	
210009	Infiltration basin	III	6/30/2019	
FY2020 Commitments				
100122	Underground detention	III	6/30/2020	
130322	Infiltration basin	III	6/30/2020	
020094	Infiltration trench	III	6/30/2020***	
020434	Infiltration trench	III	6/30/2020***	
020456	Infiltration trench	III	6/30/2020***	
030123	Dry extended detention pond	III	6/30/2020***	
030175	Dry pond	III	6/30/2020***	
030245	Infiltration trench	III	6/30/2020***	
060158	Infiltration trench	III	6/30/2020***	
070012	Dry pond	III	6/30/2020***	
070013	Dry pond	III	6/30/2020***	
100046	Dry pond	III	6/30/2020***	
100325	Bioswale	III	6/30/2020***	
100326	Bioswale	III	6/30/2020***	
100327	Bioswale	III	6/30/2020***	
100328	Bioswale	III	6/30/2020***	
100329	Bioswale	III	6/30/2020***	
100330	Bioswale	III	6/30/2020***	
100331	Bioswale	III	6/30/2020***	
100471	Other filtering	III	6/30/2020***	
120291	Wet pond	III	6/30/2020***	
122002	Grass channel	III	6/30/2020***	
130421	Wet pond	III	6/30/2020***	
132056	Grass channel	III	6/30/2020***	
150201	Infiltration trench	III	6/30/2020***	
150232	Infiltration trench	III	6/30/2020***	
150285	Dry pond	III	6/30/2020***	
150352	Dry pond	III	6/30/2020***	
150555	Infiltration trench	III	6/30/2020***	

Table 1-4: MDOT SHA BMPs for Maintenance Work Orders

SWM Facility Number	Facility Type	MDOT SHA Action Rating	Work Order Completion Commitment	Remediation Comments
150706	Infiltration trench	III	6/30/2020***	
160187	Wet swale	III	6/30/2020***	
160203	Shallow marsh	III	6/30/2020***	
160378	Dry pond	III	6/30/2020***	
160408	Infiltration trench	III	6/30/2020***	
160427	Infiltration trench	III	6/30/2020***	
160505	Wet pond	III	6/30/2020***	
160616	Sand filter	III	6/30/2020***	
160656	Dry extended detention pond	III	6/30/2020***	
160737	Wet pond	III	6/30/2020***	
160747	Wet extended detention pond	III	6/30/2020***	
160805	Bioretention	III	6/30/2020***	
160806	Wet pond	III	6/30/2020***	

* Requires a JPA or small pond / 378 review
** Under construction
*** Added to the list in FY17 Annual Report

During the reporting period, MDOT SHA performed maintenance and remediation construction of stormwater BMPs to ensure facilities are performing as designed, and providing water quality. MDOT SHA is focused on improving its process for performing inspections, ratings and maintenance assessments. During this reporting period, MDOT SHA performed inspector training, optimized workflows, and implemented SOPs to improve rating consistency. This resulted in the re-evaluation of several stormwater BMPs; in some cases, it was determined that the original inspection results were not accurate. In these instances, revised engineer reviews modified previous BMP ratings. Table 1-5 reflects remediation progress achieved during the reporting period, as well as rating modifications resulting from the revised engineer reviews.

Table 1-5: MDOT SHA BMP Remediation Progress

SWM Facility Number	Facility Type	Revised MDOT SHA Action Rating
Construction complete		
030117	Dry Detention Pond	I
130169	Wet pond	II
030225	Infiltration trench	I
030226	Infiltration trench	I
030229	Infiltration trench	I
Engineer re-evaluated inspection rating and facility is providing water quality		
020421	Infiltration trench	I
Engineer re-evaluated inspection rating and facility is providing water quality. Minor routine maintenance required		
020233	Infiltration trench	II
020246	Infiltration trench	II

Table 1-5: MDOT SHA BMP Remediation Progress

SWM Facility Number	Facility Type	Revised MDOT SHA Action Rating
Construction complete		
030117	Dry Detention Pond	I
130169	Wet pond	II
030225	Infiltration trench	I
030226	Infiltration trench	I
030229	Infiltration trench	I
Engineer re-evaluated inspection rating and facility is providing water quality		
020421	Infiltration trench	I
020256	Wet pond	II
020272	Dry pond	II
020341	Infiltration trench	II
020485	Retention Pond	II
020537	Infiltration trench	II
020544	Wet pond	II
020572	Infiltration trench	II
030113	Infiltration trench	II
080027	Wet swale	II
080089	Infiltration basin	II
080090	Infiltration basin	II
080093	Infiltration trench	II
100048	Shallow marsh	II
100068	Shallow marsh	II
100094	Micropool extended detention pond	II
130330	Shallow Marsh	II
130334	Underground detention	II
Removed BMP for MD-32 highway project		
130238	Infiltration trench	N/A

In addition to the remediation requirements outlined in Table 1-5 above, MDOT SHA has identified 20 stormwater facilities in the MS4 area requiring major remediation or enhancements originating from inspections and engineer reviews greater than three years ago. These facilities are listed in Table 1-6. As shown in the "Remediation Comments" column, 6 of these stormwater facilities were reclassified from an MDOT SHA Action Rating of III to IV during the reporting period. Additionally, 5 other stormwater facilities were added to the retrofit list for the first time: These BMPs have revised commitment dates of Fall 2021, reflecting the additional work necessary to complete the facility retrofits.

As a subset of the overall maintenance program, MDOT SHA has prioritized the retrofit or enhancement of the 20 BMPs listed in Table 1-5 by their anticipated completion dates. MDOT SHA is committed to re-establishing the intended design functionality, or enhancing the original design of these BMPs, and is currently claiming credit for these BMPs in the impervious surface area assessment. MDOT SHA continues to improve its tracking of maintenance procedures during the permit term to ensure BMP major retrofit and enhancement is performed in a timely manner. MDOT SHA will report on its progress completing major remediation and enhancement on these 20

stormwater facilities in the FY18 MS4 Annual Report.

MDOT SHA has provided the stormwater BMP maintenance information in the BMP table (BMP) as specified in the May 2017 MDE Geodatabase Guideline format. All baseline BMPs submitted for credit in the impervious surface area assessment, exclusive of the BMPs presented in Table 1-5 and Table 1-6, had maintenance performed within the required timeframe: These maintenance dates are provided in the geodatabase. BMPs with recent inspections yielding required maintenance activities are being evaluated and will be contracted for completion prior to the next three-year inspection cycle. MDOT SHA continues to improve its tracking of all remediation, retrofit and enhancement procedures during the permit term to ensure BMP performance is as originally designed. MDOT SHA's remediation program expanded significantly in 2017 by adding additional support staff, the creation of a BMP Master list tracking file, and the implementation of standardized work order procedures. As permit coordination becomes increasingly complex, the expansion and standardization of this process has increased the amount of remediation possible, and is necessary to meet facility functionality requirements.

Details of MDOT SHA's Stormwater and Drainage Asset Management Program are included as Part Two of this report. Part Two includes a detailed discussion of SWM inventory inspection results, maintenance, remediation, retrofit and enhancement efforts undertaken over the past year.

Table 1-6: Priority MDOT SHA BMPs for Major Remediation or Retrofits

SWM Facility Number	Facility Type	MOT SHA Action Rating	Retrofit Completion Commitment	Remediation Comments
FY 2019 Commitments				
020260	Infiltration basin	IV	Fall 2018	
020268	Infiltration basin	IV	Spring 2018	
FY2021 Commitments				
020061	Infiltration basin	IV	Fall 2020	
020388	Infiltration basin	IV	Fall 2020	
020393	Infiltration basin	IV	Fall 2020	
020394	Infiltration basin	IV	Fall 2020	
020850	Infiltration basin	IV	Fall 2020	
030189	Infiltration basin	IV	Fall 2020	Re-classified as a retrofit
030214	Infiltration basin	IV	Fall 2020	Re-classified as a retrofit
030224	Infiltration trench	IV	Fall 2020	Re-classified as a retrofit
080015	Infiltration trench	IV	Fall 2020	Re-classified as a retrofit
130315	Infiltration basin	IV	Fall 2020	Re-classified as a retrofit
130316	Infiltration basin	IV	Fall 2020	Re-classified as a retrofit
130375	Infiltration basin	IV	Fall 2020	
210008	Infiltration basin	IV	Fall 2020	
FY2022 Commitments				
020092	Infiltration trench	IV	Fall 2021***	
020177	Dry swale	IV	Fall 2021***	
020226	Infiltration trench	IV	Fall 2021***	
020338	Infiltration basin	IV	Fall 2021***	
160225	Infiltration trench	IV	Fall 2021***	

*** Added to the list in FY17 Annual Report

MDOT SHA has performed major retrofits of priority stormwater BMPs to redesign, construct, and enhance facility performance. Resolution of major remediation issues restores water quality functions of the facilities. During the reporting period, MDOT SHA completed the retrofit of five priority stormwater BMPs – listed in Table 1-7 below.

Table 1-7: Priority MDOT SHA BMP Major Remediation and Retrofit Progress

SWM Facility Number	Facility Type	Revised MDOT SHA Action Rating
Construction Complete		
020015	Infiltration basin	I
020017	Infiltration basin	I
020037	Infiltration basin	I
020039	Infiltration trench	I
020040	Infiltration trench	I

D.2 Erosion and Sediment Control

Requirements under this condition include:

a) Implement program improvements identified in any MDE evaluation of SHA's erosion and sediment control program;

b) Ensure construction site operators have received training regarding erosion and sediment control compliance and hold a valid Responsible Personnel Certification as required by MDE;

c) Record program activity on MDE's annual report database and submitted as required in Part V of this permit;

d) Ensure all applicable construction projects obtain a notice of intent (NOI) for stormwater associated with construction activity.

D.2.a SHA's Erosion and Sediment Control Program

MDOT SHA continues to comply with Maryland State and federal laws and regulations for ESC as well as MDE requirements for permitting. MDOT SHA maintains compliance with the NPDES Stormwater Construction Activity permit for projects that disturb one acre or more of land. MDOT SHA continues to submit applications for coverage under this general permit for all qualifying roadway projects as described under Section D.2.d below.

As discussed in Section D.1.b above, MDOT SHA and MDE signed an MOU designating SHA as an approving authority for stormwater management and erosion and sediment control for all MDOT SHA projects. PRD maintains a database to track ESC submittals and design progress on all MDOT SHA projects. MDOT SHA continues to comply with the *Maryland Erosion & Sediment Control Guidelines for State and Federal Projects* published in January 1990 and revised in January 2004. In December 2011, MDE published the 2011 *Maryland Standards and Specifications for Soil Erosion and Sediment Control*. Projects are designed and constructed in compliance with these new specifications.

During FY 2017, PRD approved 113 final plans statewide. It should be noted that approval of the final plans does not necessarily indicate that a grading permit has been issued as there are often several other permits that may be required prior to earth disturbance being initiated. Due to the timing of the change of permit review from MDE to PRD, there were several projects that MDE granted approval for as they had initiated project review prior to the change in procedures. MDE approved 2 ESC projects during this time. MDOT SHA PRD approved 81 projects that ultimately received grading approval during the permit term. An additional 22 projects received NPDES Construction General Permit approvals during FY17. It is important to note that there were 16 projects that received both a NPDES Construction General Permit and PRD approvals leading to a grading permit during FY17. In total, and without double-counting projects, there were 89 unique projects receiving grading permits for activity within Maryland. These grading permits approved the disturbance of 411.26 acres of land statewide. Within the MS4 areas, 74 projects were approved that had a combined disturbance area of 369.47 acres. MDOT SHA has provided the grading permit program information in the Quarterly Grading Permit feature class (QGP) and the Quarterly Grading Permit information table (QPI) as specified in the May 2017 MDE Geodatabase Guideline

SHA ensures that permits and plan approval conditions are adhered to by performing unannounced inspections at project sites. During FY17, MDOT SHA performed 3,877 inspections at 382 project sites. These inspections resulted in the identification of 25 projects deemed to be non-compliant with ESC plans or standards. Eleven projects had their grading operations shut down until corrective actions were completed. Fourteen projects were completely shut down until corrective actions were completed. No fines were issued and no court enforcement actions were initiated. MDOT SHA utilizes liquidated damages against the contractors responsible for improper ESC activities and generally does not issue fines. Liquidated damages reduce the payment amount due contractors because of these types of violations. These damages are not considered fines.

MDOT SHA has provided the erosion and sediment control program information in the Erosion Sediment Control table (ESC) as specified in the May 2017 MDE Geodatabase Guideline format. A summary by MS4 jurisdiction is presented in Table 1-8. It is important to note that plans reviewed and approved by PRD will not necessarily correlate directly to the number of permits issued during any reporting period. This reflects the fact that PRD's approval by itself does not constitute permit issuance as projects must meet additional regulatory criteria beyond MDE's standards. Additionally, the number of inspections and the associated number of projects on which these inspections were performed include projects whose approvals were issued during previous fiscal years and are therefore not included in the sum of permit activity presented below.

Table 1-8: Erosion and Sediment Control Permits and Disturbance Acreage

Jurisdiction	Number of Permits Issued	Acreage of Disturbance	Violations	Stop Work Orders	Fines Issued	Court Cases
Anne Arundel	8	50.27	2	1	0	0
Baltimore	10	54.6	4	2	0	0
Carroll	6	31.81	0	0	0	0
Cecil	4	22.45	2	2	0	0
Charles	2	1.49	0	0	0	0
Frederick	10	99.41	0	0	0	0
Harford	2	10.81	0	0	0	0
Howard	3	13.14	2	1	0	0
Montgomery	11	18.96	0	0	0	0
Prince George's	14	50.13	10	5	0	0
Washington	4	16.44	1	1	0	0
MS4 Total	**74**	**369.47**	**21**	**12**	**0**	**0**
Outside MS4	15	41.79	4	2	0	0
Statewide Total	**89**	**411.26**	**25**	**14**	**0**	**0**

Notes:

1. Permits and project activity associated with "Areawide" projects, or those spanning multiple counties or jurisdictions, have been assigned to the county in which the general center of the project occurs.
2. In the event that more than one permit (Construction General Permit or Grading Permit) has been issued for the same project, the numbers provided above consider that to be a single permit activity. There are 16 such occurrences within FY17.
3. Although fines are not explicitly issued, MDOT SHA reserves the right to utilize Liquidated Damages resulting from contractor's non-compliance with ESC and SWM approved plan elements. Historically, these damages have not been applied, but the potential amounts are communicated to the contractor in the notice of violation and subsequent reporting documents.
4. Violations, Stop Work Orders, Fines and Court Cases occur in direct response to the results of ESC inspections. Inspections occurring on projects whose permits were issued prior to this Fiscal Year are included in this summary table.

Note that although fines are not explicitly issued, MDOT SHA reserves the right to utilize liquidated damages resulting from contractor's non-compliance with ESC and SWM approved plan elements. Historically, these damages have not been applied, but the potential amounts are communicated to the contractor in the Notice of Violation and subsequent reporting documents. Results of an MDE field audit found that while most of MDOT SHA's erosion and sediment control program elements were being implemented effectively, two important issues needed attention:

- Approximately a quarter of the sites visited by MDE required stabilization or improved stabilization. The main issues identified were poor coverage of mulch and seed and the maintenance of stabilized construction entrances (SCEs).

- Two sites had offsite impacts as a result of dewatering activities.

The issues were identified and addressed as follows.

General Issue #1 Identified the need to improve stabilization due to: lack of stabilization, poor coverage of seed and mulch, questionable maintenance of SCEs.

Not all stabilization improvements required a programmatic change from the Quality Assurance Program compliance check, however, they did allow MDOT SHA to identify additional improvements to the general program. The QA Program does verify the project record to see if the correct application of amendments has been placed per the contract documents. Program improvements included:

- The QA Program continues to meet monthly to engage in discussions, exercises, specification review, lessons learn, etc. These meetings are an effort to build consistency and improve knowledge base.

- The QA Program implemented a peer review (of field work) where RECs review, critique and document each other's efforts for group discussion and improvement. Improving stabilization remains an item of focus.

- The QA Program also implemented an oversight spot check where team leaders review REC's field work with a focus on improving stabilization.

- The QA Program participated in specification changes to eliminate the stabilization exemption at subgrade, the use of matting in lieu of straw mulch for smaller areas, and the increase use of wash racks to prevent tracking onto roadways in 2017.

- From July 1, 2016 through June 30, 2017, 25 non-compliances ("D" and "F" ratings or where non-compliance was otherwise indicated in the QA Toolkit) were given and 19 of them involved questionable stabilization practices. The same period also identified 3 projects with questionable SCE practices. While these statistics demonstrate continuing issues, they show an increase in compliance observation.

General Issue #2 Identified the need to reduce offsite impacts due to questionable dewatering activities. Any dewatering failures found are unacceptable and considered non-compliant. Program improvements included:

- The QA Program continues to meet monthly to engage in discussions, exercises, specification review, lessons learn, etc. These meetings are an effort to build consistency and improve knowledge base.

- The QA Program implemented a peer review (of field work) where RECs review, critique and document each other's efforts for group discussion and improvement. Reducing offsite impacts due to questionable dewatering activities remains an item of focus.

- The QA Program implemented an oversight spot check where team leaders review REC's field work with a focus on improving dewatering activities.

- From July 1, 2016 through June 30, 2017, 25 non-compliances ("D" and "F" ratings or where non-compliance was otherwise indicated in the QA Toolkit) were given and 3 of them involved questionable dewatering practices. Increased compliance observation remains part of the solution to improving dewatering activities.

D.2.b MDE Responsible Personnel Certification

MDE Responsible Personnel Certification is required for anyone overseeing the installation and maintenance, or performing the installation and maintenance, of erosion and sediment control practices and measures in Maryland. MDOT SHA specifications require that the Contractor assigns an employee as the Erosion and Sediment Control Manager (ESCM) for each construction project. The ESCM and the superintendent must have successfully completed the MDE Responsible Personnel Certification course along with MDOT SHA's Erosion and Sediment Control Certification (Yellow Card). In addition, MDOT SHA also requires all Quality Assurance (QA) Inspectors, also known as Regional Environmental Coordinators (RECs) and who inspect each project for compliance with the approved erosion and sediment control plan, hold valid certifications. The entire MDOT SHA PRD, consisting of the Division Chief, the Assistant Division Chief, four Team Leaders, and consultant review staff are all

required to hold a valid MDE Responsible Personnel Certification. The MDE Responsible Personnel Certification is currently only available through an on-line training course through MDE's website, so numbers of MDOT SHA personnel certified through that website is not reported here.

SHA Erosion and Sediment Control Certification (Yellow Card)

The MDOT SHA, in cooperation with the Maryland Transportation Builders and Materials Association (MTBMA), continues to offer updated erosion and sediment control training, initiated in 2004. This erosion and sediment control on-line training is mandatory for MDOT SHA contractor superintendents and ESC managers and is highly recommended for contractor project managers, field personnel, and personnel responsible for erosion and sediment control.

Figure 1-9: MDOT SHA Yellow Card Certification

Each participant is required to hold a valid MDE Responsible Personnel Certification prior to taking this course. The class covers the basic science of erosion and sediment control, installing and maintaining E&S controls, using the ESC Quality Assurance checklist to monitor compliance, reviews key requirements of the NPDES construction activity permit, details ESC specifications, and reviews the process for addressing ESC modifications during construction.

Certification is contingent upon successful completion of an exam. Successful completion requires a score of 80 percent or higher on the exam. This certification expires three years from the date of issuance. In FY16, MDOT SHA implemented on-line training for Yellow Card Certification. This is also a prerequisite for MDOT SHA's Erosion and Sediment Control Certification for Designers, described in the following sections. The number of MDOT SHA personnel certified during the reporting period is summarized in Table 1-9.

SHA Erosion and Sediment Control Re-Certification (Yellow Card Re-Certification)

MDOT SHA Erosion and Sediment Control Re-Certification (Yellow Card Re-Certification) is only available for those that have previously completed the MDOT SHA Yellow Card Certification. Topics covered include any changes to the specifications and environmental regulations along with updated information related to the MDOT SHA Quality Assurance program. Re-certification is contingent upon passing an exam and re-certification is valid for three years. In FY16, MDOT SHA provided on-line re-certification training. The number of MDOT SHA personnel re-certified during the reporting period is summarized in Table 1-9.

Table 1-9: MDOT SHA ESC Training

Type of Training	Number Certified
MDOT SHA Erosion and Sediment Control Certification (Yellow Card)	478
MDOT SHA Erosion and Sediment Control Re-Certification (Yellow Card Re-Certification)	322

***SHA Erosion* and Sediment Control Certification for Designers**

Designers holding valid professional engineering licenses for the State of Maryland are held to the standards of the profession and therefore MDOT SHA will not offer a separate design certification for designers. Designers are required to hold valid MDE Responsible Personnel Certification and valid MDOT SHA Erosion and Sediment Control Certification (Yellow Card).

Design guidelines for aspects and concerns pertinent to MDOT SHA are being developed and will be published when available.

D.2.c Recording Program Activity

MDOT SHA has provided the erosion and sediment control program information in the Erosion Sediment Control table (ESC) as specified in the May 2017 MDE Geodatabase Guideline format

D.2.d NOI for Stormwater Associated with Construction Activity

The MDE issued the 2014 General Permit for Stormwater Associated with Construction Activity, which took effect on January 1, 2015. Projects that disturb one acre or more of earth must obtain a General or Individual Permit for Stormwater Associated with Construction Activity before beginning any earth disturbance.

MDOT SHA's HHD reviews all MDOT SHA advertised project's limit of disturbance (LOD) as reported on the stormwater management (SWM) and erosion & sediment control (ESC) final approvals – along with subsequent approval modifications, to determine if an NPDES Permit Associated with Construction Activity is needed. Completed NPDES Notice of Intent (NOI) applications are submitted to MDE by HHD via the MDE e-Permits Portal, an online application system. HHD tracks the status of each NOI and ensures that any applicable NPDES permits are obtained and transferred to the pertinent responsible personnel prior to the issuance of notice-to-proceed for construction. The NPDES permit is posted at each construction site. During the reporting period, between July 1, 2016 and June 30, 2017, a total of 93 MDOT SHA construction projects receiving Notice to Proceed (NTP) required an NPDES permit associated with construction activity.

D.3 Illicit Discharge Detection and Elimination

Requirements under this condition include:

a) Field screen at least 150 outfalls annually;

b) Conduct annual visual surveys of commercial and industrial areas to discover, document and eliminate pollutant sources;

c) Maintain program to address and, if necessary, respond to illegal discharges, dumping and spills;

d) Use appropriate procedures to investigate and report illicit discharges, illegal dumping and spills to local or State authorities as applicable for control or clean-up. Report significant discharges to MDE for enforcement and/or permitting.

e) Coordinate with surrounding jurisdictions when illicit connections originate from beyond SHA's rights-of-way; and

f) Report illicit discharge detection and elimination activities as specified in Part V of this permit.

D.3.a Illicit Discharge Screening

In this section of the 2016 annual report, MDOT SHA discussed the Storm Drain Outfall Inspection and Remediation program (SOIRP). Moving forward, this section will focus on the IDDE program established by MDOT SHA's Environmental Compliance Division (ECD), and will not discuss the structural integrity of outfalls and downstream channels; preventative maintenance inspections are discussed in Section D.2.d of this report.

During the reporting period, 180 outfalls were screened. Of these outfalls, 57 had a discernible dry-weather flow and were sampled. Only one was identified as an illicit discharge (ID) requiring additional follow-up. Table 1-10 summarizes field screening efforts for the reporting period.

Table 1-10: Field Screening Summary

County	Number of Outfalls Field Screened	Discharges requiring follow-up
Anne Arundel	19	0
Montgomery	96	0
Prince Georges	65	1
Totals	**180**	**1**

D.3.b Annual Visual Surveys of Commercial and Industrial Areas

As discussed in Section C.2, a GIS layer has been developed that identifies industrial sites within MDOT SHA right-of-way that have the potential to contribute pollutants to MDOT SHA storm drain systems. The MDOT SHA sites include industrial NPDES 12-SW general permitted facilities. The MDOT SHA facilities will be inspected in accordance with MDOT SHA's current 12-SW inspection program.

The 12-SW General Permit for Stormwater Discharges associated with Industrial Activity requires MDOT SHA maintenance shops to perform three types of inspections:

- Routine Facility Inspections;
- Annual Comprehensive Site Compliance Evaluation (CSCE);
- Quarterly Visual Monitoring.

MDOT SHA's routine facility inspection program for 12-SW facilities includes two inspections:

1. A weekly/monthly inspection performed by shop personnel;
2. A quarterly inspection performed by ECD's District Environmental Coordinator (DEC).

Inspection checklists are completed and uploaded to the MDOT SHA web-based database for both types of inspections. A separate summary report is generated by the DECs following the quarterly inspections.

A comprehensive site compliance evaluation (CSCE) is performed in the 4th quarter of every calendar year. The 12-SW permit requires MDOT SHA to prepare an annual report summarizing the evaluation and implementation of site storm water management for the year. The annual report is generated prior to January 31st.

D.3.c Illegal Discharge, Dumping, and Spill Program

MDOT SHA's Environmental Compliance Division (ECD) manages a program to address and respond to illegal discharges, dumping and spills. During the reporting period ECD finalized the requirements document for a GIS-based database that will be used to track all actions related to illicit discharges. Efforts to develop and implement this system are underway. As part of the overarching program ECD continues to coordinate with MDE, surrounding jurisdictions and property owners to eliminate illicit discharges, and clean up spills and dumping.

MDOT SHA has developed a process flow diagram, included with this report as Appendix D, which illustrates the procedures to investigate and correct illicit discharges. As illicit discharges are identified through the illicit discharge screening process and other sources, ECD utilizes an agreement with Maryland Environmental Service (MES) to follow-up and collect samples for laboratory analysis. If laboratory analysis indicates the discharge exceeds acceptable parameters, ECD coordinates elimination of the discharge with local NPDES coordinators, property owners and MDE. MES also performs on-call inspections of potential illicit discharges, spills and dumping that are reported by MDOT SHA field staff or the public.

Discharges are deemed illicit based on two main criteria: flow and exceedance of discharge parameter(s). Any no-flow outfalls showing signs of potential pollution are investigated further to ensure no stormwater pollution is occurring.

D.3.d Investigation and Report of Illicit Discharge, Illegal Dumping and Spills

Section D.3.d has been combined with Section D.3.e below. This combined section discusses the investigation and reporting of illicit discharges as well as coordination with surrounding jurisdictions.

As discussed in Section D.3.c, MDOT SHA follows the process flow diagram found in Appendix D to investigate and correct suspected illicit discharges. Currently, MDOT SHA notifies MDE and the appropriate county NPDES coordinator, or their IDDE designee, when illicit discharges to the MDOT SHA storm drain system are discovered.

MDOT SHA ECD may be initially notified of an illicit discharge by many sources, including MDOT SHA's routine NPDES illicit discharge (ID) screening process, right-of-way inspections, citizen reporting, spills, illegal dumping or construction division inspections. If a suspected illicit discharge is encountered through MDOT SHA's routine NPDES ID screening process, there is an attempt to identify the source of the illicit discharge and a report is written and submitted to ECD. In all cases, and upon being advised of a dry weather flow or other unnatural indicators, ECD contacts its IDDE investigation team (MES) to request a site visit. Once this occurs, it is now considered an open investigation in IDDE tracking.

If the outfall is dry at the time of the site visit, the IDDE tracking is considered closed, and the investigation ends, unless there is evidence of pollution present. If the site visit confirms an illicit discharge, a flow sample is collected and sent to a lab for testing. MES then provides ECD with lab analysis results and an additional report, which are saved as records for IDDE tracking. The investigation ends if the lab results provide no indication of an illicit discharge.

When lab results confirm an illicit discharge, ECD contacts the applicable county and the property owner of the source of the illicit discharge. ECD remains in contact with whichever entity (county or property owner) agrees to manage the illicit discharge, to confirm follow-ups and corrective actions until the illicit discharge is corrected and the investigation can be closed. A field test may be required to verify corrective actions have been taken to cease the illicit discharge.

If an illicit discharge is still present at the site after these steps have been taken, ECD contacts Maryland Department of the Environment (MDE) Compliance Program to inspect the site. If the inspection confirms the illicit discharge has been corrected, all communication and corrective actions are saved or updated for IDDE tracking, and the investigation can be closed. If the illicit discharge persists, MDE manages the investigation through to resolution.

Once the eGIS IDDE database is in full service, the business process will involve inputting all documentation, including communication, lab results, reports, and corrective actions. Users will be able to manage and track IDDE investigations from initiation to closing.

To achieve better elimination results and increase public awareness of the issue, SHA notifies property owners when they are determined to be the origin of the illicit discharge. Educational materials such as the flyer depicted in Figure 1-10 on non-stormwater discharges and MS4 permits are included with the initial notification.

Figure 1-10: MDOT SHA Illegal Dumping and Illicit Discharge Flyer

D.3.e Annually Report Illicit Discharge Detection and Elimination Activities

Outfalls were screened in three Phase I counties for illicit discharges including Montgomery, Prince Georges, and Anne Arundel. MDOT SHA has provided the illicit discharge detection and elimination program information in the IDDE table (IDD) as specified in the May 2017 MDE Geodatabase Guideline. During the reporting year, one illicit discharge was identified during the screening process. The discharge was eliminated by the property owners after MDOT SHA coordinated with Prince George's County. The commercial property was under construction, and through washing activities, sediment and detergents were released into MDOT SHA's MS4, above acceptable limits. Prince George's County contacted the property owner asking them to discontinue their washing operations and repair erosion and sediment controls. The property owner corrected the issue upon the Prince George's County request.

During the reporting period MDOT SHA had two illicit discharges reported outside the normal screening process. Both were discovered during BMP inspections. The first was a Baltimore County restaurant discharging fats and grease, and the second was a Frederick County concrete

business, discharging solids. Both counties were contacted and are following up with the property owners.

Table 1-11 below shows information for the three illicit discharges requiring follow-up.

Table 1-11: Illicit Discharge Requiring Follow-up

Number	County	SHA Structure #	Date Identified	Potential Pollutant	Status
1	Prince Georges	1600052.001	08/03/2016	Detergents	Closed
2	Baltimore County	BMP 0305091	03/30/2017	Fats and Grease	Open
3	Frederick County	BMP 100085	05/10/2017	Solids	Open

D.4 Trash and Litter

Requirements under this condition include:

a) Document litter problems on properties, ways of eliminating litter, and opportunities for overall improvement;

b) Within one year of permit issuance, as part of the public education program, SHA shall develop and implement a public education and outreach program with specific performance goals to reduce littering. This shall include:

i) Educating the transportation community on the importance of reducing, reusing, and recycling;

ii) Disseminating information by using signs, articles and other media outlets; and

iii) Promoting educational programs for SHA employees, consultants, contractors, travelling/trucking public, vacationers and commuters, etc.;

c) Evaluate annually the effectiveness of the education program; and

d) Submit an annual report that details progress toward implementing the public education and outreach program and trash reduction strategies.

D.4.a Document Litter Problems and Ways to Eliminate Litter

The MDOT SHA has long maintained an anti-litter program, and continues to implement improvements to this program to minimize litter. This helps to increase safety, improve the health of our environment, and keep our state beautiful.

MDOT SHA's Office of Maintenance and regional maintenance shops evaluate and document litter control problems within MDOT SHA right-of-way throughout the entire State. Besides general roadside litter problems, typical problem areas identified include isolated dumping sites, highway interchange ramps, areas that are in close proximity to a landfill, and bus stops.

MDOT SHA has many programs in place to address and control litter within MDOT SHA right-of-way. A critical aspect of MDOT SHA's year-round highway maintenance is the removal of litter from roadway shoulders and drainage systems. MDOT SHA uses a multi-pronged approach to control litter utilizing MDOT SHA employees, state workers, contractors, inmate clean-up crews, as well as labor donated through the Sponsor-A-Highway program and partnerships with Adopt-A-Highway volunteers. MDOT SHA also has taken several steps to "green" our litter removal efforts. For instance, instead of just picking up litter, MDOT SHA now provides our crews and volunteers with the means to separate recyclables from trash. All seven MDOT SHA Districts are currently recycling roadway litter in a formal manner. As the recycling efforts increase, the volume of waste taken to landfills continues to decrease.

MDOT SHA currently collects a substantial amount of litter and trash including pick-up along state roads, inlet cleaning, and structural stormwater control structures. MDOT SHA's primary efforts to clean up and prevent litter and trash along our roadways are described in detail below.

Maintenance Crew Clean-Ups

MDOT SHA currently has 28 maintenance shops across the state, and 18 are responsible for areas within the 11 MS4 jurisdictions. Each maintenance shop is responsible to perform several routine activities including trash clean-up as well as mowing, plowing, and other activities to ensure safety and environmental stewardship along the ROW. Trash clean-ups are performed regularly throughout the Spring and Summer mowing seasons. At times, additional trash pick-ups are scheduled upon public request. During the reporting period, MDOT SHA maintenance crews, inmate crews and contracted litter crews collected 5,069 truckloads of trash statewide, which is approximately 1.77 million pounds. Trash pick-up by each district shop is summarized in Table 1-12 below.

Contracted Clean-Ups

In addition to MDOT SHA maintenance crew clean-ups, MDOT SHA enters into contractual agreements for supplemental clean-ups along the right-of-way. This includes contracts with private companies as well as inmate crews contracted with various state penitentiaries. Contracts are awarded for designated roadway segments and contractors are required to pick up on a regular schedule. MDOT SHA provides dump trucks, maintenance of traffic, crash attenuators, and other safety precautions for field crews working to pick up trash along the roadway. Contracted clean-up activities occur throughout the state, including MS4 jurisdictions.

Table 1-12: Maintenance/Contracted/Inmate Right-of-Way Trash/Litter Removal

Jurisdiction	Truckloads	Conversion to Pounds
Anne Arundel	781.04	273,364
Baltimore	1591.68	557,088
Carroll	66.86	23,401
Cecil	175.3	61,355
Charles	118.56	41,496
Frederick	215.16	75,306
Harford	209.93	73,476
Howard	371.87	130,155
Montgomery	616.84	215,894
Prince George's	752.08	263,228
Washington	169.76	59,416
Totals	**5,069**	**1,774,178**
Data extracted for period 7/1/2016 to 6/30/2017		

Adopt-A-Highway Program

This program encourages volunteer groups (families, non-profit organizations, schools and civic organizations) to pick up litter along one to two mile stretches of non-interstate roadways four times a year for a two-year period as a community service. MDOT SHA provides each group with training, safety vests, trash bags, and tips on how to pick up trash and recyclables. The trash collected is placed in bags that are picked up by MDOT SHA maintenance crews. MDOT SHA will also place signs recognizing the organization or group at both ends of the adopted roadside (See Figure 1-11).

Figure 1-11: MDOT SHA Adopt-A-Highway Sign

Since the Adopt-A-Highway program started in 1989, MDOT SHA has partnered with more than 120,000 Marylanders who have cleaned and enhanced over 15,000 miles of roadway. Table 1-13 identifies the participation for the Adopt-A-Highway program throughout the current reporting period.

Table 1-13: Adopt-A-Highway Program
Right-of-Way Trash/Litter Removal

Jurisdiction	Number of Groups	Number of Bags	Miles Adopted
Anne Arundel	6	120	10
Baltimore	40	648	44
Carroll	10	105	12
Cecil	13	159	16
Charles	4	42	6
Frederick	16	169	15
Harford	12	162	16
Howard	7	87	6
Montgomery	1	20	1
Prince George's	4	41	3
Washington	17	176	23
Totals	130	1,729	152
Data extracted from the Adopt-A-Highway database for the period 07/01/2016 to 06/30/2017.			

Sponsor-A-Highway Program

Maryland has joined numerous other states in the Sponsor-A-Highway national effort to reduce litter along our roads. Each year, SHA spends millions of dollars to remove litter and debris from our roadways, which can create safety and environmental hazards for motorists, cyclists, and pedestrians. Litter removal also forces SHA maintenance staff to commit time, money, and manpower to this effort when they should be concentrating on other highway safety activities.

SHA's corporate sponsorship program allows corporations to sponsor sections of Maryland roadways by funding contracted clean-ups for one-mile sections of Maryland roadways. The sponsor enters an agreement with a maintenance provider to remove litter from the sponsored highway segment, typically an interstate roadway. The maintenance providers are responsible for removal of trash from sponsored segments of roadways.

Each sponsor is acknowledged by a sign with a recognition panel that is placed at the beginning of the highway segment they are sponsoring. MDOT SHA does not receive any reimbursement from the sponsor or maintenance provider. MDOT SHA's primary role is to ensure litter removal is properly performed, recognition signs are installed to MUTCD standards, manage the inventory of segments available for sponsorship, review additional areas for inclusion in the program, and approve artwork submitted for sponsor panels.

Figure 1-12: MDOT SHA Sponsor-A-Highway Sign

Table 1-14 below shows the miles currently being sponsored through the Sponsor-A-Highway program. Currently, 382 out of 532 available roadway segments, or 72% have been sponsored.

Table 1-14: Sponsor-A-Highway Program

Jurisdiction	Available Miles	Miles Sponsored
Anne Arundel	41.3	86
Baltimore	5.6	113
Carroll	1.7	0
Cecil	0	0
Charles	7.9	11
Frederick	11.8	13
Harford	8	1
Howard	15.9	42
Montgomery	4.2	48
Prince George's	22.7	70
Washington	11.5	6
Totals	**130.3**	**390**
Data extracted from the Sponsor-A-Highway database for the period 07/01/2016 to 06/30/2017.		

Stormwater Management Facilities

Stormwater Management (SWM) facilities are designed to capture stormwater runoff, allowing the velocity to reduce and the pollutants to settle out before being released to an outfall structure or infiltrate directly into the ground. Many SWM facilities are constructed with a forebay and a riser structure with a trash rack. The main purpose of

the forebay is to reduce water velocities and collect sediment as stormwater enters the facility. An additional benefit is that it helps to collect and concentrate trash, debris, and floatable material within the stormwater management basin. Trash racks prevent large debris, trash, and floatable materials from entering the outfall conveyance structure. Maintenance crews can then collect the trash and debris contained within the SWM facilities during routine maintenance.

MDOT SHA Litter Report 2017

MDOT SHA has prepared a report on litter removal efforts during the 2017 Fiscal Year. This report includes additional information on existing litter removal programs, expenditures, and data trends. This report can be found in Appendix E of this annual report.

D.4.b Litter Education and Outreach Program

MDOT SHA has had a multi-faceted existing public education program with goals to educate the public on environmental stewardship and reduce littering. MDOT SHA's Office of Communications (OC) and Office of Maintenance (OOM) collaborate on program components which include disseminating information through articles, social media, and hosting environmental awareness events at schools and civic events. The program offers materials such as coloring books, brochures, and speakers to help educate the public. Furthermore, MDOT SHA's website http://www.roads.maryland.gov offers additional information about recycling and litter prevention.

Some key components of MDOT SHA's existing public education efforts are discussed below.

Figure 1-13: Example of MDOT SHA's Use of Social Media in Promoting Litter Education

MDOT SHA "We Live Here, Too" Education Effort

In April 2017, MDOT SHA launched the "We Live Here, Too" education effort in conjunction with Earth Day, to reinforce the message about the harmful impacts of litter on the state's roadsides and natural resources.

This effort is part of a continuing public education campaign showing MDOT SHA's total commitment to the environment and the protection of the State's natural resources and wildlife. One of MDOT SHA's priorities is to ensure that Maryland remains a viable, clean and attractive place to live, visit and work.

An April 21, 2017 news release announced the launch of the new education effort. This news release encouraged the transportation community and business partners to volunteer to adopt or sponsor a State roadway, with links to learn more about the Adopt-A-Highway and Sponsor-A-Highway programs. This news release can be found online at:

http://www.roads.maryland.gov/pages/release.aspx?newsId=2817.

On May 24, 2017, an Op-Ed, written by MDOT SHA Administrator Gregory Slater, titled "Don't trash Maryland", appeared in the Baltimore Sun. This Op-Ed highlighted the efforts and costs to remove litter along Maryland highways, as well as the harmful effects of littering to the environment and Chesapeake Bay. Gregory Slater's Op-Ed is included within Appendix E of this annual report.

Earth Day

MDOT SHA held Earth Day events from April 18-20th to promote environmental education to all MDOT SHA employees, consultants, contractors and the public. A list of events held at the MDOT SHA Headquarters Building can be found below.

- Landscape Architecture Consulting 4/18/2017): The Earth Day team hosted an interactive Lunch & Learn where SHA HQ employees could bring their landscape questions, pictures, and/or dream ideas and meet one-on-one with a member of the Landscape Architecture team. Seven Landscape Architects and Foresters were on hand with their expertise to answer questions from approximately 10 employees about their gardens, the design of their landscape, and identification of plants.

- Service Project: Get Your Hands Dirty by Beautifying SHA HQ (4/19/2017): Eleven SHA employees volunteered their time during lunch to perform a service activity at SHA Headquarters. Volunteers came from multiple offices such as Office of Structures, Office of Planning and Preliminary Engineering, Office of Highway Development, Office of Equal Opportunity, Office of Communications, and the Office of Environmental Design. The Earth Day team asked that volunteers "Get ready to get your hands dirty!" as the Earth Day team continued its annual service project of beautifying the walkways surrounding HQ entrances. Volunteers watered plants in need, cleaned up planters, and removed dead matter. The project culminated in the planting of new annuals that bloom from Spring through Fall to brighten employees' and visitors' days as they enter SHA Headquarters.

Figure 1-14: MDOT SHA Earth Day Service Project

- "Urban Agriculture in Baltimore City" Lunch & Learn (4/20/2017): Twenty-five SHA employees turned out for a Lunch and Learn on Urban Agriculture in Baltimore, provided by a Guest Speaker from Baltimore City's Office of Sustainability. The Lunch and Learn event focused on urban farming in Baltimore, and the City's policies, and activities that support local food production. Urban agriculture is connected to a wide variety of environmental topics including reclamation of urban lands, infill development/reduction of sprawl, reduction of greenhouse gases from food transportation, support of local economies and communities, and equitable access to healthy food.

Park(ing) Day

On September 16, 2016, MDOT SHA participated in the worldwide 11th annual PARK(ing) Day event, where artists, designers and citizens transform metered parking spots into temporary public parks.

MDOT SHA's theme revolved around urban agriculture while highlighting the importance of fostering growth of urban pollinator habitats.

Located adjacent to the MDOT SHA Headquarters Building on Calvert and Monument streets in Baltimore's Mount Vernon neighborhood, MDOT SHA's PARK(ing) Day display modelled the ideal habitat to attract pollinators such as butterflies and bees. MDOT SHA, in cooperation with Baltimore City Department of Transportation, temporarily converted one parking spot on Monument Street to a mini-park for the day.

Representatives from the University of Maryland's (UMD) Entomology Department in the School of Agriculture provided information about pollinators and their declining population. MDOT SHA has partnered with UMD to create bee and butterfly friendly habitats through roadside vegetation management best practices.

All pollinator plants included in MDOT SHA's display were transplanted outside of MDOT SHA Headquarters following the event.

Figure 1-15: MDOT SHA's 2016 PARK(ing) Day Display

Keep Maryland Beautiful Environmental Education Grants

The Maryland Environmental Trust (MET) awards grants to nonprofits, community groups, and schools to carry out environmental education projects across the state. This annual program is funded by the MET, Maryland Department of Housing and Community Development, and MDOT SHA. During the reporting period, 49 Keep Maryland Beautiful grants were awarded throughout nineteen counties and Baltimore City, totaling over $160,000.

MET / MDOT SHA Tree Planting & Stream Restoration

The MET and MDOT SHA are now offering free tree plantings and stream restoration projects on MET easement properties in Anne Arundel, Baltimore, Carroll, Cecil, Charles, Harford, Howard, Frederick, Montgomery, Prince George's, and Washington County. This program was announced in an article within the 2017 MET Spring/Summer Newsletter. As a result of this program, one tree planting site and one stream restoration project are in design.

Future Partnerships

A new tactic of MDOT SHA's multi-faceted public education program involves working toward partnerships with the Anacostia Watershed Society, Blue Water Baltimore, and the National Aquarium in Baltimore City. Agreements are currently being discussed and drafted with these organizations. The goal of these agreements is to meet MDOT SHA NDPES public education and trash reduction goals through stream cleanups, educational outreach and other partnership opportunities.

D.4.c Evaluation of Litter Education and Outreach Program

One way that MDOT SHA evaluates its litter reduction efforts is through MDOT's Excellerator program, which includes MDOT SHA Performance Measure 8.1 – *Percent of Half-Mile Segments of Roadway with Acceptable Litter Levels*. This measure is based on the Level of Service (LOS) assessments conducted by the MDOT SHA OOM. The rating for Calendar Year 2016 is 86.7 percent. See Figure 1-16.

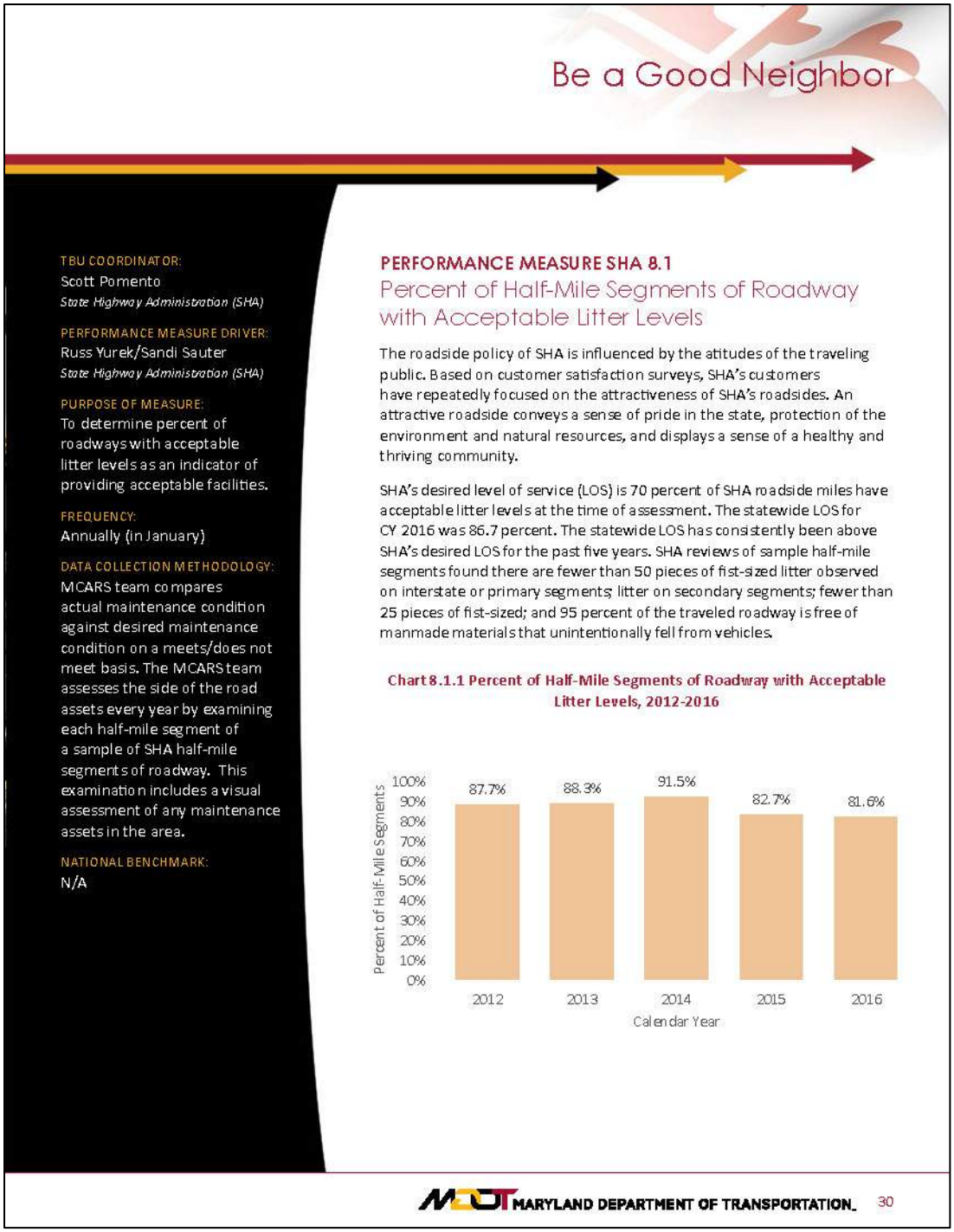


Figure 1-16: MDOT SHA Performance Measure 8.1 – Percent of Half-Mile Segments

MDOT also engages the public through a survey and outreach to better understand the impact that its facilities and operations have on communities and how the Department can be a better neighbor. This assessment involves collecting input from the public on a variety of topics including cleanliness and appearance. These surveys, completed in Spring 2017, show that 82 percent believe that MDOT operations exceeds their expectations.

Additionally, during the reporting period, MDOT SHA initiated a strategic, multi-phase market research study across the State of Maryland to establish baseline levels of litter awareness, perceptions, behavior, and motivation towards littering. These research endeavors included qualitative data collection via online, bulletin board focus groups, and follow-up quantitative data collection via 1,200 online surveys. A summary report detailing the results of these research endeavors can be found in Appendix E of this annual report. This research is being reviewed by MDOT SHA to develop future tactics of the existing education program.

D.4.d Progress Implementing Litter Education and Outreach Program

MDOT SHA has had a multi-faceted existing public education program with goals to educate the public on environmental stewardship and reduce littering. Components of this program as well as program tactics are outlined in Section D.4.b above. MDOT SHA Office of Communication and the Office of Public Involvement – Graphics Team are involved throughout the year in coordinating these efforts.

In addition to maintaining these programs, MDOT SHA actively works to meet the MDOT Performance Measure 8.1 (discussed in Section D.4.c) and has completed a strategic, multi-phase market research study across the State of Maryland to establish baseline levels of litter awareness, perceptions, behavior, and motivation towards littering.

A communication plan was developed at the conclusion of this research study can be found within Appendix E of this annual report. This plan presents a recommended three-year marketing strategy that expands existing MDOT SHA public education programs to further help reduce littering on roadways. The communication plan draws from the market research study which evaluated the effectiveness of existing program components. The plan includes a discussion of aims, objectives, tactics, and strategies to be implemented as well as goals to be achieved.

During the reporting period, MDOT SHA spent approximately $41,000 coordinating the multi-faceted market research study, reviewing and evaluating the results, and developing the communication plan found in Appendix

D.4.e Property Management and Maintenance

Requirements under this condition include:

a) Ensure that an NOI has been submitted to MDE and a pollution prevention plan developed for each SHA-owned facility requiring NPDES stormwater general permit coverage. The status of the pollution prevention plan development and implementation for each SHA-owned municipal facility shall be reviewed, documented and submitted to MDE annually;

b) Continue to implement a program to reduce pollutants associated with maintenance activities at SHA-owned facilities including garages, roadways parking lots, rest areas and park and rides. The maintenance program shall include, but not be limited to, these activities:

- *i) Street sweeping;*
- *ii) Inlet inspection and cleaning;*
- *iii) Minimizing the use of pesticides, herbicides, fertilizers and other pollutants associated with vegetation management through increased use of integrated pest management;*
- *iv) Minimize to the MEP the use of winter weather deicing materials through research, continual testing and improvement of materials, equipment calibration, employee training and effective decision-making; and*
- *v) Ensure that all SHA staff receives adequate training in pollution prevention and good housekeeping practices.*

SHA shall report annually on the changes in any maintenance practices and the overall pollutant reductions resulting from the maintenance program. Within one year of permit issuance, an alternative maintenance program may be submitted for MDE approval

indicating the activities to be undertaken and associated pollutant reductions.

D.4.f NOI Submission and Pollution Prevention Plan Development

As discussed in previous annual reports, MDOT SHA has implemented an Environmental Management System (EMS) to ensure multi-media compliance at maintenance facilities statewide. The EMS covers procedures for management of environmental compliance issues, including those related to Industrial NPDES at maintenance facilities, such as spill response, material storage and vehicle washing. It includes the implementation of Standard Operating Procedures (SOPs), routine compliance inspections and environmental training covering a variety of media areas including stormwater management and spill prevention and response.

The EMS includes routine multimedia compliance inspections of 162 MDOT SHA facilities. These inspections include recommendations for stormwater improvements and pollution prevention. As shown in Table 1-15, certain facilities are currently covered under the General Discharge Permit (12-SW). Actions taken to meet 12-SW requirements include:

- Updated Storm Water Pollution Prevention Plans (SWPPP) and maps
- Roll-out and training of standard operation procedures for Quarterly Visual Monitoring
- Updated internal self-assessment compliance checklists for routine and annual inspections
- Trained shop personnel on pollution prevention requirements and incorporated updates in annual environmental awareness training provided to all MDOT SHA maintenance staff
- Established a specific training program for pollution prevention team members performing stormwater inspections and quarterly visual monitoring assessments
- Evaluated all permitted facilities for the presence of non-stormwater sources
- Completed annual comprehensive site compliance evaluations

Table 1-15: Industrial NPDES Permit Status

District	Maintenance Facility	Permit Type
1	Berlin	General
	Cambridge	General
	Princess Anne	General
	Salisbury	General
	Snow Hill	General
2	Centreville	Individual – SW
	Chestertown	General
	Denton	General
	Easton	General
	Elkton	General
3	Fairland	General
	Gaithersburg	General
	Laurel	General
	Marlboro	General
4	Churchville	General
	Golden Ring	General
	Hereford	General
	Owings Mills	General
5	Annapolis	General
	Glen Burnie	General
	La Plata	General
	Leonardtown	General
	Prince Frederick	General
	Hanover Auto Shop	General
6	Hagerstown	General
	Keyser's Ridge	Individual – GW
	La Vale	General
	Oakland	General
7	Dayton	General
	Frederick	General
	Thurmont	General
	Westminster	General
Notes: SW = Surface Water, GW = Groundwater		

MDOT SHA maintenance facility staff are continuing to perform monthly inspections and the MDOT SHA Environmental Compliance Division (ECD) is continuing to perform inspections at all MDOT SHA facilities through its District Environmental Coordinators (DEC). ECD, through the DECs, is performing annual comprehensive site compliance evaluations for all 12-SW permitted facilities. Quarterly and annual inspections are performed to ensure stormwater pollution prevention BMPs are implemented and

the 12-SW permitting requirements are being met. The DEC and facility staff are responsible for ensuring compliance with all applicable permits, plans, and regulations at facilities in their region.

MDOT SHA has provided the erosion and municipal facility and SWPPP information in the Municipal Facilities feature class (MUN) as specified in the May 2017 MDE Geodatabase Guideline format.

12-SW Bay Restoration

As a MS4 permit holder, MDOT SHA has assessed the Bay Restoration requirement for facilities covered under the 12-SW permit and included them in the MDOT SHA MS4 20 percent impervious baseline and restoration implementation. Further discussion of MDOT SHA's impervious baseline assessment and 20 percent restoration goal can be found in MDOT SHA's July 31, 2017 submission to MDE (*MDOT SHA Response to MDE Impervious Area Assessment Report Comments*) as well as in Section E.2.a of this annual report.

MDOT SHA performed an impervious accounting assessment of all industrial facilities covered under the 12-SW permit. The assessment of the controlled and uncontrolled impervious surfaces on the property of MDOT SHA industrial facilities was included in the overall impervious accounting assessment for the entire MDOT SHA MS4 area submitted on July 31, 2017 to MDE.

The 12-SW permit is applicable to the discharge of stormwater associated with industrial activities to waters of the state. MDOT SHA considers any site that is partly industrial as if it is entirely industrial and this was the methodology applied to the entire property boundary of the maintenance shop. This impervious accounting information, for each maintenance facility, has been updated to align with the revised baseline and the data provided in the July 31, 2017 submittal to MDE.

As presented in Table 1-16 below, each MDOT SHA maintenance facility covered under the 12-SW in MS4 areas of responsibility has a controlled and uncontrolled impervious area and an associated 20 percent restoration requirement.

Table 1-16: 12-SW Impervious Accounting Included in MS4 Baseline

Maintenance Facility	Total Impervious Area (AC)	Controlled Area (AC)	Uncontrolled Area (AC)	20% Impervious Restoration Requirement (AC)
Annapolis	6.57	3.16	3.42	0.68
Cambridge	0.00	0.00	0.00	0.00
Churchville	6.07	3.45	2.61	0.52
Dayton	6.92	4.99	1.93	0.39
Elkton	9.69	1.96	7.74	1.55
Fairland	5.52	0.90	4.62	0.92
Frederick	8.75	8.57	0.19	0.04
Gaithersburg	10.14	1.79	8.35	1.67
Glen Burnie	7.34	0.89	6.45	1.29
Golden Ring	6.09	2.24	3.85	0.77
Hagerstown	6.11	0.00	6.11	1.22
Hanover	14.26	9.69	4.57	0.91
Hereford	5.57	1.04	4.52	0.90
LaPlata	6.18	4.74	1.45	0.29
Laurel	5.86	3.79	2.07	0.41
Marlboro	10.53	8.87	1.66	0.33
Owings Mills	7.46	7.42	0.04	0.01
Salisbury	0.00	0.00	0.00	0.00
Thurmont	3.25	0.39	2.86	0.57
Westminster	7.81	7.15	0.66	0.13
Totals	**134.13**	**71.04**	**63.09**	**12.62**

Table 1-16: 12-SW Impervious Accounting Included in MS4 Baseline

Maintenance Facility	Total Impervious Area (AC)	Controlled Area (AC)	Uncontrolled Area (AC)	20% Impervious Restoration Requirement (AC)
Note: This accounting is presented to illustrate MDOT SHA 12-SW permitted areas that are covered under the MS4 impervious baseline and 20 percent treatment requirement of 4,709 acres. See Section E.2.a for more discussion on the MDOT SHA impervious accounting and 20 percent impervious restoration.				

As described above, MDOT SHA continues to maintain an effective Industrial Stormwater NPDES Program through ECD to ensure pollution prevention and permit requirements are being met at MDOT SHA maintenance facilities. Annually, and as change dictates, MDOT SHA updates its combined Storm Water Pollution Prevention Plans (SWPPP) and Spill Prevention, Control, and Countermeasure (SPCC) Plans. As a continuing best management practice, MDOT SHA has developed SWPPPs for facilities that are typically not required to have one (e.g. salt storage facilities).

Throughout the reporting year, MDOT SHA continued to address potential stormwater pollution issues by implementing Best Management Practices (BMPs) and designing/constructing capital improvements. BMPs were identified during pollution prevention plan updates and routine facility inspections. The status of BMP implementation for maintenance facilities is tracked by each DEC during routine inspections. Potential capital improvements are prioritized based on risk to human health and the environment, and funding availability. The following list details the major pollution prevention efforts and maintenance facility improvements since the last annual report.

Completed Projects:

- 12-SW quarterly visual monitoring and annual comprehensive site compliance evaluations
- Update of all associated SWPPP Maps
- Standard Operating Procedure creation and updates to ensure compliance with 12-SW permit
- Updating existing and creation of a new training program to ensure compliance with 12-SW permit
- Petroleum storage tank system upgrades at various SHA maintenance facilities, including the elimination of an individual discharge permit at MDOT SHA's Churchville maintenance facility through installation of a holding tank for wash bay wastewater

Ongoing Projects / Efforts:

- Routine Statewide stockpile management assessment, planning, and design for new structural controls, including covered/roofed storage structures for erodible material
- Statewide brine tank upgrades and replacement
- Design and construction of new wash bays to ensure indoor vehicle washing
- Salt barn repair plan and development of on-call repair contracts
- Initial assessment reports and preliminary design completed for erosion issues noted at various facilities statewide
- Statewide discharge sampling and reporting program for facilities with Individual Discharge Permits
- compliance inspections at all MDOT SHA facilities
- Annual multimedia compliance training provided to maintenance shop personnel

Table 1-17 shows the MDOT SHA capital expenditures towards industrial pollution prevention BMPs from the current and past 13

fiscal years. Projected expenditures for Fiscal Year 18 are also included.

Table 1-17: Capital Expenditures for Pollution Prevention BMPs

Fiscal Year	Expenditure
2005	$ 613,210 - actual
2006	$ 592,873 - actual
2007	$ 450,608 - actual
2008	$ 590,704 - actual
2009	$ 478,889 – actual
2010	$ 613,766 - actual
2011	$ 595,984 - actual
2012	$ 664,577 - actual
2013	$ 917,902 - actual
2014	$641,512 - actual
2015	$2,339,971 - actual
2016	$1,858,544 - actual
2017	$2,006,170 - actual
2018	$5,524,000 - projected

D.4.g Maintenance Activity Pollution Reduction Program

MDOT SHA continues to implement programs and activities aimed at reducing pollutants associated with maintenance activities at MDOT SHA owned facilities. Such activities include street sweeping and inlet cleaning, and are discussed in the following sections. In addition, MDOT SHA is conducting efforts to minimize the use of pesticides, herbicides, and fertilizers associated with vegetation management and minimizing the use of winter weather deicing materials.

i. Street Sweeping

The current MDOT SHA street sweeping program is predicated upon operational and safety needs for maintaining drainage from roadways, keeping roadsides free from lose debris that can be thrown by turning wheels, and keeping roadsides visually attractive. As MDOT SHA has developed the Impervious Restoration and Coordinated TMDL Implementation Plan discussed in Section E.2.b, other water quality modeling, reduction calculations, data tracking and reporting, and practice implementation standards have entered into the decision-making processes. Street sweeping programs to address water quality issues and various guidance from MDE and the Chesapeake Bay program are under development. This section of the report addresses operational and safety needs for street sweeping. Section E.4 of future MS4 annual reports will discuss MDOT SHA's progress in implementing street sweeping routes, equipment, frequencies, and disposal methods in compliance with water quality standards.

Vacuum assisted sweeping of the roadway is essential in the collection and disposal of loose material, debris, and litter. This material, such as dirt, sand, small rocks, trash, and other debris collects along curbs and gutters, bridge parapets, inlets, and outfall pipes. Street sweeping prevents buildup along sections of roadway and allows for the free flow of water from the highway to enter the storm drain system. MDOT SHA sweeps a selected number of roadways regularly during the Spring, Summer, and Fall months from April through November. The collected material is then properly disposed of in an approved landfill. See Figure 1-17 for an example of MDOT SHA's street sweeping activity.

Figure 1-17: MDOT SHA Nighttime Street Sweeping Operation

The MDOT SHA desired operational condition is 95 percent of the traveled roadway clear of loose material or debris. In addition, 95 percent of closed section roadways (curb and gutter) should have less than 1-inch depth of loose material, debris, or

excessive vegetation that can capture debris in the curb and gutter.

ii. Inlet Cleaning

As stated above under Section D.5.b.i for street sweeping, inlet cleaning is another operations practice that has been identified as useful in meeting water quality standards. The current MDOT SHA inlet cleaning program is predicated upon operational and safety needs for maintaining drainage from roadways, deterring flooding, minimizing ice development during winter storms, keeping roadsides free from lose debris that can be thrown by turning wheels, preventing damage to underground inlets and pipes, and keeping roadsides visually attractive. MDOT SHA is currently developing inlet cleaning programs to address water quality standards, MDE and Chesapeake Bay Program guidance, data tracking and reporting, and modeling and reduction calculations. This report addresses operations and safety components of the current MDOT SHA inlet cleaning program and future reports will discuss progress in implementing inlet cleaning efforts to meet water quality standards under Section E.4.

Inlets are structures that allow water to flow from the roadway surface and enter closed storm drain systems. These storm drain systems convey runoff to a discharge point at a ditch, channel, or waterway. Some inlets have been designed with catch basins, chambers where sediment, trash, and debris are captured before it can enter the waterway. These catch basins, along with "self-cleaning" inlets that have been clogged with debris, are cleaned periodically by MDOT SHA maintenance crews using vacuum trucks to remove the sediment and debris and to allow free flow through the inlet and prevent the storm drain system from becoming clogged. MDOT SHA maintenance personnel perform routine inlet inspection and cleaning. This helps to ensure proper water flow, protects drainage structures, and lessens the likelihood of flooding. In many cases, measures are employed to prevent erosion and sedimentation, as well as protect aquatic life in adjacent streams and rivers.

MDOT SHA owns and operates four vacuum pump trucks used to routinely clean storm drain inlets along roadways. Sediment and trash make up the majority of the material that is removed. The vacuum trucks operate in central Maryland, spanning the following counties: Anne Arundel, Baltimore, Calvert, Carroll, Charles, Frederick, Harford, Howard, Montgomery, Prince George's, and St. Mary's. See Figure 1-18 and Figure 1-19 for examples of inlet cleaning equipment and before and after results.

Table 1-18 presents the number of inlets and tons collected from MDOT SHA inlet cleaning efforts in FY2017.

Figure 1-18: MDOT SHA Vacuum Truck Used to Clean Inlets

Figure 1-19: Inlet Before and After Cleaning

Table 1-18: Number of inlets cleaned and tons collected in FY2017

County	MDOT SHA Shop	Total Number of Inlets Cleaned[1]	Tons[2] Collected
Anne Arundel	Annapolis	31	3
	Glen Burnie	50	5
Baltimore	Golden Ring	421	44
	Hereford	563	59
	Owings Mills	505	53
Carroll	Westminster	15	2
Cecil	Elkton	14	2
Charles	La Plata	7	1
Frederick	Frederick	23	2
Harford	Churchville	267	28
Howard	Dayton	15	2
Montgomery	Fairland	826	87
	Gaithersburg	380	40
Prince George's	Laurel	855	90
	Upper Marlboro	659	69
Washington	Hagerstown	18	2
Total		**4649**	**489**

[1]Excludes front-end loader records in which the cleaning took 1 hour or less per inlet. If the time per inlet is longer than this, it is assumed the inlet was deep cleaned using the front-end loader.

[2]Following the assumption that 300 lbs of wet weight cleaned from each inlet. Applied 0.7 to calculated wet weight to estimate dry weight and converted to tons.

iii. Minimize Use of Pesticides, Herbicides, Fertilizers and Other Pollutants

One of MDOT SHA's standards for maintaining the highway system is the *MDOT SHA Integrated Vegetation Management Manual for Maryland Highways, October 2003* (IVMM). The IVMM is currently undergoing an update. The anticipated release date of the latest edition is Winter of 2017. This manual provides guidelines for performing activities involved in the management of roadside vegetation including application of herbicides, mowing, and the management of woody vegetation. In order to maximize the efficiency of funds and to protect the roadside environment, an integration of these activities is employed. MDOT SHA has provided the chemical application program information in the Chemical Application table (CAP) as specified in the MDE 2017 Geodatabase Guideline format.

The Office of Environmental Design offers Pesticide Applicator Training (ENV 100, ENV 200, ENV 210, ENV 220 and ENV221) classes throughout the year. ENV 100 allows participants to become a Registered Pesticide Applicator with the Maryland Department of Agriculture (MDA) and receive a Pesticide Service ID card. Training covers pesticide safety, emergency protocols, plant identification, drift reduction, water quality, and Integrated Pest Management.

ENV 200 provides recertification credits for MDOT SHA and MDTA employees, consultants and contractors. Certified Pesticide Applicators are required by MDA to annually obtain continuing education credits in order to renew certifications. Training topics are developed by MDOT SHA and approved by MDA.

ENV 210 is a Pesticide Core and Right-of-Way Certification preparation class. OED has added two new pesticide classes: ENV 220 and ENV 221. ENV 220 is an aquatic pesticide training to qualify MDOT SHA personnel to take the MDA Pesticide Category 5 Aquatic test. ENV 221 is the Aquatic

preparation class. Table 1-19 below lists classes and participation rates during this reporting period.

Table 1-19: Pesticide Applicator Training

Date	Training Sessions				
	ENV 100	ENV 200	ENV 210	ENV 220	ENV 221
7/22/2016	8		17		
8/12/2016			3		
8/18/2016			1		
9/8/2016				9	
9/13/2016				6	
10/20/2016			7		
10/20/2016					1
10/21/2016			1		
10/21/2016					6
10/26/2016			2		
10/27/2016					1
12/9/2016			3		
12/12/2016					1
2/15/2017					2
3/9/2017		13			
3/21/2017		8			
3/23/2017		10			
3/28/2017		19			
3/30/2017		12			
4/4/2017		18			
4/6/2017		15			
4/19/2017		7			
4/20/2017	9				
4/28/2017		6			
Sum Total	17	108	34	15	11
Total	**185**				

MDOT SHA is continuing to work with MDA on a program to control selected species of invasive plants using biocontrol methods, such as the introduction of Mile-a-Minute vine weevil and Purple Loosestrife beetle in appropriate areas. MDA released weevils and beetles at 14 locations within the MDOT SHA Right-of-Way: 5 new sites for weevils, 2 new sites for beetles, and 7 existing sites for weevils.

Herbicide Application

The majority of MDOT SHA's vegetation management is accomplished mechanically through the use of mowers and brush axes. However, in areas where mechanical control is not practical or feasible, MDOT SHA manages vegetation through the use of targeted applications of herbicide. Vegetation controlled by MDOT SHA includes noxious weeds, invasive weeds and plant material that is a safety hazard.

MDOT SHA promotes the safe and responsible use of herbicide for the control of vegetation. All MDOT SHA employees and contractors who apply herbicide on MDOT SHA rights-of-way must be registered with the MDA and operate under the supervision of a MDA-certified pesticide applicator.

Environmental stewardship is a primary focus of MDOT SHA's business plan, and MDOT SHA uses selective herbicides when available and targeted application, rather than broad application of non-selective herbicides. MDOT SHA uses the lowest pressure and largest droplet size for each application. Along with the addition of anti-drift agents, these measures help reduce the potential for drift, runoff, and non-point source contamination.

The selection of herbicide to be used is based on the plant species that is being targeted. This helps to ensure the effects on other plants are minimized and soil residual activity is limited. Application rates are based on the labeled minimum amount required to control the targeted plant species, which further reduces the potential for runoff and non-point source pollution.

Table 1-20 lists, the herbicides that were applied statewide during the reporting period to MDOT SHA property by MDOT SHA personnel and contractors.

Table 1-20: Herbicides Applied to MDOT SHA Property

Chemical	Gallons
2,4-Dichlorophenoxyacetic acid, dimethylamine salt	1,750
Aminopyralid	11.9
Ammonium salt of imazapic	4
Chlorsulfuron	68
Clopyralid	380
Dithiopyr	37.2
Fosamine	1,100
Glyphosate	14,039
Halosulfuron-methyl	0.2
Isopropylamine Salt of Glyphosate	61.5
Mefluidide, diethanolamine salt	70
Metsulfuron	0.2
Oryzalin	153
Triclopyr	523.5
Trifluralin (lbs)	3,631
Trinexapac-ethyl	162
Total Gallons Herbicide	**21,991.5**

Herbicide application equipment is routinely inspected and calibrated to ensure that applications are accurately applied in accordance to the IVMM, Maryland State law, and the herbicide label.

Nutrient Management Plans

The Maryland Lawn Fertilizer Law limits the total amount and timing of fertilizer applications associated with turfgrass establishment and maintenance. MDOT SHA uses slow-release nitrogen and low or no phosphorus fertilizers when establishing turf, meadows, and other vegetation. Topsoil, both existing and supplied, is sampled and tested for major and minor plant nutrients, pH, organic matter, and soluble salts. The test results are used to develop a Nutrient Management Plan (NMP) for each soil to ensure optimal nutrient levels and growing conditions and to avoid the application of excess fertilizer.

All MDOT SHA topsoil producer's stock piles are tested every two months. Soil tests are used to develop NMPs. If existing soil on a construction site will be seeded or is proposed to be salvaged and reused, it will be tested and the test results will be used to write the NMP. NMPs tell contractors the amount of fertilizer to apply based on the soil test and in conformance with Maryland's Lawn fertilizer law. MDOT SHA follows the law's guidelines even when establishing meadows or other non-lawn areas. MDOT SHA's contractors only apply fertilizer when establishing turf or other ground cover vegetation. MDOT SHA does not fertilize established turf or meadows.

The Maryland Fertilizer Law requires that fertilizers are applied by a MDA-licensed Professional Fertilizer Applicator. While MDOT SHA personnel do not directly apply fertilizer, they do have two Professional Fertilizer applicators on staff.

Fertilizer use during the reporting period includes:

- 154,200 lbs of 20-16-12 Ureaform (UF), Monoammonicum Phosphate (MAP), Potassium Sulfate (SOP),
- 47,307 lbs of 38-0-0 UF, and
- 4,994 lbs of 15-30-15.

MDOT SHA is working with UMD's Appalachian Lab on a research project that is studying various grass species on the roadside that can thrive under roadside conditions with limited inputs, including fertilizers.

MDOT SHA is working with UMD College Park on a research project that is studying the use of compost to improve grass establishment. By using compost to amend the soil MDOT SHA would be able to eliminate the use of additional fertilizer when establishing grass and meadow.

Both research projects are discussed further in Section E of this Annual Report.

Mowing Reduction & Native Vegetation Establishment

A major initiative at MDOT SHA is to reduce the extent of frequently mowed areas within our right-of-way. There are also instances where MDOT

SHA must maintain shorter vegetation for safety reasons. Shorter vegetation provides greater sight distance at intersections and curves, and allows for greater visibility of signs. Within clear zones, vegetation must be less than four inches in diameter to provide an area for errant vehicles that leave the road to safely stop. MDOT SHA's Turfgrass Management Policy has been revised to provide consistent guidance to decrease the size of mowed areas and the number of mowing cycles per year while still meeting the safety goals.

Several projects have been completed throughout the state to install and maintain forested and native meadow areas. Forested and native meadow areas require infrequent mowing, enhance and preserve native vegetation, and provide stormwater benefits such as increased nutrient uptake.

Minimize Use of Winter Weather Deicing Materials

MDOT SHA continues to test and evaluate new winter materials, equipment and strategies in an on-going effort to improve the level of service provided to motorists during winter storms while at the same time minimizing the impact of its operations on the environment.

One method employed to decrease the overall application of deicing materials is to increase application of deicing materials prior to and in the early stages of a winter storm (anti-icing). This prevents snow and ice from bonding to the surface of roads and bridges and ultimately leads to lower material usage during storm events, thus lessening the overall usage of deicers.

MDOT SHA will have Direct Liquid Application (DLA) Snow Routes in six of its seven engineering districts. This operation identifies a designated snow route that only uses a critically measured salt brine solution to prevent the snow and ice from bonding to the pavement. Unlike anti-icing, which takes place prior to the event, this operation continues for the duration of the winter storm event and has proven to be quite effective. Data has shown that at an average application rate of 120 lbs / lane mile / inch, this operation met MDOT SHA's level of service metric and helped reduce LaPlata facility's usage rate by 52 percent in the past season and a combined 70 percent over the previous two seasons.

In addition, MDOT SHA is continuing its 'sensible salting' training of State and hired equipment operators in an on-going effort to decrease the use of deicing materials without jeopardizing the safety and mobility of motorists during and after winter storms. Table 1-21 lists the types of materials and quantities applied by MDOT SHA in winter deicing operations.

Table 1-21: MDOT SHA Deicing Materials

Material	Characteristics	FY17 Quantity Applied Statewide
Sodium Chloride (Rock and Solar Salt)	The principal winter material used by SHA. Effective down to 20° F and is relatively inexpensive.	91,494 tons (does not include the salt used to make the liquid brine)
Abrasives	These include sand and crushed stone and are used to increase traction for motorists during storms. Abrasives have no snow melting capability.	15,207 tons (only applied in Alleghany and Garrett Counties)
Calcium Chloride	A solid (flake) winter material used during extremely cold winter storms. SHA uses limited amounts of calcium chloride.	0 gallons
Salt Brine	Liquid sodium chloride or liquefied salt is a solution that can be used as an anti-icer on highways prior to the onset of storms, or as a deicer on highways during a storm. Used extensively by SHA. Freeze point of -6° F.	1,169,839 gallons
Magnesium Chloride (Mag)	A liquid winter material used by SHA for deicing operations in its northern and western counties. It has a freeze point of -26° F and has proven cost effective in colder regions.	0 gallons

New Road Salt Management

On May 20, 2010, the Governor approved Senate Bill 775, requiring MDOT SHA, in consultation with the MDE, to develop a best practices road salt management guidance document by October 2011. This document is necessary to reduce the adverse environmental impacts of road salt storage, application, and disposal on Maryland's water and land resources. The objective and goal of this Statewide Salt Management Plan (SMP) is to provide a framework for highway agencies to deliver safe, efficient roadway systems during winter storms in a cost-effective manner, while recognizing their obligation to do so in the most environmentally sensitive manner applicable.

MDOT SHA posted the SMP on its website in October 2011. The SMP was subsequently updated in October 2012 and October 2015 and has recently been revised and approved for publication in 2016. The current October 2016 SMP can be accessed via the SHA website: http://www.roads.maryland.gov/OOM/Statewide_Salt_Management_Plan.pdf

The SMP provides guidance on snow and ice control operations with an emphasis on reducing the impact of salt on the environment. The SMP covers all aspects of winter operations including:

- Safety and mobility of motorists during and after winter storms;
- Defining levels of service provided during winter storms;
- Establishing long-term goals to lessen the usage of salt, and reduce its impact on the environment;
- Salt and other winter materials;
- Material storage and handling;
- Winter storm fighting equipment;
- Training initiatives;
- Winter storm management from pre-storm preparations through post-storm operations;
- Post-storm material and equipment cleanup;
- Post-storm and post-season data analysis;
- Public education and outreach, and
- Testing and evaluation of new materials, equipment, and strategies for continual improvement.

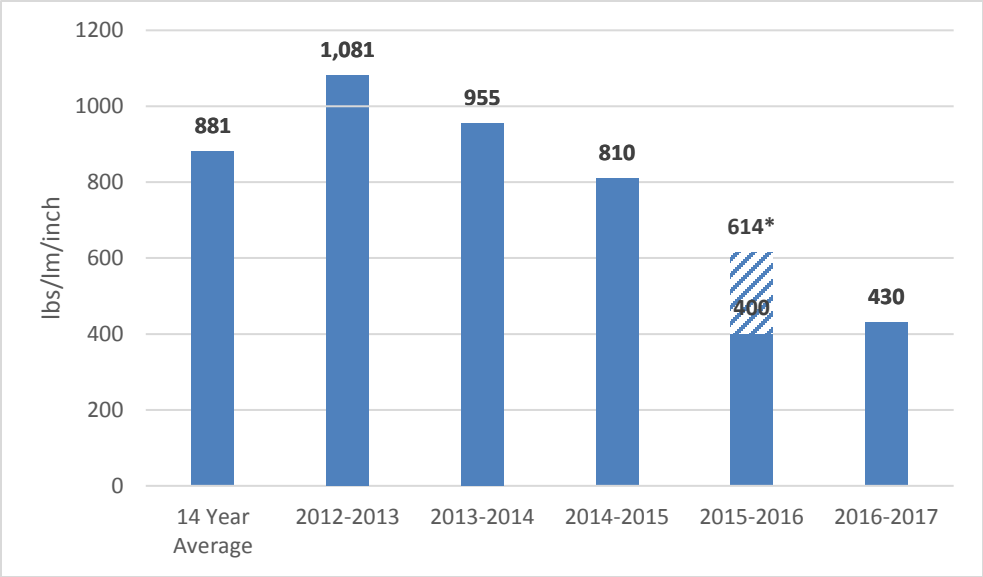
Roadside Deicer Application

MDOT SHA has been tracking road salt usage for approximately 15 years. Table 1-22 displays application data starting from the adoption of the SMP such as the yearly average number of storms fought by MDOT SHA and the average amount of precipitation in inches. The salt usage in tons, shown in Table 1-22, is a statewide seasonal total and includes areas outside of the MS4 Permit areas. Within the areas covered under the MS4 Permit, MDOT SHA applied a total of 54,088 tons of salt, including that used to mix salt brine liquids. Expressed as a function of pounds of salt per road lane mile per inch of precipitation, the amount of salt applied during FY17 across the state is 430 lbs/lm/inch.

Table 1-22: Recent Salt Usage Statewide

Winter	Storms	Inches	Salt Used (tons)
2011 to 2012	5.2	11.8	85,536
2012 to 2013	10.3	25.0	205,212
2013 to 2014	17.3	66.5	551,443
2014 to 2015	16.0	47.4	340,083
2015 to 2016	7.6	40.0	137,358
2016 to 2017	7.8	27.16	91,494

Focusing on the future, a trend seems to be developing that shows movement toward reduced road salt usage, represented by the graph in Figure 1-20. In reading the graph, it is important to understand how MDOT SHA makes comparisons of road salt usage. MDOT SHA uses a metric of pounds of road salt per total lane miles per inch of snow. This allows an equal comparison across the state in the measurement of road salt usage.



***Adjusted salt usage rate. Extraordinary snow accumulation from blizzard removed from calculations.**

Figure 1-20: Comparison of Salt Usage Normalized by Snow Depth Statewide

Prior to the 2014-2015 winter season, a challenge was issued by MDOT SHA management to reduce road salt usage by five percent. This challenge resulted in a statewide reduction in pounds per lane mile per inch of 14 percent. MDOT SHA's salt usage numbers dropped again this past season by 31 percent and 56 percent over the last 3 years.
By encouraging the expanded use of salt brine for anti-icing and re-application (liquid-only routes), reduced granular road salt application, and improved weather forecasting, further reduction of deicing applications is achievable without impacting the level of service to the traveling public.

MDOT SHA Annual Snow College

This training is offered annually at each of the seven MDOT SHA districts for new maintenance shop hires as well as 20 percent of veteran shop forces. The goal is to train all maintenance personnel over a five-year period and repeat the process. This ensures that all maintenance personnel are exposed to current trends and technologies. The training presentations are included in the Statewide Salt Management Plan, Appendices II and III. Snow College includes the following subjects: safety, pre-season and pre-storm preparations, use of chemicals, environmental impacts of winter operations, weather information and data collection, equipment maintenance, plowing tips and techniques, and post-storm operations. During the reporting period, seven Snow College sessions were held and more than 100 employees were trained. See Table 1-23 for number of participants trained during this reporting period.

Table 1-23: MDOT SHA Snow College Training

SHA District Shops	Dates	Attendees
1 DO, WI, WO, SO	12/12/16 – 12/13/16	23
2 CE, KE, QA, CO, TA	12/7/16 – 12/8/16	21
3 MG, MF, PL, PM	11/28/16 – 11/29/16	39
4 BG, BH, BO, HA	11/21/16 – 11/22/16	8

Table 1-23: MDOT SHA Snow College Training

SHA District Shops	Dates	Attendees
5 AA, AG, CV, CA, CH, SM	11/14/16 – 11/15/16	19
6 GA, AL, WA	11/16/16 – 11/17/16	16
7 FR, CL, HO	12/5/16 – 12/6/16	29
	12/19/16 – 12/20/16	28
	Total	**183**

Annual Maintenance Shop Winter Meetings

In 2015, MDOT SHA developed training on Best Practices for Salt Management and Environmental Stewardship during Winter Operations. Training is based on the practices outlined in the Salt Management Plan and is targeted specifically at the facility maintenance employees who manage or perform winter emergency operations. During the reporting period, 28 sessions were held and approximately 1,000 employees were trained.

Hired Equipment Operator Training

Prior to the start of each winter season, MDOT SHA provides this training to hired equipment contractors and operators. The training presentations are included in the Statewide Salt Management Plan, and topics covered include effective plowing, sensible salting, TMDL regulations, and adhering to all pertinent MDOT SHA policies and procedures. This training has also been made available in a bilingual format aiding in information decimation. During the reporting period, more than 28 sessions were held and approximately 2,100 hired equipment operators were trained.

iv. Pollution Prevention and Good Housekeeping Training

SWPPP Training

MDOT SHA continues to provide annual training to its maintenance personnel as described in the previous section. Environmental compliance training covers a variety of media areas including stormwater management, spill prevention and response, pollution prevention requirements, and training for pollution prevention team members performing stormwater inspections and quarterly visual monitoring assessments.

Each facility has a designated Pollution Prevention Team that is responsible for developing, implementing, maintaining control measures, utilizing corrective actions when required, and revising the SWPPP.

The Pollution Prevention Team is responsible for making sure that all operations staff understands the components of the SWPPP, how it will be implemented, and their role in contributing to the effectiveness of stormwater control measures. The Resident Maintenance Engineer is responsible for coordinating discharge prevention activities at the facility. Appropriate training and instruction is given to all employees regarding the SWPPP. Initial training occurs within six months of hiring. At a minimum, personnel training will be conducted annually to provide consistent understanding of pollution prevention and to notify employees of SWPPP changes.

Training documentation is maintained on MDOT SHA's Online Learning Center. Table 1-24 includes information related to SWPPP training during this reporting period.

Table 1-24: SWPPP Training by Shop

District	Maintenance Facility	Training Date	Total Trained
1	Cambridge	10/2016	21
1	D1 Office	10/2016	2
1	Princess Anne	10/2016	19
1	Salisbury	10/2016	28
1	Snow Hill	10/2016	23
2	Centreville	09/2016	31
2	Chestertown	09/2016	25
2	D2 Office	09/2016	4
2	Denton	09/2016	23
2	Easton	09/2016	26
2	Elkton	09/2016	32
3	Fairland	08/2016	29
3	Gaithersburg	08/2016	24
3	Laurel	08/2016	23
3	Upper Marlboro	08/2016	34
4	Churchville	07/2016	40
4	Golden Ring	10/2016	6
4	Owings Mills	07/2016	34
5	Annapolis	07/2016	50
5	D5 Office	08/2016	2
5	Glen Burnie	07/2016	48
5	La Plata	07/2016	30
5	Leonardtown	07/2016	34
5	Prince Frederick	07/2016	29
6	Keysers Ridge	08/2016	43
6	La Vale	07/2016	30
7	Dayton	08/2016	37
7	Frederick	08/2016	55
7	Westminster	08/2016	38
OOM	Hanover	05/2017	16
		Total	**836**

SWM Maintenance Training

During FY17, the Drainage and SWM Asset Team made several presentations to MDOT SHA maintenance personnel at various meetings and training events with the purpose of highlighting the importance of SWM facility maintenance in extending the service life of these facilities. The primary audience was maintenance staff, but training was also presented to additional staff.

These training sessions facilitated a round table discussion at the Monthly RME Coordination Meeting on April 20 to get feedback for the maintenance manuals that had been previously distributed, to learn about BMP safety and coordinate upcoming inspection efforts. The team also present at the MDOT SHA State-Wide Quality Council Meeting on May 11. This presentation was expanded to include discussions about contracting mechanisms and aging drainage infrastructure.

The final SWM maintenance training presentation during FY 2017 was held on June 16 at the District 1 Team Leader Day. This discussion also involved both training and a round table discussion. The results of all combined trainings showed a definite increase in communication among the Drainage and SWM Asset Management Team and maintenance staff from all over the state. Final internal training efforts were also made within the Drainage and SWM Asset Management Program itself when updated inspection trainings were presented in April.

D.5.c Changes in Maintenance Practices and Overall Pollutant Reductions

The MS4 permit also requires MDOT SHA to report annually on the changes in any maintenance practices and the overall pollutant reductions resulting from the maintenance program. MDOT SHA has reviewed its current maintenance program and determined that the program is adequately meeting the requirements. No alternative maintenance program was submitted to MDE in FY16.

Concerning overall pollutant reductions resulting from the MDOT SHA maintenance program, we are assuming that data relative to this condition is for deicing, fertilizer, and herbicide. The Chemical Application (CAP) Table from the May 2017 MDE Geodatabase Guidance has been provided along with this report and provides detailed information regarding applied chemicals.

The MDOT SHA FY16 Annual Report did not provide detailed quantities of specific types of chemicals applied on SHA property. MDOT SHA has included in this year's Geodatabase and narrative report detailed information regarding the specific chemicals and quantities that have been applied to MDOT SHA lands during this permit term. It continues to be a goal for MDOT SHA to avoid or minimize chemicals applications across the state.

Since FY17 is the first year MDOT SHA has reported detailed information regarding chemical applications, there is no historical data from which to perform an analysis identifying reduced applications. MDOT SHA will provide detailed application analysis in future reports concerning trends in applied quantities.

Section E.4, TMDL Compliance, contains details regarding the pollutant reductions associated with MDOT SHA's street sweeping and inlet cleaning programs. Additionally, these two restoration strategies are detailed within the attached Geodatabase under the AltBMP elements.

D.5 Public Education

Requirements under this condition include:

a) Maintain a compliance hotline or similar mechanism for public reporting of water quality complaints, including suspected illicit discharges, illegal dumping and spills;

b) Provide information to the transportation community about the benefits of:

- *i) Stormwater management implementation and facility maintenance;*
- *ii) Proper erosion and sediment control practices;*
- *iii) Increasing proper disposal of vehicle fluids such as brake fluid or motor oil (not in inlets or catch basins);*

iv) Refraining from and reporting roadside dumping;

v) Proper litter and trash disposal;

vi) Decreasing vehicle idling;

vii) Utilizing alternative modes of transportation (bus, train, walking, biking, carpooling);

viii) Car care and washing; and

ix) Proper pet waste management at rest areas and welcome centers.

c) Provide information regarding the following water quality issues to the regulated community when requested:

i) NPDES permitting requirements;

ii) Pollution prevention plan development;

iii) Proper housekeeping; and

iv) Spill prevention and response.

D.5.a Mechanism for Public Reporting

The MDOT SHA Customer Care Management System, better known as CCMS, was implemented in July 2007 as a central customer service reporting and tracking system for MDOT SHA. CCMS is updated regularly based on input from its primary users and the CCMS Administrator. Every MDOT SHA administrative office, district office, and maintenance shop participates in CCMS.

Customers can submit their concerns or requests directly into CCMS from the MDOT SHA webpage at:

http://marylandsha.force.com/customercare/request_for_service

This feature reduces emails to generic and project specific group email accounts. Once the customer clicks the submit request button, the ticket is in the system and on its way to the correct work unit. Inputs to CCMS are monitored and tracked daily. Each request is handled individually and closed out of the tracking system once MDOT SHA completes the service or addresses an inquiry. The system can be used to report a variety of service requests including water quality complaints such as suspected illicit discharges, illegal dumping, spills, and trash and litter problems along MDOT SHA roadways and facilities.

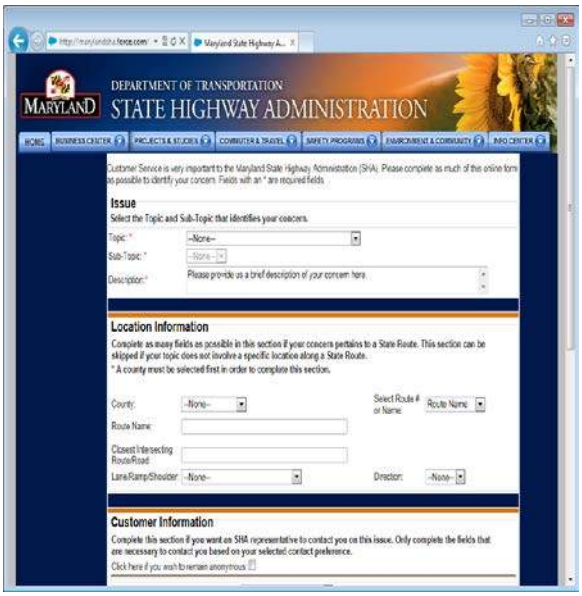


Figure 1-21: Screen Capture of CCMS

During the reporting period of July 1, 2016 through June 30, 2017, MDOT SHA's CCMS system received approximately 23,000 service requests. There were 2,200 service requests regarding littering and illegal dumping related issues of which 2,136 are closed. Tickets reporting debris, litter, and graffiti account for 10 percent of all CCMS tickets. Such tickets peak in late February and March following the winter season.

An email reporting mechanism has also been implemented via wpd@sha.state.md.us.

D.5.b Provide Information to the Transportation Community

MDOT SHA is dedicated to providing resources to members of the transportation community interested in learning about ways to reduce stormwater pollution in local waterways and the Chesapeake Bay. A new MDOT SHA educational outreach webpage has been developed for this purpose and can be accessed at:

https://www.roads.maryland.gov/Index.aspx?pageid=48.

The webpage includes information related to the following topics:

i. Stormwater Management Implementation and Facility Maintenance

As discussed in the 2016 MS4 Annual Report, MDOT SHA has created a brochure titled MDOT SHA *Chesapeake Bay and Local Waterway Restoration Projects*.to educate the transportation community regarding stormwater management implementation as it relates to our Bay restoration strategies. This brochure is currently being updated to provide additional information concerning the MS4 restoration program. The new version will be available on the website by December 2017. Once updates are finalized, this brochure will be included with project notification letters that are sent to adjacent property owners when a restoration project is planned in their area.

The current brochure provides information on environmental concerns resulting from increased stormwater runoff from urbanization along with descriptions of various stormwater management restoration strategies MDOT SHA utilizes, such as structural stormwater controls, non-structural stormwater and natural resource controls, land use change, and pollutant source controls.

ii. Proper Erosion and Sediment Control Practices

MDOT SHA has a well-established erosion and sediment control training program which serves to educate and bring awareness to MDOT SHA designers, construction employees, design consultants, and contractors. See Section D.2 for information on training provided throughout the reporting period.

Since 2004, MDOT SHA's Erosion and Sediment Control Certification (Yellow Card) has served to provide up to date awareness and education, and this certification is a requirement to conduct construction business with MDOT SHA. This training can now serve a greater number of participants since it went on-line.

In addition to these training courses MDOT SHA has created a variety of other media to provide education and awareness of the regulatory requirements on MDOT SHA projects. For instance, MDOT SHA has published an *Environmental Guidelines for Construction* along with an erosion and sediment control Field Guide to support the 2011 MDE ESC specifications and standards, and illustrate increased requirements. A reference library (on-line/CD) was also created for project personnel use and is available on the MSOT SHA OED QA Toolkit. This program also uses in-field education and working partnerships throughout MDOT SHA to help end users understand and meet environmental requirements.

To increase public awareness regarding proper erosion and sediment control practices, the MDOT SHA educational outreach webpage includes links to the MDE erosion and sediment control page for community members interested in learning more about the program.

iii. Increasing Proper Disposal of Vehicle Fluids (Not in Inlets or Catch Basins)

MDOT SHA's education outreach webpage includes valuable information about the importance of proper vehicle fluid disposal, along with links to MDE's Maryland Used Motor Oil Recycling Program webpage.

iv. Refraining from and Reporting Roadside Dumping

As part of MDOT SHA's public education initiative to discourage and report problems associated with illegal roadside dumping, MDOT SHA created a flyer titled *Keep Our State Waterways Clean* (see Figure 1-10). This flyer provides information as to the definition of illegal dumping, the problems associated with illegal dumping, common items associated with illegal dumping, and steps to report illegal dumping if encountered along MDOT SHA roadways. The flyer can be found via MDOT SHA's education outreach webpage along with links to the MDOT SHA CCMS to report roadside dumping. Additionally, MDOT SHA has strategically placed "No Dumping" signs throughout the state.

v. Proper Litter and Trash Disposal

MDOT SHA has had a multi-faceted existing public education program in effect with goals to

educate the public on environmental stewardship and reduce littering. See Section D.4 for more information on litter education.

The MDOT SHA educational outreach webpage includes information and links about proper litter and trash disposal and how members of the transportation community can help reduce the volume of trash entering local waterways.

vi. Decreasing Vehicle Idling

MDOT SHA is saving money and reducing emissions through a vehicle equipment idling policy. The newest idling policy for MDOT SHA's vehicle and equipment fleet took effect on September 22, 2009. The policy restricts operation of a motor vehicle engine for more than five consecutive minutes when the vehicle is not in motion. The two exceptions to this policy are when a unit is deployed along a state route in preparation for winter operations, or when a unit functioning under an emergency situation or maintaining traffic through the use of emergency lighting. The policy applies to all operators of MDOT SHA vehicles and equipment, as well as drivers of consultant support vehicles.

To increase public awareness regarding the benefits of reducing vehicle idling, educational information has been provided on the MDOT SHA educational outreach webpage.

vii. Utilizing Alternative Transportation

MDOT SHA offers several incentives to reduce the number of drivers and/or number of commuter days/miles per week by Administration employees. Fewer commuter days and miles mean less vehicle pollutants entering the watershed.

Alternate Work Schedules for Employees

Alternate work schedules include flexible work hours allowing employees to work compressed workweeks reducing the total number of commuting days and miles.

Teleworking for Employees

Teleworking allows employees to work from a remote location (presumably at or close to home) and reduces the number of commuting days and miles per week. Each office has or is developing a teleworking policy.

Carpooling

Carpooling reduces the number of commuters on the road, and has been encouraged at MDOT SHA for both its employees and the traveling public for many years. MDOT SHA carpooling incentives for employees include prioritizing parking space allocation to those in a designated car pool and administrative assistance in locating a carpool within the employee's residential area for those that wish to carpool to work.

MDOT SHA promotes carpooling for the traveling public by constructing and maintaining park and ride facilities throughout the entire state. All MDOT SHA park and ride facilities are free and can accommodate carpools and van pools. Overnight parking is also permitted. MDOT SHA currently has more than 100 park and ride locations throughout Maryland that provide more than 12,000 free parking spaces for commuters. There is an interactive map on MDOT SHA's web page to help the traveling public locate and get directions to all MDOT SHA's park and ride facilities, see Figure 1-22. It can be accessed from the link below:

http://roads.maryland.gov/pages/parkandridemaps.aspx?PageId=248&d=57

Figure 1-22: Screen Capture of MDOT SHA's Park and Ride Facility Locator Interactive Map

HOV Lanes

In addition to park and ride facilities, MDOT SHA has also constructed High Occupancy Vehicle (HOV) lanes on some of its interstates to promote carpooling. HOV lanes are reserved for carpools, vanpools, buses, and motorcycles during designated time periods. HOV lanes are intended to save commute time for carpool users and bus riders by enabling them to bypass areas of heavy traffic congestion. By giving carpool users and bus riders a faster and more reliable ride during peak traffic periods, HOV lanes serve as a strong incentive for ridesharing, which in turn helps to manage congestion and contributes to improved air quality. HOV lanes are generally designated via white diamonds on signage and pavements markings. MDOT SHA currently has two HOV facilities, along I-270 in Montgomery County and along US 50 in Prince George's County.

MDOT SHA hosts an HOV page on its website that can be accessed at the link below. The page includes information about regulations concerning HOV lane usage, maps of HOV lane locations in Maryland, and contact information.

http://www.roads.maryland.gov/index.aspx?PageId=249

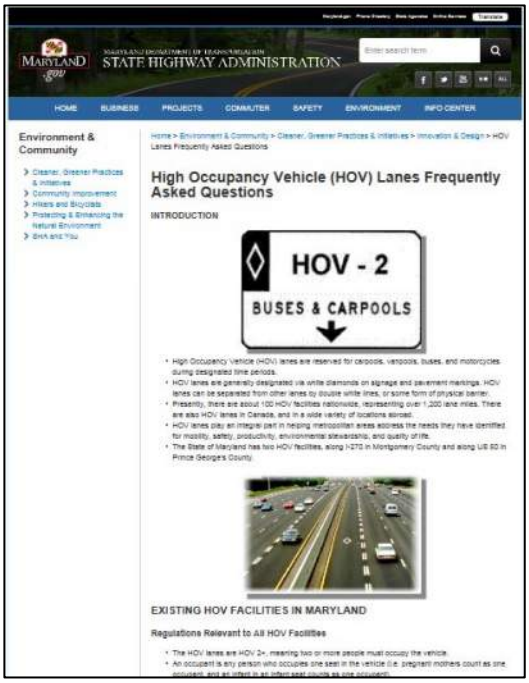


Figure 1-23: MDOT SHA HOV Lane

National Bike to Work Day

In advance of Bike to Work Day and throughout spring and summer 2017, MDOT SHA raised awareness about bicyclist safety through its continuing education and outreach campaign: "Look Out for Each Other". On billboards, radio and television public service announcements, transit ads, and social media, the campaign reminded drivers that the next cyclist they encounter could be someone they know.

In July 2017, MDOT SHA sponsored a booth along West Mount Royal Avenue at the 2017 Artscape Festival. The booth was titled "Look Out for Each Other: A Bicyclist May be Someone You Know". MDOT SHA participants provided valuable safety information to festival attendees. MDOT SHA was a sponsor of Bike to Work Day 2017, and hosted a pit-stop in Baltimore City on Guilford Avenue for the public taking part in the event.

When developing highway improvement projects MDOT SHA engineers evaluate bicycle access, enhancements and signage. In recent years,

MDOT SHA improved more than 132 miles of roadways with bike lanes or wide shoulders.

Figure 1-24: MDOT MVA Administrator Paul Comfort (left) and SHA Administrator Gregory Slater (right) Participating in Bike to Work Day 2017

National Bike to School Day

National Bike to School Day provides an opportunity for schools across the country to join together to celebrate and to build off of the energy on National Bike Month. National Bike to School Day was held on May 10, 2017. MDOT SHA promoted this event through public outreach using its social media feeds such as Facebook, Twitter, and Instagram.

International Walk to School Day

To promote walking, MDOT SHA promoted International Walk to School Day in October through its social media feeds on Instagram. This is a global event that involves communities from more than 40 countries walking to school on the same day. Over time, this event has become part of a movement for year-round routes to school and a celebration. This event was held on October 5, 2016.

Safe Routes to School

MDOT SHA's Safe Routes to School program focuses on improving the safety of children who walk or bicycle to school through the use of sidewalks, crosswalks, signage, pedestrian signals, and bike racks. This enables and encourages children in grades K-8 to walk and bicycle to school and makes walking and bicycling to school a safer and more appealing transportation alternative. The end result is improved safety, reduced traffic, fuel consumption, and air pollution in the vicinity of elementary and middle schools.

Mass Transit

The MDOT SHA public education webpage includes information regarding the benefits of using alternative transportation as well as links to learn more about the above-mentioned programs.

Proper Car Care and Washing

Improper car care and car washing can readily contribute pollutants into the adjacent storm drain system. Simply following a few simple steps when maintaining or washing your vehicle can help to conserve water and protect the quality of nearby water bodies.

To increase public awareness regarding proper car care and washing, educational information has been provided on the MDOT SHA educational outreach webpage.

viii. Proper Pet Waste Management

MDOT SHA currently owns and maintains seven Welcome Centers and Rest Areas within the MS4 jurisdictions of Charles, Frederick, Howard, and Washington Counties. MDOT SHA Welcome Centers and Rest Areas are provided as a service to the traveling public. Not only do these facilities allow humans to rest from long journeys, but they also provide areas to walk pets.

The risk of water pollution increases when pet waste is left on rest area sidewalks, parking lots, and grassy areas as stormwater runoff can carry pet waste left on the ground into storm drains and nearby waterways. MDOT SHA has addressed proper pet waste management at some of its rest areas and welcome centers.

For instance, at MDOT SHA's newer welcome centers, such as the I-70 Eastbound and Westbound Rest Area and Welcome Center situated on South Mountain between Fredrick and Hagerstown in Frederick County, MDOT SHA has incorporated designated pet walking areas. These areas contain pet waste disposal stations which feature pet waste bag dispensers, educational signs, and trash bins

specifically for the collection and proper disposal of pet waste. The disposal stations aim to educate the public on the importance of proper pet waste management and to encourage pet owners to pick up and properly dispose of their pet's waste, thereby keeping pet waste out of our waterways.

Figure 1-25: Pet Waste Disposal Station at the I-70 Eastbound Rest Area

ix. Other MDOT SHA Water Quality Awareness Training

Chesapeake Bay Field Trips

These annual Chesapeake Bay field trips are led by Tiffany Granberg and Adam Wickline of the Chesapeake Bay Foundation. The trips demonstrate the link between highway runoff and its impacts on streams, rivers, and the health of the Chesapeake Bay. It is a great opportunity for MDOT SHA employees to learn about one another's careers as well as habits and actions in our daily work and home environment that may affect the health of the Chesapeake Bay.

This field trip is offered through MDOT SHA's On-line Learning Center sign up, College of Engineering, environmental design training (ENV400. It is a class that requires no pre-requisite training and is offered to all employees seeking to improve their environmental awareness. Therefore, this class has a mixture of employees from all over the state with varied levels of experience and educational background.

The training includes visits to important environmental sites including wetlands, streams, forests, and a boat trip on the Bay. Four trips were taken during this reporting period on September 14, 2016, September 22, 2016, April 19, 2017, and April 21, 2017 with 69 participants attending in all. See Figure 1-26 for an image from the September 22, 2016 training.

Figure 1-26: September 2016 MDOT SHA Chesapeake Bay Field Trip

WPD Presentation at February 2017 American Society of Highway Engineers Technical Meeting

On February 21, 2017, two WPD team leaders, Ryan Doran and Travis Vance, presented at ASHE's February Technical Meeting. The theme of this meeting was water resources. This presentation addressed requirements of the current MDOT SHA NPDES permit, as well as MDOT SHA's plan to maintain compliance as outlined in the 2016 MDOT SHA Impervious Restoration and Coordinated TMDL Plan.

The presentation provided the audience with an opportunity to ask questions, and gain an understanding of the current NPDES permit requirements. The presentation included an overview of the Chesapeake Bay TMDL, and

illustrated MDOT SHA's stormwater management implementation efforts including strategies for impervious land restoration, as well as current and future efforts to ensure compliance with the permit.

Figure 1-27: WPD Team Leader Ryan Doran, Presenting at the February 2017 ASHE Technical Meeting

FHWA Mid-Atlantic Chesapeake Bay Peer Exchange

From June 19 to 22, 2017, MDOT SHA Office of Environmental Design (OED) participated in a peer exchange hosted by the Federal Highway Administration (FHWA) Resource Center that targeted Chesapeake Bay restoration efforts and MS4 permits within the FHWA Mid-Atlantic Region 3 DOTs including MDOT SHA, DelDot, VDOT, and PennDOT. The purpose was to discuss how each DOT handles various MS4 permit requirements and to share experiences and innovations. The agenda included the following topics for which all the DOTs including MDOT SHA shared information:

- MS4 Permit Structure and Conditions
- IDDE
- Construction Runoff Control
- Good Housekeeping/Pollution Prevention
- Post Construction Stormwater Control Measures
- EPA Audits
- TMDL Funding and Budgeting
- TMDL WIP/WQIP
- TMDL Connecting the Regulators
- Project Delivery
- Operations and Maintenance

2017 Bay-Wide Stormwater Partner's Retreat

The Baywide Partner's Retreat is held every two years and is hosted by the Chesapeake Stormwater Network and the Chesapeake Bay Alliance. This year's retreat was held March 15 to 17, 2017 and MDOT SHA OED Deputy Director presented on MDOT SHA Stormwater Implementation Highlights and Challenges. The OED Director and Chief of the Water Programs Division also attended.

D.5.c Information for the Regulated Community

i. NPDES Permitting Requirements

Information relating to NPDES Construction Activity Permits is available on the MDE website, and MDOT SHA directs requests for information to that site.

ii. Pollution Prevention Plan Development

Stormwater Pollution Prevention Plans (SWPPP) are required by NPDES General Permit No. 12—SW for each of MDOT SHA's industrial facilities. The SWPPPs are available for review upon request.

iii. Proper Housekeeping

Proper housekeeping measures are identified in MDOT SHA's Stormwater Pollution Prevention Plans for industrial facilities. These documents are available upon request.

Proper housekeeping measures include sweeping areas in front of salt and material storage structures, pick-up and proper disposal of garbage and floatable debris, routine inspections of drums, tanks, and other containers, and conducting vehicle and equipment repairs indoors or under cover.

iv. Spill Prevention and Response

SHA maintains Standard Operating Procedures related to spill prevention and response that are available upon request. These documents are

updated on a routine basis per MDOT SHA's Environmental Management System.

E. Restoration Plans and Total Maximum Daily Loads (TMDLs)

In compliance with §402(p)(3)(B)(iii) of the CWA, MS4 permits require stormwater controls to reduce the discharge of pollutants to the MEP. By regulation at 40 CFR §122.44, BMPs and programs implemented pursuant to this permit must be consistent with applicable wasteload applications (WLAs) developed under EPA approved TMDLs.

In pursuit of these goals, SHA shall coordinate watershed assessments with surrounding jurisdictions and annually report on restoration plans, opportunities for public participation, and TMDL compliance status to MDE. As required below, watershed assessments and restoration plans shall include a thorough discussion of water quality analysis findings based on coordination with surrounding jurisdictions, TMDL documents and other resources when available, identification of water quality improvement opportunities, and a schedule for BMP and programmatic implementation to meet stormwater WLAs included in EPA approved TMDLs. SHA shall address both specific WLAs and target loads when SHA is part of larger aggregate loads. A list of EPA approved TMDLs for SHA in the permit area is included in Attachment B of the permit.

Research Activity

By employing improvements to practices, MDOT SHA can ensure the most effective use of ROW, funding and other resources. On-going research activities performed during the permit term are discussed below.

Assessment of Stream Restoration Projects

As discussed in the MDOT SHA 2016 Annual Report, Dr. R. P. Morgan and his students at UMCES continue to assess and monitor completed and proposed MDOT SHA stream restoration projects. This assessment provides a framework and historical database of recommendations for future MDOT SHA stream restoration projects, and for the assessment and potential revitalization of existing MDOT SHA restoration projects throughout the state of Maryland. The full 2016-2017 monitoring report is included in Appendix F starting on page F-3.

The following sites were monitored in FY17:

- Deep Run (Anne Arundel County)
- Fahrney Branch (Frederick County)
- Israel Creek (Frederick County)
- Unnamed Tributary to Little Gunpowder (Baltimore County)
- Long Draught Branch (Montgomery County)
- Unnamed Tributary to Seneca Creek at Watkins Mill Road (Montgomery County)

Meeting Local TMDLs for PCBs

To assist in the establishment of benchmarks and timeframes for TMDL program implementation, MDOT SHA has initiated a research study on polychlorinated biphenyls (PCBs) in MDOT SHA watersheds and stormwater. The study is focused on PCB concentrations, the relationship to sediment concentrations and sediment grain sizes, and the relationship between PCB removal and sediment removal. This research will determine the effectiveness of stormwater control practices in removing PCBs. The research is being performed by Dr. Davis, Dr. Kjellerup, and their students from the University of Maryland. A progress report of their work is included in Appendix F starting on page F-71.

Inlet Cleaning Pollutant Characterization Study for TMDL Compliance

A prime challenge of meeting TMDL requirements is the mandate to quantify the pollutants captured and removed from inlets and road surfaces. Defining the composition of those captured solids is of major interest for MDOT SHA for compliance planning, implementation, and reporting. MDOT SHA has contracted with Morgan State University (MSU) in partnership with the Center for Watershed Protection, Inc. (CWP) to evaluate its inlet cleaning operations and recommend how MDOT SHA can optimize their inlet cleaning operations to maximize nutrient, sediment, and trash load reduction credits for TMDL compliance.

The scope of work includes a monitoring effort to characterize and quantify the amount of material and debris, to include nutrients, sediment and trash, collected in inlets maintained by MDOT SHA. Currently, MDOT SHA estimates that 300 pounds of wet sediment is removed from each inlet MDOT SHA performs deep cleaning on. Deep cleaning involves removing the inlet cover and either manual cleaning or using a Vactor Vacuum Truck to clear debris in the catch basin and connecting pipes. At the end of this research study, a definitive average amount of sediment will be attributed to each inlet cleaned.

A quarterly progress report of this study is included in Appendix F, starting on page F-89. This quarterly report discusses progress achieved as well as work anticipated to take place during the next quarter.

Assessment of Bioswale Performance

Bioswales, bioretention facilities, and other stormwater management techniques are now becoming common practices to treat roadway runoff. There is a critical need to understand their short and long-term efficiency as well as their lifetime expectancy, especially under real life field conditions. As discussed in the 2016 Annual Report Update, Dr. R. P. Morgan and his students at the Appalachian Laboratory of the University of Maryland Center for Environmental Science (UMCES) continue to evaluate the effectiveness of bioswales and their pollutant removal efficiency in Phase II of their Assessment of Bioswale Performance.

There are four distinct project objectives for this project:

The first objective is to determine if there are reductions in base pollutant levels (primarily focusing on TSS, TN and TP) as roadway stormwater runoff passes through MDOT SHA bioswale design facilities (both lined and unlined), with a corollary objective to examine selected heavy metal concentrations, or other important roadway pollutants associated with roads, in both runoff and bioswale soil samples.

The second objective is to continue to develop field procedures employed in this study to monitor the ability of the designed bioswale facilities to infiltrate storm water flowing into the facilities over an extended period, as well as to characterize the bioswale filter soil to determine its long-term efficiency and usefulness. This element is of great importance to MDOT SHA since the bioswale material will eventually need to be replaced.

The third objective is to understand the dynamics of water movement through the bioswales in order to determine whether these systems have been optimally designed.

The fourth objective is to examine the potential recharge capacity of unlined bioswales at the interface of the bioswale and the underlying soil.

The 2016 progress report which includes details on hydrologic and chemistry findings on the bioswales and the control site is included in Appendix F starting on page F-99.

Use of Compost to Establish Permanent Vegetation

MDOT SHA is working with UMD College Park on a research project to evaluate the performance of select compost products in establishing permanent vegetation as part of construction site SWM systems. By using compost to amend the soil, MDOT SHA would be able to eliminate the use of additional fertilizer when establishing grass and meadow. Specific objectives of the research project include:

- Identify and document the optimum compost-to-top soil ratio to evaluate the performance of compost blankets for establishing permanent vegetation and reducing soil erosion

- Install compost blankets as well as control units (i.e., top soil) at two construction sites in central Maryland Counties.

- Evaluate the performance of compost blankets installed at these sites through visual and imaging monitoring, collected field data, and focused greenhouse investigations. The application of performance standards will be

focused on rapid establishment of vegetation growth and sediment and erosion control.

The findings of this research will be immediately implementable on the potential use of compost-based BMPs in highway construction applications. This research project began in June 2016 and has an anticipated end date of November 2018.

A quarterly report discussing progress from January 1, 2017 – March 31, 2017 is included in Appendix F starting on Page F-167.

Identification of Low Growing, Salt Tolerant Turfgrass Species Suitable for Use along Highway Right of Way – Experimental Field Trials

MDOT SHA maintains turfgrasses along highway right-of-ways to provide sight distance and an aesthetic landscape to motorists. However, the turfgrass seed mixtures currently used in Maryland require frequent mowing in often narrow and congested areas, elevating maintenance costs, and placing maintenance staff in danger. Further, seed mixtures often fail to establish persistent turf along roadsides, leading to erosion, nutrient leaching, and unsightly roadside environments.

SHA is working with UMD's Appalachian Lab on a research project to test the efficacy of planting alternative roadside grasses and seed mixtures that require less maintenance but that will establish rapidly, be resilient in the harsh roadside environment, have neutral or positive effects on ecosystems and watersheds, and are available and affordable through commercial growers.

Following an extensive literature search and discussion with turfgrass experts, MDOT SHA identified the following alternative grass species for study in field trials along Maryland roads: Sporobolus, side-oats grama, purple lovegrass, weeping lovegrass, hard fescue, little bluestem, upland bentgrass, tufted hairgrass, and red fescue. Specific objectives of the research project include:

- Select at least one potential field site within each of the three climatic regions within Maryland corresponding to western Maryland, central Maryland, and southern Maryland (including the Eastern Shore).

- Quantify environmental conditions at each potential field site, including slope and aspect, soil compaction, soil pH, soil salinity, soil nutrients, and light availability. These data will help in prioritizing the final selection of one field site within each of the three climatic regions.

- Establish field experiments (1 per region) in collaboration with MDOT SHA. MDOT SHA will provide equipment and equipment operators for spraying herbicides and moving and grading topsoil. Specifically, existing vegetation will be killed with herbicides, topsoil will be removed to be 10 cm (4 inches) below grade, 10 cm of MDOT SHA-approved topsoil will be applied to each experimental site, and species treatments will be sown by hand into plots. Species treatments will include sowing species or cultivars in monoculture as well as establishing mixed species treatments.

- Monitor each field experiment through the first establishment year and for 2 subsequent years. This will include measuring germination, survival, and growth within the first 6 weeks after sowing, as well as quantifying density, cover, and height of sown species, and weed cover.

This research project began in January 2017 and has an anticipated end date of December 2019. A quarterly report discussing progress during April 1, 2017 – June 30, 2017 is included in Appendix E starting on Page E-173.

TMDL Salt Management Planning

MDOT SHA is currently conducting a research study geared toward reducing long term salt use. The purpose of the study is to review and update MDOT SHA 's current Salt Management Plan (discussed in Section D.5.b.iv), identify other effective methods of snow removal, and develop an implementation plan that could address a future TMDL requirement to reduce chlorides. Finally, the study will provide a method for MDOT SHA to

demonstrate that road salt use is appropriate given weather conditions, and that it is achieving the lowest salt usage while maintaining public safety to the maximum extent practicable. The following activities were completed in the last year:

- Reviewed the current Salt Management Plan; made revisions and posted an updated version to the public information website here: http://www.roads.maryland.gov/OOM/Statewide_Salt_Management_Plan.pdf.

- Prepared a Brine Expansion Plan which provided an analysis of existing and potential liquid only routes. The plan identified potential water sources for brine production, discussed water reuse / reclaimed water regulations, developed a map of water treatment facilities and alternatives to fresh water use, and recommended new liquid-only routes across the state.

- Researched Weather Severity Indexes (WSI) which could be a more accurate measure of storm patterns than inches of snowfall, Salt usage is highly dependent on the duration, intensity, and type of winter precipitation, such as freezing rain and icing conditions, or blowing snow and drifts. The study reviewed alternatives and options for a WSI for MDOT SHA that can be used in regions across the state, from the Eastern Shore to the mountains, and that relies on weather data that is currently available.

Targeting Sediment, Nitrogen, and Phosphorus for TMDLs with SPARROW

During the reporting period, MDOT SHA entered into an agreement with USA Department of the Interior (DOI) – USGS to employ a state-of-the-art nutrient and sediment data collection and analysis approach called Sediment Fingerprinting, designed to target optimal areas for impervious area treatment based on their SPARROW surface water-quality modeling tool. This will advance restoration efforts and stream monitoring impacts on water quality within the impaired Chesapeake Bay watershed for MDOT SHA.

At this time, there is no progress of note. Progress made on this multi-year study will be reported in subsequent annual reports.

E.1 Watershed Assessments

Requirements under this condition include:

a) Coordinate watershed assessments with surrounding jurisdictions, which shall include, but not be limited to the evaluation of available State and county watershed assessments, SHA data, visual watershed inspections targeting SHA rights-of-way and facilities, and approved stormwater WLAs to:

i) Determine current water quality conditions;

ii) Include the results of visual inspections targeting SHA rights-of-way and facilities conducted in areas identified as priority for restoration;

iii) Identify and rank water quality problems for restoration associated with SHA rights-of-way and facilities;

iv) Using the watershed assessments established under section a. above to achieve water quality goals by identifying all structural and nonstructural water quality improvement projects to be implemented; and

v) Specify pollutant load reduction benchmarks and deadlines that demonstrate progress toward meeting all applicable stormwater WLAs.

E.1.a Watershed Assessment

MDOT SHA has coordinated with county MS4 jurisdictions concerning watershed assessments and the development of TMDL implementation plans for each watershed for which MDOT SHA has a wasteload allocation. Summaries of county assessments and MDOT SHA activities within the individual TMDL watersheds are included in each TMDL implementation plan MDOT SHA has developed. Additional discussion of the MDOT SHA TMDL implementation plans is included under Section E.2 of this report.

MDOT SHA has established an outreach team tasked with coordinating the pollution reduction

strategies in each of the MS4 jurisdictional counties. The purpose is to establish a cooperative relationship and identify partnering opportunities. This coordination is important to ensure that locals jurisdictions are informed and able to provide input on MDOT SHA's planned activities, and that efforts are complimentary and not duplicated. These meetings result in more efficient efforts to address TMDL load reductions in targeted areas and help establish relationships to coordinate other MS4 program initiatives, such as the litter education and outreach initiative.

Additionally, MDOT SHA is utilizing information from each county's watershed assessments to help identify specific watershed issues and restoration project opportunities. This methodology and individual assessment summaries are presented in the MDOT SHA Implementation Plans, discussed in the following sections.

i. Current Water Quality Conditions

Designated uses and water quality criteria are discussed in each TMDL implementation plan MDOT SHA has developed. It is these designated uses and water quality criteria upon which TMDLs are based. County watershed assessments are reviewed and used to determine current water quality conditions, problem areas, and suggested methods to remediate water quality issues.

Summaries of these evaluations are included in each MDOT SHA implementation plan under each individual watershed section. Additional discussion of the MDOT SHA TMDL implementation plans is included under Section E.2 of this report.

ii. Visual Inspections Targeting SHA ROW

Visual inspections targeting MDOT SHA right-of-way are described in Part III.C of the 2016 MDOT SHA *Impervious Restoration and Coordinated TMDL Implementation Plan*. Summaries of these evaluations are included in Part IV of the 2016 plan under each individual watershed section. Implementation plans that were developed subsequent to the 2016 plan contain visual inspections targeting MDOT SHA right-of-way in Section C and summaries of these evaluations are included in Section F. Additional discussion of the MDOT SHA TMDL implementation plans is included under Section E.2 of this report.

iii. Water Quality Problems for Restoration

MDOT SHA uses several ways to identify and rank water quality problems. First, county watershed assessments are evaluated. These assessments identify and rank water quality problems for restoration within the local watersheds. Summaries of these evaluations are included in Part IV of the 2016 MDOT SHA implementation plan under each individual watershed section and in Section F of the subsequent TMDL implementation plans.

The visual assessment process that MDOT SHA has developed to assess the right-of-way for suitable restoration sites, also evaluates field conditions. This process is described in Section III.C of the 2016 MDOT SHA implementation plan and summaries of these evaluations are included for each TMDL watershed plan located in Part IV of the 2016 plan and Section F of the subsequent plans.

Outfall inspections are another means that MDOT SHA employs to assess water quality problems within the right-of-way for restoration. An inspection protocol has been developed and includes a process for field inspection, assessment, and ranking of severity of stabilization issues. From these inspections come outfall restoration projects that are used to resolve stabilization issues, reduce pollutant loads, and meet impervious restoration requirements. This protocol will be revised in the upcoming year to include criteria for water quality and impervious restoration projects.

Additional discussion of the MDOT SHA TMDL implementation plans is included under Section E.2 of this report.

iv. Water Quality Improvement Projects

County watershed assessments prioritize and rank structural and non-structural improvement projects to be implemented. Summaries of these evaluations are included in MDOT SHA TMDL implementation plans in Part IV in the 2016 plan and in Section F for the subsequent plans.

Additional discussion of the MDOT SHA TMDL implementation plans is included under Section E.2 of this report.

v. Pollutant Load Reduction Benchmarks and Deadlines

Refer to Sections E.2.b and E.4.b of this report for discussion concerning benchmarks for both impervious restoration and local TMDL compliance.

E.2 Restoration Plans

Requirements under this condition include:

a) Within one year of permit issuance, SHA shall submit an impervious surface area assessment consistent with the methods described in the MDE document "Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated, Guidance for National Pollutant Discharge Elimination System Stormwater Permits" (MDE, August 2014 or subsequent versions). Upon approval by MDE, this impervious surface area assessment shall serve as the baseline for the restoration efforts required in this permit.

By the end of this permit term, SHA shall commence and complete the implementation of restoration efforts for twenty percent of SHA's impervious surface area consistent with the methodology described in the MDE document cited in PART IV.E.2.a. that has not already been restored to the MEP. Equivalent acres restored of impervious surfaces, through new retrofits or the retrofit of pre-2002 structural BMPs, shall be based upon the treatment of the WQv criteria and associated list of practices defined in the 2000 Maryland Stormwater Design Manual. For alternate BMPs, the basis for calculation of equivalent impervious acres restored is based upon the pollutant loads from forested cover.

b) Within one year of permit issuance, a coordinated TMDL implementation plan shall be submitted to MDE for approval that addresses all EPA approved stormwater WLAs (prior to the effective date of the permit) and requirements of Part VI.A., Chesapeake Bay Restoration by 2025 for SHA's storm sewer system. Both specific WLAs and aggregate WLAs which SHA is a part of shall be addressed in the TMDL implementation plans. Any subsequent stormwater WLAs for SHA's storm sewer system shall be addressed by the coordinated TMDL implementation plan within one year of EPA approval. Upon approval by MDE, this implementation plan will be enforceable under this permit. As part of the coordinated TMDL implementation plan, SHA shall:

i) Include the final date for meeting applicable WLAs and a detailed schedule for implementing all structural and nonstructural water quality improvement projects, enhanced stormwater management programs, and alternative stormwater control initiatives necessary for meeting applicable WLAs;

ii) Provide detailed cost estimates for individual projects, programs, controls, and plan implementation;

iii) Evaluate and track the implementation of the coordinated implementation plan through monitoring or modeling to document the progress toward meeting established benchmarks, deadlines, and stormwater WLAs; and

iv) Develop an ongoing, iterative process that continuously implements structural and nonstructural restoration projects, program enhancements, new and additional programs, and alternative BMPs where EPA approved TMDL stormwater WLAs are not being met according to the benchmarks and deadlines established as part of the SHA's watershed assessments.

MDOT SHA Impervious Restoration and Coordinated TMDL Implementation Plan

The 2016 MDOT SHA *Impervious Restoration and Coordinated TMDL Implementation Plan* was submitted to MDE on October 7, 2016. The plan was revised on 7/31/2017 to update the impervious baseline accounting as discussed below in Section E.2.a. The plan was revised on 10/09/2017 to include results of revised modeling requested by MDE WSA as discussed in Section E.2.b.

The revised 2016 implementation plan combines the impervious restoration and TMDL load reduction implementation plans into one

document. Part II focuses on impervious accounting and presents the MDOT SHA 20 percent restoration plan. Parts III and IV focus on local TMDL requirements and watershed implementation plans. The plan is available on the MDOT SHA website at the link below:

http://www.roads.maryland.gov/Index.aspx?pageid=336

This annual report will not reintegrate the content of the implementation plan, but rather will reference pertinent sections as appropriate. The implementation plan is updated with revised pages when necessary to address changes in methods, requirements, or to address comments. This section of the 2017 annual report discusses progress in implementing the 2016 plan as of FY17. The revised 2016 implementation plan consists of the following content and should be consulted directly for specifics:

Part I: Program Introduction

A. Purpose
B. Scope
C. Background
D. SHA MS4 Permit Requirements
E. Project Implementation Methodology
F. Restoration Practice Descriptions

Part II: Impervious Restoration & Chesapeake Bay TMDL Compliance

A. Urbanization and Impervious Surface Restoration
B. Impervious Area Assessment
C. Impervious Treatment
D. Schedule and Funding
E. Comprehensive List of Restoration Practices

Part III: Coordinated TMDL Implementation Plan

A. Water Quality Standards and Designated Uses
B. Watershed Assessment Coordination
C. Visual Inspections Targeting MDOT SHA ROW
D. Benchmarks and Detailed Costs
E. Pollution Reduction Strategies

Part IV: SHA Watershed TMDL Implementation Plans. Part IV consists of separate local TMDL watershed plans and each one consists of five sections:

1. Watershed Description
2. SHA TMDLs within the Watershed
3. SHA Visual Inventory of ROW
4. County Assessment Review Summary
5. SHA Pollutant Reduction Strategies

MDOT SHA developed TMDL implementation plans for recently issued TMDLs and these plans are comprised of the same content as Parts III and IV of the 2016 implementation plan, outlined above. The recent plans are also loaded to the webpage linked above.

E.2.a Impervious Surface Area Assessment and Restoration Plan

MDOT SHA has performed a reevaluation of its impervious baseline accounting to fall in line with the MDE 2014 guidance and expectations for baseline year of 2002. The previous baseline had been established as 2010 to coincide with the expiration of the last MDOT SHA MS4 permit (10/21/2010). The revised impervious baseline assessment is based on baseline years that vary across the geographic MS4 jurisdictions and range from 2002 to 2005 and represent the best available data closest to 2002. Detailed information to verify these numbers was submitted to MDE with the MDOT SHA July 31, 2017 deliverable as Attachment A and is included with this report at Appendix A: Restoration Accounting Methodology.

Revised Impervious Surface Area Assessment

A summary of the revised MDOT SHA impervious baseline accounting is presented in Table 1-25, which displays the various baseline dates, total impervious surface area under MDOT SHA responsibility, and updated baseline treated and untreated impervious acres. The revised MDOT SHA 20 percent restoration goal to be met by October 8, 2020 is 4,709 acres. Figure 1-28 presents a graphic illustration of the treated and untreated impervious surfaces by county.

MDOT SHA has provided the updated impervious surface area feature class in the MDOT_SHA_Supplemental_2017geodatabase.
MDOT SHA has provided the impervious area assessment results in the Impervious Surface (IMP) table and the baseline treatment BMP information in the BMP Point of Investigation feature class (BMPPOI) and the BMP table (BMP)as specified in the May 2017 MDE Geodatabase Guideline format

Grass Swale Process Addendum

During the reporting period, MDOT SHA made enhancements to procedures used to implement the Existing Water Quality Grass Swale Identification Protocol (dated April 13, 2016 and approved by MDE on July 12, 2016). These improvements use field-collected channel cross-section geometry gathered during the Protocol's field verification phase and applies a refined hydraulic analysis to the data.

This additional analysis will be used to reevaluate declassified XX swales against MDE's grass swale design criteria to determine if they can be re-categorized as 2A swales with associated impervious treatment that can be subtracted from the baseline untreated surface. This Grass Swale Process Addendum is included with this annual report as Appendix L.

Impervious Re-Assessment for 2019

MDOT SHA will continue to investigate, research, and evaluate baseline treatment that is provided throughout the MS4 area for the purposes of refining and reducing the baseline treatment requirement during the permit term. Below are future initiatives that MDOT SHA may pursue:

- Apply the grass swale process addendum
- Additional BMP treatment determination;
- Additional BMP ownership verifications;
- County restoration research to remove from MDOT SHA baseline;
- Offsite treatment research;
- Inventory impervious disconnections; and
- Research impervious ownership transfers.

Table 1-25: MDOT SHA Baseline Impervious Surface by County (Acres)

County	Baseline Date	Total MDOT SHA Owned Impervious	Baseline Treated Impervious	Untreated MDOT SHA Owned Impervious
Anne Arundel	12/31/2005	3,310	455	2,854
Baltimore	12/31/2005	3,461	165	3,296
Carroll	12/31/2005	1,232	33	1,200
Cecil	12/31/2005	1,142	31	1,111
Charles	12/31/2004	1,237	90	1,147
Frederick	12/31/2005	2,308	132	2,175
Harford	12/31/2004	1,589	58	1,531
Howard	12/31/2002	1,948	270	1,679
Montgomery	12/31/2004	3,328	247	3,081
Prince George's	12/31/2005	4,010	424	3,586
Washington	12/31/2005	1,936	53	1,884
Total:		**25,501**	**1,957**	**23,544**
			20% Restoration Goal:	**4,709**

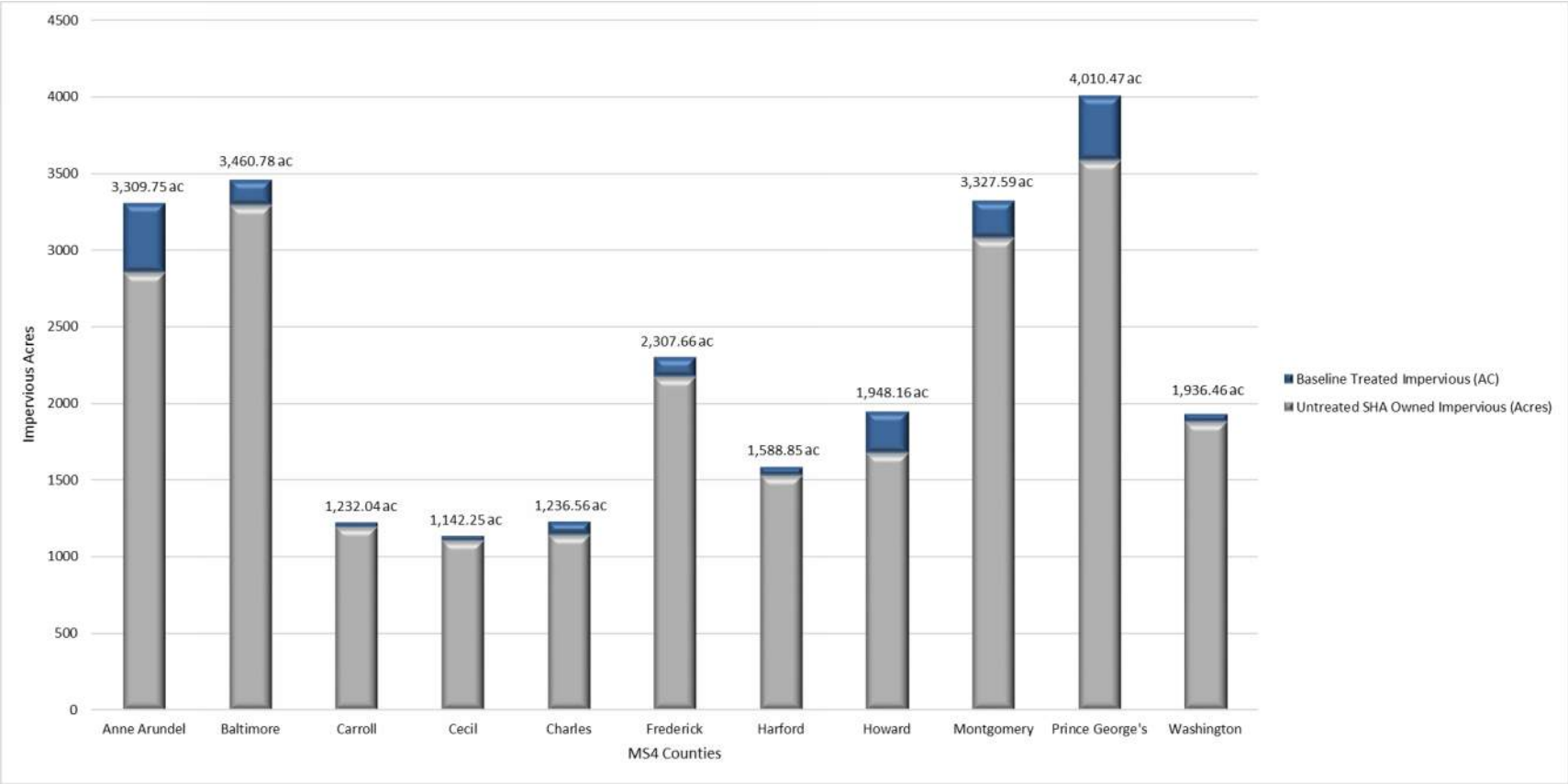


Figure 1-28: MDOT SHA Baseline Treated and Untreated Impervious Surfaces by County

Impervious Restoration Plan

As stated above, the MDOT SHA impervious restoration plan is included in the 2016 MDOT SHA *Impervious Restoration and Coordinated TMDL Implementation Plan* in Part II. The implementation plan was revised on 7/31/2017 to incorporate the recent re-assessment of baseline impervious surfaces and treatment requirement. In order to meet the 20 percent impervious restoration requirement by October 8, 2020, a specific number of acres have been planned for treatment each fiscal year. Part II.D of the 2016 plan projects the cumulative percentages of impervious treatment by fiscal year.

Refer to the MDOT SHA website link referenced above to access the most current version of the implementation plan.

Discussion of progress in meeting the 20 percent impervious restoration requirement is combined with the TMDL Compliance discussion below in Section E.4

E.2.b TMDL Implementation Plan

As stated above, the MDOT SHA TMDL implementation plans are included in the 2016 MDOT SHA *Impervious Restoration and Coordinated TMDL Implementation Plan* in Parts III and IV. The implementation plan was revised to address changes in modeling requested by MDE WSA, includes revisions to Tables 3-2 and 3-3, and revised pages are included with this report as Appendix G.

The 2016 implementation plan addressed all EPA approved stormwater WLAs prior to the effective date of the permit in 21 watersheds. WLAs for MDOT SHA include sediment, phosphorus, bacteria, PCBs, and trash. During the FY17 reporting period, the EPA approved four new TMDLs for which MDOT SHA was included in an aggregated WLA. A fifth TMDL was approved during FY18 and is added to the list. Those TMDLs are listed below:

- The TMDL of Polychlorinated Byphenyls in the Bush River Oligohaline Segment, Harford County, Maryland, EPA approval date 8/02/16
- The TMDL of Sediment in the Swan Creek Watershed, Harford County, Maryland, EPA approval date 9/30/16
- The TMDL of Polychlorinated Byphenyls in the Gunpowder River and Bird River Subsegments of the Gunpowder River Oligohaline segment, Baltimore County and Harford County, Maryland, EPA approval date 10/03/16
- The TMDL of Sediment in the Lower Gunpowder Falls Watershed, Baltimore County, Maryland, EPA approval date 5/04/17
- The TMDL of Polychlorinated Byphenyls in the Patuxent River Mesohaline, Oligohaline and Tidal Fresh Chesapeake Bay Segments, EPA approval date 9/19/17

Implementation plans for three of the recent TMDLs have been posted to the MDOT SHA website at the link above including the Bush River PCB, Patuxent River PCB, and Swan Creek Sediment. The Gunpowder and Bird River PCB implementation plan will be posted shortly. The Lower Gunpowder Sediment implementation plan is being developed.

i. Schedule

Implementation plans for three of the five WLAs approved by the EPA during the reporting period were submitted to MDE according to Table 1-26

Table 1-26: TMDL Implementation Plans Submitted since 2016 Annual Report

TMDL	Date Plan Submitted to MDE
TMDL of PBCs in the Bush River Oligohaline Segment, Harford County	August 2, 2017
TMDL of Sediment in the Swan Creek Watershed, Harford County	September 30, 2017

Table 1-26: TMDL Implementation Plans Submitted since 2016 Annual Report

TMDL	Date Plan Submitted to MDE
TMDL of PBCs in the Gunpowder River and Bird River Subsegments of the Gunpowder River Oligohaline segment, Baltimore and Harford Counties	October 3, 2017

ii. Cost Estimates

MDOT SHA advertises construction projects on eMaryland Marketplace. Detailed cost estimates for projects that are under design cannot be published due to the bidding process. Once project bids have been opened, the three lowest bids are posted on the MDOT SHA website.

Detailed costs for specific construction projects are available on MDOT SHA's website linked below by searching for Bid Tabulations at the bottom of the page:

http://www.roads.maryland.gov/pages/cic.aspx?PageId=857

Total costs including design, right-of-way, and construction for each restoration contract completed for the current fiscal are included in Section E.4.

Lists of proposed practices and estimated costs by FY to achieve the required reductions are included in Part IV of the 2016 MDOT SHA implementation plan under each individual watershed section and in the plans submitted subsequent to the 2016 plan.

iii. Documenting Progress

Benchmarks and deadlines for meeting established WLAs are discussed in Parts III and IV of the 2016 MDOT SHA implementation plan and in the plans submitted subsequent to the 2016 plan. Information related specifically to reduction strategies and modeling to track progress are included in the 2016 implementation plan Part III, Section E, Pollution Reduction Strategies, and the MDOT SHA *Automated Modeling Protocol (revised October 2017)* included as Appendix H in this annual report.

iv. Adaptive Management

If benchmarks are not being met, both the Bay TMDL and the MDE MS4 permit allow for adjustments in the plan to accommodate shortages. This 'adaptive management' concept is discussed in Part II, Section C of the 2016 MDOT SHA implementation plan. Section E.4 of this report discusses progress in meeting the 20 percent impervious restoration requirement compared to benchmarks set in the 2016 plan as well as the local TMDLs.

MDOT SHA employs adaptive management measures to ensure implementation progress remains on track. Using database tools to track project development progress, schedules are adjusted frequently within the portfolio of projects to account for unforeseen issues such as political pressure against implementing projects within MDOT SHA ROW, SWM and dam safety permitting delays, loss of property owner cooperation, or excessive costs. Other methods that have been employed include alternative contracting mechanisms such as full delivery stream restoration contracts, development of alternative crediting protocols, purchasing listed properties, and partnerships with other jurisdictions. Through these measures, MDOT SHA will ensure that the 20 percent restoration goal will be met.

E.3 Public Participation

Requirements under this condition include:

SHA shall provide opportunity to the public regarding the development of its coordinated TMDL implementation plan by allowing for public participation, soliciting input, and incorporating any relevant ideas and program improvements that can aid in achieving TMDLs and water quality standards according to the actions below. SHA is required to provide:

a) Notice in a regional newspaper and SHA's website outlining how the public may obtain information on the development of the

coordinated TMDL implementation plan and opportunities for comment;

b) *Procedures for providing copies of the coordinated TMDL implementation plan to interested parties upon request;*
c) *A minimum 30 day comment period before finalizing the coordinated TMDL implementation plan; and*
d) *A summary in each annual report of how SHA addressed or will address any material comment received from the public.*

As discussed in Section E.2.b, the EPA approved four new TMDLs during the reporting period and an additional one during FY18 for which MDOT SHA was included in an aggregated WLA. MDOT SHA developed and submitted to MDE implementation plans for three of the five TMDLs. Plans for the remaining TMDLs will be submitted once complete and prior to the one-year deadline for each.

For the three plans that were delivered to MDE this past year, public notices were issued in both the Baltimore Sun and the Washington Post. The plans were also posted for 30 days on the MDOT SHA website with instructions for downloading the plan and submitting comments. Notices and public comment periods for each plan is discussed below and example notices are included.

Bush River Oligohaline Segment PCB TMDL Implementation Plan

- Notices were posted in the classified section of The Baltimore Sun and The Washington Post on June 29, 2017 and June 30, 2017, respectively.
- The public comment period was held from June 28, 2017 to August 2, 2017. No comments were received during the public comment period.

Swan Creek Watershed Sediment TMDL Implementation Plan

- Notices were posted in the classified section of The Baltimore Sun and The Washington Post on August 25, 2017.
- The public comment period was held from August 25, 2017 to September 25, 2017. No comments were received during the public comment period.

Gunpowder River and Bird River Subsegments of the Gunpowder River Oligohaline Segment PCB Implementation Plan

- Notices were posted in the classified section of The Baltimore Sun and The Washington Post on September 1, 2017.
- The public comment period was held from September 1, 2017 to October 1, 2017. No comments were received during the public comment period.

OPPORTUNITY FOR PUBLIC REVIEW AND COMMENT

DRAFT IMPLEMENTATION PLAN FOR TOTAL MAXIMUM DAILY LOAD (TMDL) OF POLYCHLORINATED BIPHENYL (PCB) IN THE BUSH RIVER OLIGOHALINE SEGMENT, HARFORD COUNTY, MARYLAND

The Maryland Department of Transportation State Highway Administration (MDOT SHA) was issued a National Pollutant Discharge Elimination System Municipal Separate Storm Sewer System (MS4) Permit, (Permit No. 11-DP-3313), by the Maryland Department of the Environment (MDE) on October 9, 2015. This permit covers stormwater discharges from the storm drain system owned or operated by MDOT SHA within Anne Arundel, Baltimore, Carroll, Cecil, Charles, Fredrick, Harford, Howard, Montgomery, Prince George's, and Washington Counties. The permit requires MDOT SHA to submit an implementation plan to MDE that addresses Environmental Protection Agency (EPA)-approved stormwater waste load allocations (WLAs) within one year of EPA approval.

EPA approved the *Total Maximum Daily Load of Polychlorinated Biphenyls in the Bush River Oligohaline Segment, Harford County, Maryland* on August 2, 2016. The MDOT SHA Office of Environmental Design (OED) is soliciting comments on its draft Implementation Plan to meet this WLA as required under the MS4 Permit. A 30-day public comment period will take place from June 28, 2017 to July 28, 2017. The draft Implementation Plan is available on MDOT SHA's website at **http://www.roads.maryland.gov/Index.aspx?PageId=362**.

Comments should be submitted to MDOT SHA on or before July 28, 2017 by emailing to wpd@sha.state.md.us, faxing to (410) 209-5003, or mailing to:

Maryland Department of Transportation
State Highway Administration
Office of Environmental Design, C-303
707 N. Calvert Street Baltimore, MD 21202

Please note that comments should include the name and address of the person submitting the comments. Responses to comments will not be provided directly, but material comments received during the comment period will be considered and the draft Implementation Plan will be revised as appropriate prior to submittal to MDE. A summary of comments received will be included in the MDOT SHA MS4 annual report submitted to MDE annually on October 9 and posted to this website: **http://www.roads.maryland.gov/Index.aspx?pageid=336**.

Figure 1-29: Washington Post Public Notice

A sample of the newspaper public notice is included as Figure 1-29. A screenshot of the MDOT SHA Public Notice webpage during the review and comment period of the Gunpowder and Bird River PCB implementation plan is presented in Figure 1-30 below.

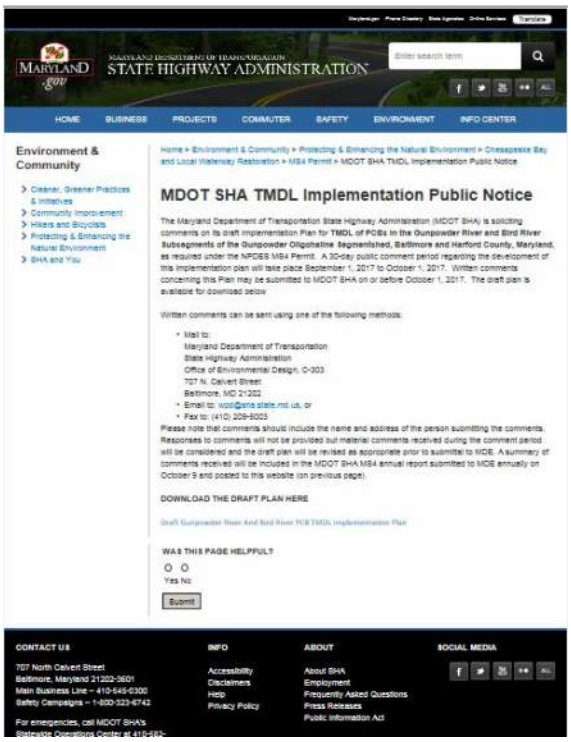


Figure 1-30: MDOT SHA TMDL Implementation Plan Webpage

E.4 TMDL Compliance

Requirements under this condition include:

SHA shall evaluate and document its progress toward meeting all applicable stormwater WLAs included in EPA approved TMDLs. An annual TMDL assessment report with tables will be submitted to MDE. This assessment shall include complete descriptions of the analytical methodology used to evaluate the effectiveness of SHA's restoration plans and how these plans are working toward achieving compliance with EPA approved TMDLs. SHA shall further provide:

a) Estimated net change in pollutant load reductions from all completed structural and nonstructural water quality improvement projects, enhanced stormwater management programs, and alternative stormwater control initiatives;

b) A comparison of the net change in pollutant load reductions detailed above with the established benchmarks, deadlines, and applicable stormwater WLAs;

c) Itemized costs for completed projects, programs, and initiatives to meet established pollutant reduction benchmarks and deadlines;

d) Cost estimates for completing all projects, programs, and alternatives necessary for meeting applicable stormwater WLAs; and

e) A description of a plan for implementing additional watershed restoration actions that can be enforced when benchmarks, deadlines, and applicable stormwater WLAs are not being met or when projected funding is inadequate.

E.4.a Progress Achieved and Practices Implemented

The progress reported here includes both impervious restoration and TMDL pollutant load reduction implementation efforts. All of the practices used to meet the impervious restoration goal were used to model TMDL reduction strategies for both the Chesapeake Bay TMDL and local TMDLs.

Additional practices were added to modeling of watersheds with local MDOT SHA WLAs when it was determined that the practices proposed to meet the 2020 impervious restoration goal would not be adequate to meet the local WLA reduction requirements for sediment and phosphorus. However, detailed planning was not undertaken for this local watershed implementation beyond the impervious restoration BMPs for 2020 implementation. While MDOT SHA is targeting watersheds with local TMDLs wherever possible with the impervious restoration efforts, resources are focused on meeting the 20 percent impervious restoration requirement as primary consideration in the short term.

MDOT SHA's impervious restoration plan includes a combination of built practices, maintenance activities, and redevelopment credit. The 2016 MDOT SHA Implementation Plan includes Tables 2-2a through 2-2g, which provide a comprehensive list of annual operations practices and completed, programmed, and planned built impervious restoration practices broken down by year. Each table entry includes location information and estimated impervious runoff treatment acreage.

Practices proposed to be built beyond the 2020 impervious restoration deadline to meet local TMDL WLAs are included in the 2016 MDOT SHA Implementation Plan, Part IV, MDOT SHA Watershed TMDL Implementation Plans.

Impervious Restoration Progress

MDOT SHA has implemented a variety of BMPs to meet the 20 percent restoration requirement of 4,709 acres. A breakdown of the restoration BMP types and the restoration credit provided by each is provided in Table 1-27 and Figure 1-31. This progress includes restoration practices implemented between the baseline year and the end of FY17. Only practices that were not previously reported as restoration practices in this timeframe are included in this credit assessment. MDOT SHA thinks that as the 2020 deadline approaches, if the restoration requirement for this permit term is exceeded, excess restoration credit should be applied to the next permit term restoration requirement. This thinking is the impetus for claiming credit for any restoration practices built after the baseline year that were not reported for the past permit in order to consistently apply this policy.

Annual Practices

MDOT SHA has implemented a suite of BMPs including capital projects and annual operations practices. Impervious credit for the annual practices of street sweeping and inlet cleaning also are included in Table 1-27. MDOT SHA began taking credit for these annual practices in FY 17 in this report and intends to increase the amount of credit claimed for these annual practices in the next fiscal years as the credit verification and tracking processes improve.

In dealing with these annual practices, it is understood that it must be ensured that a consistent level of treatment be maintained from the time the restoration credit is claimed moving forward. At this time, MDOT SHA feels confident that it is providing 33 acres and 150 acres or restoration credit for street sweeping and inlet cleaning credit, respectively. The data included with this report in shows a larger amount of inlet cleaning and sweeping achieved for FY17, but MDOT SHA is not confident this level can be achieved consistently. Therefore, the numbers reported for credit achieved are lower than the data indicates. After monitoring progress in establishing stable inlet cleaning and street sweeping programs for several years, these reported levels of restoration credit may be increased.

Data Delivery

MDOT SHA has provided restoration BMP information in the following feature classes and tables as specified in the May 2017 MDE Geodatabase Guideline format:

- Restoration BMP feature class (RST)
- Alternate BMP Polygon feature class (APY)
- Alternate BMP Line feature class (ALN)
- Stream Restoration Protocols table (SRP)

As noted in Section C.4, a document has been prepared as Appendix A (*Restoration Accounting Methodology*) of this report which provides a step-by-step procedure for calculating the MDOT SHA restoration credit using the MDOT SHA data provided in the May 2017 MDE Geodatabase Guideline format.

Table 1-27: Impervious Restoration Credit by BMP Type for Timeframe between Baseline Year* through FY17

BMP Type	Baseline Year - 2015 (acres)	2016 (acres)	2017 (acres)	Total (acres)
Impervious Surface Elimination (to Pervious)	0.49	0.00	1.89	2.38
New Stormwater Control Structures	87.41	53.53	54.77	195.71
Grass Swales	0.00	9.07	11.60	20.67
Outfall Stabilization	0.00	2.00	16.25	18.25
Retrofit Existing Stormwater Control Structures	0.00	94.43	4.78	99.21
Stream Restoration	444.04	137.24	67.00	648.28
Tree Planting	598.27	66.65	22.09	687.01
Redevelopment Credit	0.00	0.00	81.00	81.00
Inlet Cleaning	0.00	0.00	150.00	150.00
Street Sweeping	0.00	0.00	33.00	33.00
Totals	**1,130**	**363**	**442**	**1,936**
20% Restoration Target				**4,709**
% Impervious Restoration				**8.2%**
% Progress Towards Restoration Goal				**41.1%**
**See Table 1-25 for variable baseline years by MS4 County.*				

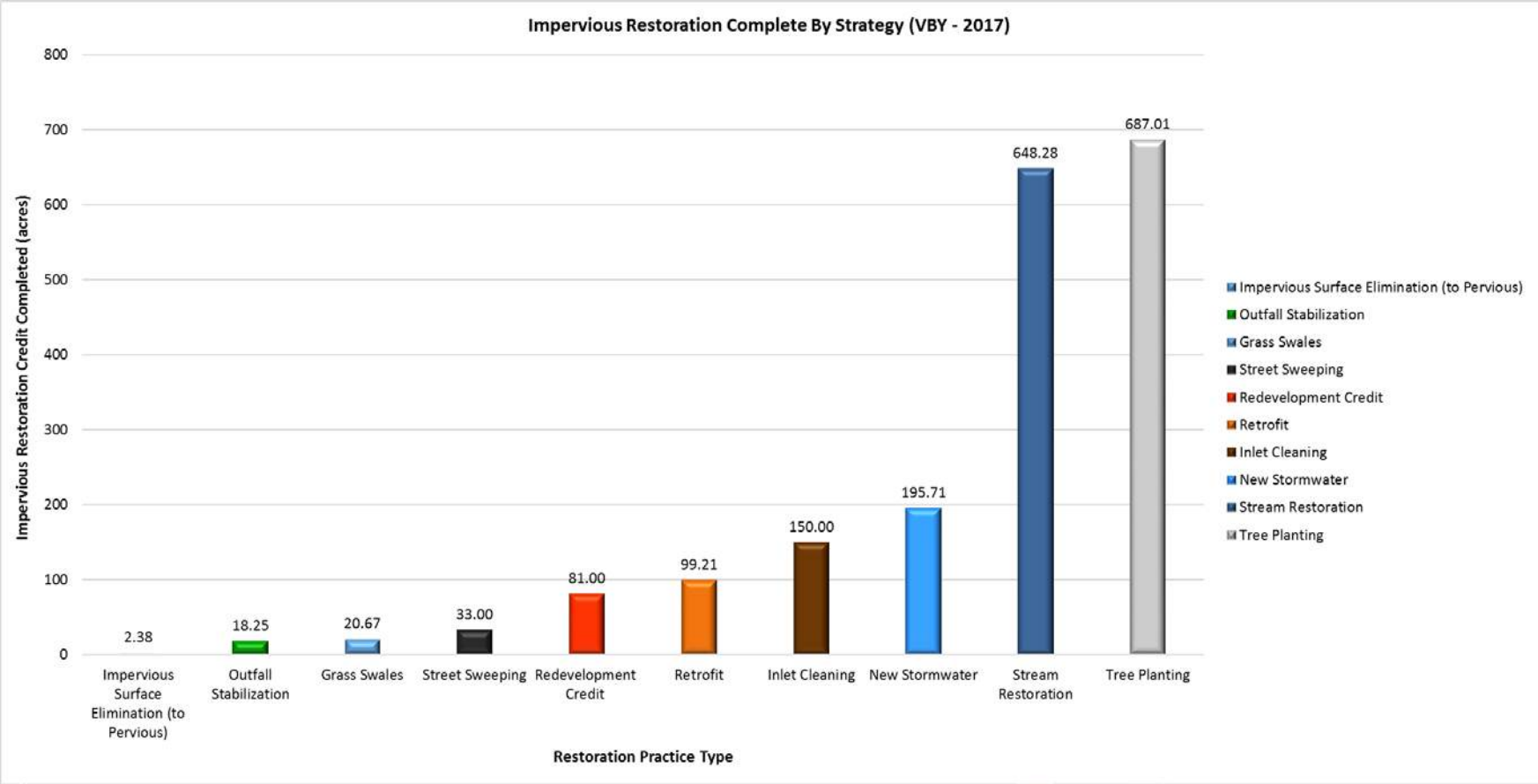


Figure 1-31: Impervious Restoration Completed by BMP Type (Baseline Year – 2017)

Pollutant Load Reductions Achieved

The 2016 MDOT SHA TMDL Implementation Plan has been revised based on the modeling approach outlined in MDE's comments dated April 26, 2017. Specifically, Tables 3-2 and 3-3 within Part III.E were updated to include re-calculated baseline loads and load reduction targets. These updated table are on pages 3-12 through 3-16 of the 2016 MDOT SHA plan and are included in Appendix G of this report. They will also be inserted into the 2016 Plan on MDOT SHA website as revised pages dated 10/09/2017.

Table 1-28 below, shows similar data as the revised 2016 plan Tables 3-2 and 3-3 but in addition details the progress that MDOT SHA has achieved toward meeting its WLA for its assigned TMDLs. Figure 1-32 and Figure 1-33 illustrate the accomplished pollutant reduction loads (in pounds) for sediment and phosphorus within each watershed.

Annual Practices

For the trash TMDL in the Patapsco River Gwynns Falls and Jones Falls watersheds MDOT SHA exceed its target reduction in FY17 by collecting 29,100 and 7,443 pounds respectively over the average baseline. Similar to inlet cleaning and street sweeping, to be consistent in how MDOT SHA manages annual operations practices, only the current WLA for each is claimed until consistency can be demonstrated in these programs.

The MDE 2014 Accounting Guidance provides for annual street sweeping removal efficiency credit based on sweeping high density urban areas twice per month (5% TN, 6% TP, 25% TSS). MDOT SHA has designated urban routes in all its maintenance districts for water quality sweeping at this frequency. Since it is not feasible to sweep year-round due to winter weather and other factors, MDOT SHA has determined the number of months that twice-monthly sweeping has taken place, and has pro-rated the removal efficiency for that fraction of a year. For example, if a route was swept for eight months, credit is calculated at 2/3 the annual efficiency; 2.67% TN, 2.67%, TP, and 6.67% TSS. MDOT SHA achieved 1,246.5 lane miles of vacuum assisted street sweeping at an average bi-weekly frequency of 32%. This correlated to approximately 52 impervious acres. credits.

MDOT SHA estimates that the process of deep cleaning inlets removes 300 lbs. of wet sediment per inlet. Using the MDE guidance, MDOT SHA is able to calculate the impervious acre credits and nutrient reduction achieved from inlet cleaning using the "Mass Loading Approach".

Revised Automated Modeling Protocol

MDOT SHA has revised its restoration modeling protocol detailing the methods used to model reductions of MDOT SHA WLAs for the current TMDL pollutants. Different modeling methods are used depending upon the pollutants and current reduction practices in use. Brief descriptions of modeling methods are included in Part III of the 2016 MDOT SHA Implementation Plan, but the *MDOT SHA Automated Modeling Protocol - Revised (October 2017)* in Appendix H should be consulted for detailed descriptions.

Table 1-28: Local TMDL Pollutant Reduction Progress Through June 30, 2017

Watershed Name	County	Pollutant	Baseline Year	Unit	MDOT SHA Baseline Load	MDOT SHA WLA	MDOT SHA % Reduction Target	MDOT SHA Reduction Target	Reduction Achieved as of 6/30/2017
Nutrient and Sediment TMDLs									
Antietam Creek	Washington	Phosphorus	2009	EOS-lbs/yr	1,307	1,027	21%	280	21
		Sediment	2000	EOS-lbs/yr	1,758,141	736,661	58%	1,021,480	30,100
Bynum Run	Harford	Sediment	2005	EOS-lbs/yr	135,225	109,127	19%	26,098	3,228
Cabin John Creek	Montgomery	Sediment	2005	EOS-lbs/yr	1,052,663	811,603	23%	241,060	13,846
Catoctin Creek	Frederick	Phosphorus	2009	EOS-lbs/yr	1,730	1,575	9%	155	12
		Sediment	2000	EOS-lbs/yr	1,237,170	629,719	49%	607,451	41,773
Conococheague Creek	Washington	Sediment	2000	EOS-lbs/yr	1,187,462	649,542	45%	537,920	17,146
Double Pipe Creek	Frederick	Phosphorus	2009	EOS-lbs/yr	1,593	542	66%	1,052	13
	Carroll								
	Frederick	Sediment	2000	EOS-lbs/yr	983,774	523,368	47%	460,406	6,598
	Carroll								
Gwynns Falls	Baltimore	Sediment	2005	EOS-lbs/yr	1,410,346	896,980	36%	513,366	18,176
Jones Falls	Baltimore	Sediment	2005	EOS-lbs/yr	448,519	351,190	22%	97,329	68,490
Liberty Reservoir	Baltimore	Phosphorus	2009	EOS-lbs/yr	1,311	721	45%	590	63
	Carroll								
	Baltimore	Sediment	2009	EOS-lbs/yr	1,190,032	654,518	45%	535,514	58,839
	Carroll								
Little Patuxent River	Anne Arundel	Sediment	2005	EOS-lbs/yr	1,591,900	1,017,224	36%	574,676	357,657

Table 1-28: Local TMDL Pollutant Reduction Progress Through June 30, 2017

Watershed Name	County	Pollutant	Baseline Year	Unit	MDOT SHA Baseline Load	MDOT SHA WLA	MDOT SHA % Reduction Target	MDOT SHA Reduction Target	Reduction Achieved as of 6/30/2017
	Howard								
Lower Monocacy River	Carroll	Phosphorus	2009	EOS-lbs/yr	4,781	3,586	25%	1,195	84
	Frederick								
	Montgomery								
	Frederick	Sediment	2000	EOS-lbs/yr	1,770,817	694,160	61%	1,076,657	35,889
	Montgomery								
Patapsco LN Branch	Anne Arundel	Sediment	2005	EOS-lbs/yr	2,731,330	2,239,690	18%	491,640	43,285
	Baltimore								
	Howard								
Patuxent River Upper	Anne Arundel	Sediment	2005	EOS-lbs/yr	377,849	334,774	11%	43,075	8,896
	Howard								
	Prince George's								
Potomac River MO County	Montgomery	Sediment	2005	EOS-lbs/yr	933,141	595,344	36%	337,797	11,771
Rock Creek	Montgomery	Phosphorus	2009	EOS-lbs/yr	1,114	758	32%	356	988
		Sediment	2005	EOS-lbs/yr	1,824,727	1,133,156	38%	691,572	653,819
Seneca Creek	Montgomery	Sediment	2005	EOS-lbs/yr	1,449,248	798,536	45%	650,712	193,569
Swan Creek	Harford	Sediment	2010	EOS-lbs/yr	60,078	52,268	13%	7,810	748
Upper Monocacy River	Frederick	Phosphorus	2009	EOS-lbs/yr	1,914	1,857	3%	57	82
	Carroll								
	Frederick	Sediment	2000	EOS-lbs/yr	894,222	456,053	49%	438,169	47,224
	Carroll								
Note: Pollutant loads and pollutant reductions are in pounds per year at the Edge of Stream (EOS)									

Table 1-28: Local TMDL Pollutant Reduction Progress Through June 30, 2017

Watershed Name	County	Pollutant	Baseline Year	Unit	MDOT SHA Baseline Load	MDOT SHA WLA	MDOT SHA % Reduction Target	MDOT SHA Reduction Target	Reduction Achieved as of 6/30/2017
PCB TMDLS									
Anacostia River Tidal	Prince George's	PCBs	2005	g/yr	16.9	0.0	99.9%	16.9	0.52
Back River Oligohaline Tidal	Baltimore	PCBs	2001	g/yr	19.8	9.2	53.4%	10.6	0.19
Baltimore Harbor	Anne Arundel	PCBs	2004	g/yr	6.3	0.6	91.1%	5.8	0.02
	Baltimore	PCBs							
Bear Creek	Baltimore	PCBs	2004	g/yr	6.5	0.6	91.5%	6.0	0.09
Bird River	Baltimore	PCBs	2010	g/yr	1.3	0.4	70.0%	0.9	0.01
Bush River Oligohaline	Harford	PCBs	2010	g/yr	11.3	4.3	62.0%	7.0	0.13
Curtis Creek/Bay	Anne Arundel	PCBs	2004	g/yr	33.4	2.2	93.5%	31.2	0.49
Gunpowder River Oligohaline	Baltimore	PCBs	2010	g/yr	0.2	-	0.0%	-	-
	Harford	PCBs							
Lake Roland	Baltimore	PCBs	2010	g/yr	16.2	11.5	29.3%	4.8	0.18
Magothy River Mesohaline	Anne Arundel	PCBs	2010	g/yr	1.4	-	0.0%	-	-
NE Branch Anacostia River	Montgomery	PCBs	2005	g/yr	8.1	0.1	98.6%	8.0	0.14
	Prince George's	PCBs							
NW Branch Anacostia River	Montgomery	PCBs	2005	g/yr	7.8	0.1	98.1%	7.7	0.18
	Prince George's	PCBs							
Potomac River Lower Tidal	Charles	PCBs	2005	g/yr	0.5	-	5.0%	-	-
	Charles	PCBs	2005	g/yr	0.3	-	5.0%	-	-

Table 1-28: Local TMDL Pollutant Reduction Progress Through June 30, 2017

Watershed Name	County	Pollutant	Baseline Year	Unit	MDOT SHA Baseline Load	MDOT SHA WLA	MDOT SHA % Reduction Target	MDOT SHA Reduction Target	Reduction Achieved as of 6/30/2017
Potomac River Middle Tidal	Prince George's	PCBs							
Potomac River Upper Tidal	Charles	PCBs	2005	g/yr	1.3	1.3	5.0%	0.1	0.02
	Prince George's	PCBs							
Severn River Mesohaline	Anne Arundel	PCBs	2010	g/yr	9	-	0.0%	-	-
South River Mesohaline	Anne Arundel	PCBs	2010	g/yr	2.8	-	0.0%	-	-
West and Rhode Rivers Mesohaline	Anne Arundel	PCBs	2010	g/yr	0.2	-	0.0%	-	-
Trash TMDLS									
Anacostia	Montgomery	Trash	2009	lbs/yr	60,585	6,044	100%	6,044	0
	Prince George's	Trash			107,692	14,134	100%	14,134	0
Patapsco - Gwynns Falls	Baltimore	Trash	2011	lbs/yr	83,729	2,415	100%	2,415	2,415
Patapsco - Jones Falls	Baltimore	Trash	2011	lbs/yr	47,251	1,490	100%	1,490	1,490
Note: For the Trash WLA MDOT SHA is required to remove the existing Trash baseline load plus an individual load set by MDE, thus the WLA here is equal to the reduction target.									
Bacteria TMDLS									
Baltimore Harbor - Marley Creek	Anne Arundel	Bacteria	2006	billion MPN/yr	29,507	7,141	75.80%	22,366	1,618
Baltimore Harbor - Furnace Creek	Anne Arundel	Bacteria	2006	billion MPN/yr	40,454	8,981	77.80%	31,473	43
Loch Raven Reservoir	Baltimore	Bacteria	2004	billion MPN/yr	114,408	14,187	87.60%	100,221	831
	Carroll								

Table 1-28: Local TMDL Pollutant Reduction Progress Through June 30, 2017

Watershed Name	County	Pollutant	Baseline Year	Unit	MDOT SHA Baseline Load	MDOT SHA WLA	MDOT SHA % Reduction Target	MDOT SHA Reduction Target	Reduction Achieved as of 6/30/2017
	Harford								
Patapsco River LN Branch	Anne Arundel	Bacteria	2003	billion MPN/yr	234,029	199,393	14.80%	34,636	369
	Baltimore								
	Carroll								
	Howard								
Patuxent	Anne Arundel	Bacteria	2009	billion MPN/yr	26,605	14,553	45.30%	12,052	45
	Prince George's								
Phase II - Chesapeake Bay TMDLS									
MS4 Area Wide	N/A	Nitrogen	2011	DEL-lbs/yr	477,602	N/A	N/A	N/A	15,209
MS4 Area Wide	N/A	Phosphorus	2011	DEL-lbs/yr	33,717	N/A	N/A	N/A	5,153
MS4 Area Wide	N/A	Sediment	2011	DEL-lbs/yr	30,043,423	N/A	N/A	N/A	3,234,463
Note: The modeling was conducted for the entire permitted area. MDOT SHA assumed a baseline year of 2011.									

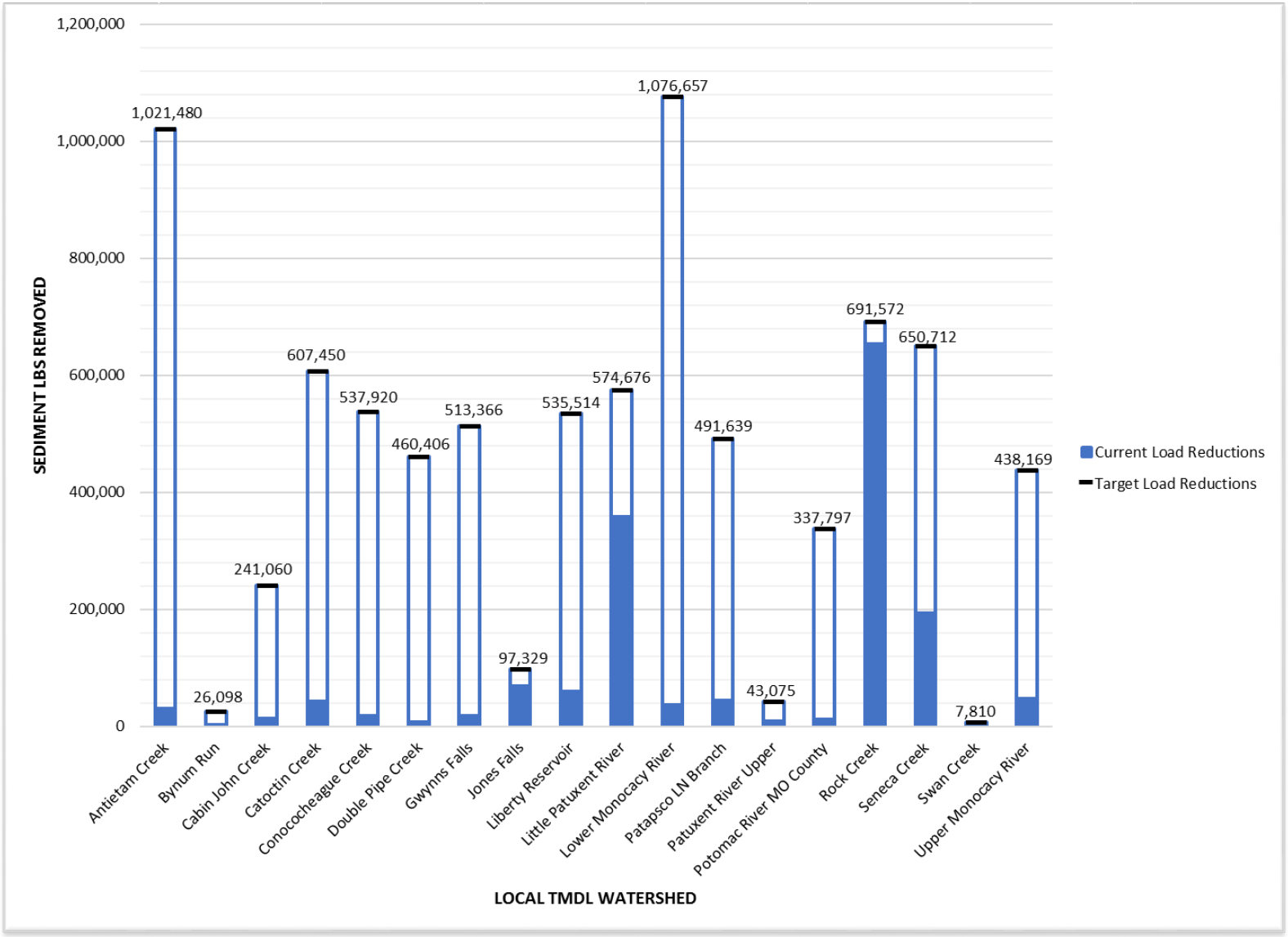


Figure 1-32: Achieved Sediment Reduction Loads

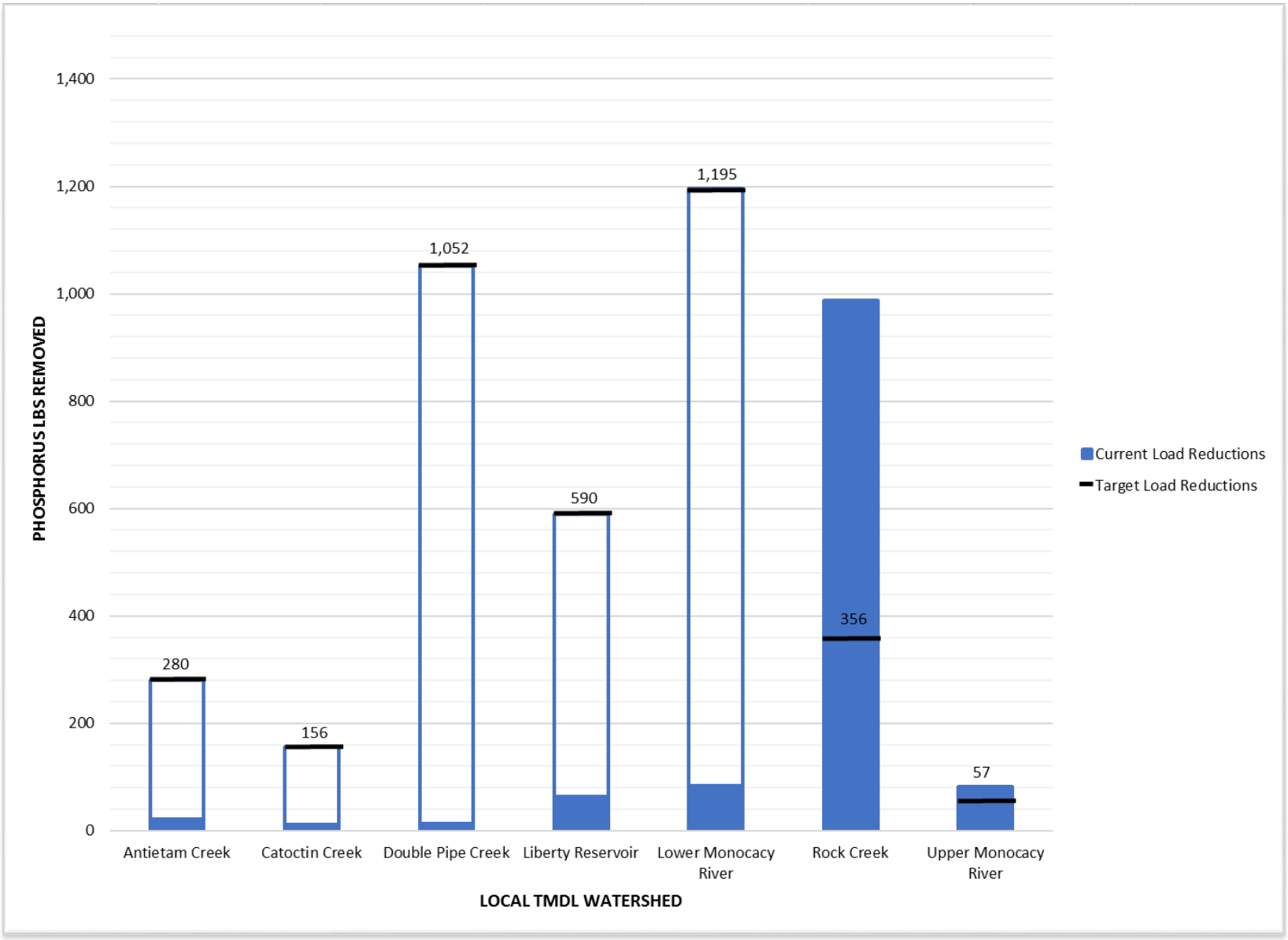


Figure 1-33: Achieved Phosphorus Reduction Loads

E.4.b Benchmark Comparisons

Impervious Restoration Benchmarks

The 2016 MDOT SHA Implementation Plan, discussed MDOT SHA's strategy to meet the 20 percent treatment requirement. The plan included a schedule projecting treatment benchmarks through the first quarter of FY21 in Part II, D. Table 1-29 and Figure 1-34 below compare MDOT SHA's impervious restoration progress through the end of FY17 to the restoration benchmarks set in the 2016 MDOT SHA implementation plan. As shown in this table and figure, MDOT SHA is currently exceeding its anticipated restoration achievements. MDOT SHA was originally projected to have achieved 40 percent of its restoration goal by the end of FY17, and has accomplished 41 percent.

Figure 1-34 displays impervious restoration progress by restoration BMP type through the end of FY17.

Table 1-29: Percentage of Impervious Treatment (Goal vs Achieved)

	Benchmarks			Actual Achieved	
Fiscal Year	Projected Acres	% Impervious Restoration	% Progress Toward Restoration Goal	Actual Restoration Achieved (Acres)	% Progress Toward Restoration Goal
Baseline to 2015	941.76	4%	20%	**1,130**	**24%**
2016	1,412.64	6%	30%	**1,493**	**32%**
2017	1,883.52	8%	40%	**1,936**	**41%**
2018	2,118.96	9%	45%		
2019	3,060.72	13%	65%		
2020	4,473.36	19%	95%		
2021	4,709	20%	100%		

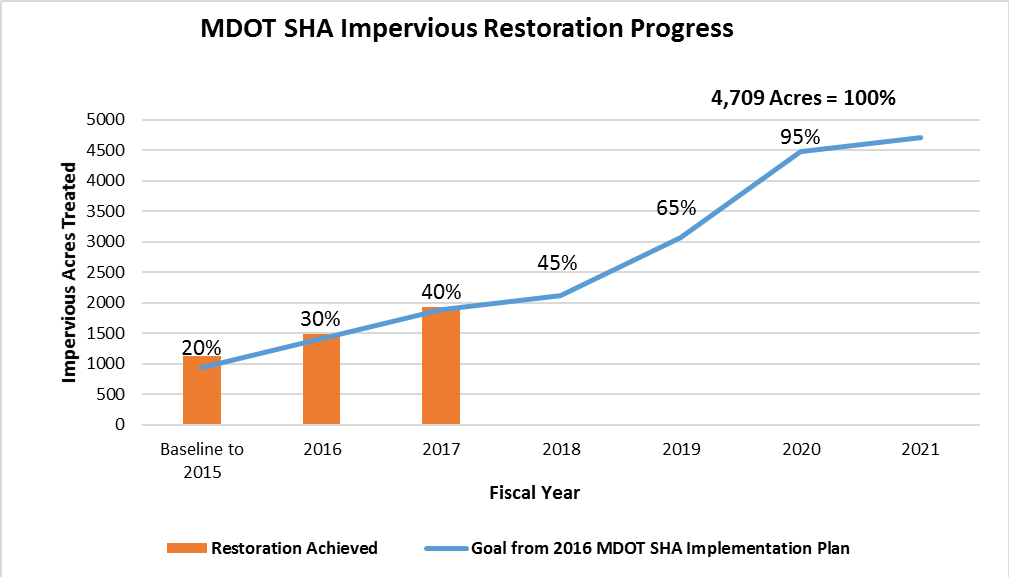


Figure 1-34: MDOT SHA Impervious Restoration Achieved Compared to Goal

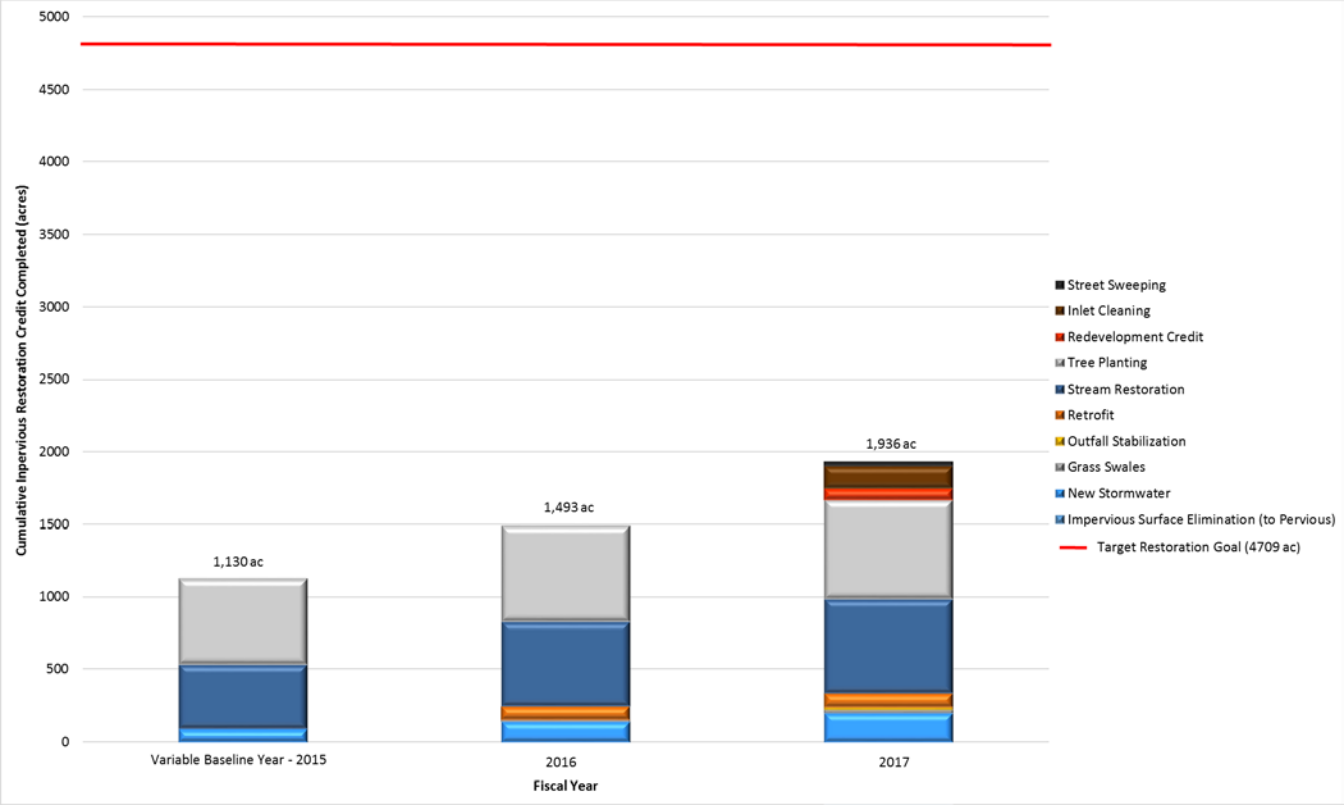


Figure 1-35: Cumulative Impervious Restoration Progress

Pollutant Load Reduction Benchmarks

Although MDE's comments (dated April 26, 2017) for the MDOT SHA 2016 annual report asked that MDOT SHA provide interim benchmarks for the local TMDL implementation plans, MDOT SHA has prioritized and focused efforts on developing, adapting, and implementing restoration efforts targeting the overall 20 percent requirement for the eleven MS4 counties by 2020. The complexity and intricacies that have been encountered for implementing each BMP type, limitations in right-or-way, permitting delays, funding constraints, and time constraints imposed for meeting the 2020 deadline make it impracticable for MDOT SHA to develop additional 26 watershed level implementation plans at this time.

It would not be prudent for MDOT SHA to commit to developing individually targeted restoration plans for each of the 26 watersheds, until the 20 percent Bay restoration work is implemented. MDOT SHA acknowledges that the restoration plans will need to be developed in the near future.

E.4.c Itemized Costs

Impervious Restoration Costs

Costs are itemized for each restoration project and detailed in Table 1-31. These costs include everything specific to implementing each BMP type and can include engineering design, right-of-way or easement acquisitions, and construction. Each restoration project contains several BMPs so providing exact costs for each individual BMP is not possible.

However, estimated expenditures have been derived by dividing the overall project cost by the impervious restoration credit provided by each project. This project per credit acre cost is then multiplied by the credit each BMP is providing to derive an estimated per BMP cost. This cost data is not included in Table 1-31 below, but is added to the IMPL_COST field in the RestBMP (RST) feature class.

MDOT SHA has provided BMP cost information for completed projects through FY17 (restoration BMPs) using the following feature classes as specified in the May 2017 MDE Geodatabase Guideline format:

- Restoration BMP feature class (RST)
- Alternate BMP Polygon feature class (APY)
- Alternate BMP Line feature class (ALN)

Additionally, a comprehensive list of restoration practices completed from 2011 to June 30, 2017, broken down by FMIS contract, is included in Appendix I. Each entry includes location information and estimated impervious runoff treatment acreages.

Local TMDL Implementation Costs

As stated above, the primary focus of MDOT SHA is on meeting the 20 percent impervious restoration target. Although the practice of evaluating locations within the watersheds with local WLAs is undertaken, the constraints in implementing each BMP are the overriding factors and maximizing treatment within the local watersheds cannot be guaranteed. Lists of proposed practices and estimated costs that if implemented would achieve the required reductions are included in Part IV of the 2016 MDOT SHA Implementation Plan and plans subsequently developed and submitted to MDE. Due to the complexity and intricacies involved, and time and cost resource limitations, these lists are not vetted through the site search and concept development process to determine feasibility.

E.4.d Cost Estimates for Completing Restoration

MDOT SHA office of Environmental Design (OED) has programmed capital funding through the Fund 82 TMDL Restoration fund to meet the impervious restoration target and fund the MS4 program in the amounts indicated in Table 1-30 below. Planning through this timeframe is accomplished accompanied by continuous project delivery assessments to adjust as necessary.

Table 1-30: Fund 82 Allocations (Capital Funds)

Fiscal Year	Allocations (Millions)
2017	$70.0

Table 1-30: Fund 82 Allocations (Capital Funds)

Fiscal Year	Allocations (Millions)
2018	$128.8
2019	$131.2
2020	$105.7
2021	$59.6
2022	$55.6
Total 2017 - 2022	**$550.9**

E.4.e Gap-Filling Watershed Action Plan

The MDOT SHA OED staff and funding resources are functioning at capacity to develop and implement the 20 percent restoration plan. Part of that effort is focused on developing more efficient ways to deliver projects for credit or reduce the restoration requirement through methods to reduce the impervious baseline. Each of these two tracks was discussed above in Sections E.2.a and E.2.b. of this report.

Table 1-31: FY 2011 to 2017 Itemized Costs for Completed Projects

FMIS	BMP Type	Project Name	Planning, Engineering & Design	ROW Expenditures	Construction Expenditures	Total Expenditures to Date	No. of BMPs in Project	No. of BMPs Constructed to Date	Impervious Treatment for Project (AC)	Impervious Treated to Date (AC)
AA1665182	Streams	I-97 SB WEST OF EAST-WEST BOULEVARD	$227,446	$1,781,399	$689,943	$2,698,789	2	2	4.5	4.5
AA7955282	SWM	AT VARIOUS LOCATSION - GROUP 1	$404,786		$770	$405,556	12	0	5.53	0
AA8955182	Streams	SRI - BROAD CREEK STREAM RESTORATION	$314,269		$1,888,228	$2,202,497	1	1	23	23
AT0415182	Trees	SRI-TREE PLANT-VAR LOC IN DISTRICT 3	$952,681		$1,470,772	$2,423,453	89	89	18.96	18.96
AT0425182	Trees	TREE PLANTING IN WASHINGTON COUNTY	Separate PP/PE Task		$1,438,520	$1,438,520	82	82	19.47	19.47
AT0445182	Swales	GRASS SWALE, ATTENUATION SWALE OR DRY SWALE	$189,758		$4,433,207	$4,622,966	37	37	20.67	20.67
AT0685282	Trees	SRI-TREE PLANTING-VAR LOC BALTIMORE CO	Separate PP/PE Task		$1,618,230	$1,618,230	135	135	31.15	31.15
AT0685382	Trees	SRI-AT VARIOUS LOCATION - D4	Separate PP/PE Task		$1,964,073	$1,964,073	116	116	32.99	32.99
AT0685482	Trees	TREE PLANTING-VAR LOC IN AA AND CH	Separate PP/PE Task		$1,102,629	$1,102,629	86	86	19.36	19.36
AT0685582	Trees	SRI-TREE PLANTING-VAR LOC IN CECIL CO	Separate PP/PE Task		$687,263	$687,263	34	34	8.92	8.92
AT0865182	Retrofits	DRAINAGE IMPROVEMENTS AT VARIOUS LOCATIONS IN DISTRICT 3	$30,000	$10,265	$4,711,354	$4,751,619	14	13	50.2	30.74

Table 1-31: FY 2011 to 2017 Itemized Costs for Completed Projects

FMIS	BMP Type	Project Name	Planning, Engineering & Design	ROW Expenditures	Construction Expenditures	Total Expenditures to Date	No. of BMPs in Project	No. of BMPs Constructed to Date	Impervious Treatment for Project (AC)	Impervious Treated to Date (AC)
AT0875182	Retrofits	TMDL STORMWATER FACILITY ENHANCEMENT IN DISTRICT 5 - DESIGN BUILD		$407,443	$4,746,950	$5,154,393	10	10	63.69	63.69
AT0875282	Retrofits	AT VARIOUS LOCATIONS IN AA COUNTY	$12,572		$1,783	$14,355	1	0	15.48	0
AT0885182	SWM	TC56-TMDL AT VARIOUS LOCATIONS IN DIST 7	$1,048,097		$5,142,872	$6,190,969	69	69	32.91	32.91
AT0895182	SWM	TC56-AT VARIOUS LOCATIONS IN DIST 5	$500,038		$1,733,145	$2,233,183	24	24	12.91	12.91
AT4285282	Impervious Removal	AT VARIOUS LOCATIONS-DISTRICT 7-GROUP 1			$1,533,465	$1,533,465	8	8	1.88	1.88
AT5025182	Trees	TC70-CHESAPEAKE BAY WATERSHED PROGRAM-D4	Separate PP/PE Task		$1,568,585	$1,568,585	107	107	37.06	37.06
AT5025282	Trees	TC70-CHESAPEAKE BAY WATERSHED PROGRAM D7	Separate PP/PE Task		$2,912,940	$2,912,940	144	144	76.51	76.51
AT5025382	Trees	TC70-CHESAPEAKE BAY WATERSHED PROG D-3,5	Separate PP/PE Task		$729,320	$729,320	46	46	23.42	23.42
AT5025482	Trees	TC70-CHESAPEAKE BAY WATERSHED PROGRAM-D6	Separate PP/PE Task		$1,212,257	$1,212,257	56	56	31.38	31.38
AT7995382	SWM	TC70-SWM AT VARIOUS LOCATIONS IN DIST 5	$166,191		$3,332,757	$3,498,948	47	47	18.86	18.86

Table 1-31: FY 2011 to 2017 Itemized Costs for Completed Projects

FMIS	BMP Type	Project Name	Planning, Engineering & Design	ROW Expenditures	Construction Expenditures	Total Expenditures to Date	No. of BMPs in Project	No. of BMPs Constructed to Date	Impervious Treatment for Project (AC)	Impervious Treated to Date (AC)
AW0445182	Trees	TREE PLANTING AT VARIOUS LOC - DIST 7	$687,021		$113,285	$800,306	94	0	31.17	0
AW0465182	Trees	TREE PLANTING AT VARIOUS LOC - DIST 3	$242,095		$304,187	$546,282	13	13	4.33	4.33
AW0475182	Trees	AT VARIOUS LOCATIONS IN ANNE ARUNDEL CO	$371,830		$118,988	$490,819	108	0	22.73	0
AW0825282	Trees	SRI-TREE PLANTING AT VAR LOC IN D-7	Separate PP/PE Task		$2,679,952	$2,679,952	196	196	53.55	53.55
AX2645182	SWM	TC11-LEGACY PAVEMENT IMP-DIST 2/DIST 4	$1,245,680		$4,995,307	$6,240,987	60	60	30.48	30.48
AX2645282	SWM	TC11-LEGACY PAVEMENT IMP-DISTRICT 3	$419,335		$2,771,928	$3,191,263	17	17	6.01	6.01
AX2645382	SWM	TC11-LEGACY PAVEMENT IMP-DISTRICT 5	Separate PP/PE Task		$1,263,859	$1,263,859	13	13	5.11	5.11
AX2645482	SWM	LEGACY PAVEMENT IMP-DIST 7/SOME DIST 6	$327,282		$3,251,672	$3,578,954	55	55	23.4	23.4
AX3765360	Streams	RESTORATION OF NW-170	Breakdown Unknown, Cost Estimated - Part of Larger Effort			$3,431,044	1	1	60.11	60.11
AX3765560	Streams	RESTORATION OF NB-1	Breakdown Unknown, Cost Estimated - Part of Larger Effort			$2,379,935	2	2	89.1	89.1
AX3765D60	Streams	RESTORATION OF PB-85	Breakdown Unknown			$2,668,256	1	1	64.5	64.5

Table 1-31: FY 2011 to 2017 Itemized Costs for Completed Projects

FMIS	BMP Type	Project Name	Planning, Engineering & Design	ROW Expenditures	Construction Expenditures	Total Expenditures to Date	No. of BMPs in Project	No. of BMPs Constructed to Date	Impervious Treatment for Project (AC)	Impervious Treated to Date (AC)
AX3765E60	Streams	RESTORATION OF PB-37, PB-108, PB-8	Breakdown Unknown, Cost Estimated - Part of Larger Effort			$1,078,402	3	3	53.61	53.61
AX3765F60	Streams	RESTORATION OF PB-119, PB-109	Breakdown Unknown, Cost Estimated - Part of Larger Effort			$1,184,596	2	2	27.26	27.26
AX3765K60	Streams	RESTORATION OF IC-62	Breakdown Unknown			$145,947	1	1	12.09	12.09
AX3765L60	Streams	STREAM RESTORATION OF CRICKET LAND TRIBUTARY (NW-4)	Breakdown Unknown			$2,886,457	1	1	51.71	51.71
AX3765N60	Streams	RESTORATION OF SC-2 - GOSHAN BRANCH	Breakdown Unknown			$3,958,336	1	1	39.91	39.91
AX3765U60	Streams	RESTORATION OF RC-2	Breakdown Unknown			$1,590,079	1	1	48.54	48.54
AX3785R60	Streams	STREAM RESTORATION OF PB-12A, PB-12B AT HOLLYWOOD BRANCH	Breakdown Unknown		$3,753,209	$3,753,209	2	2	64	64
AX7665182	Retrofits	SRI-AT VARIOUS LOCATIONS IN DISTRICT 4			$1,642,001	$1,642,001	12	3	16.29	4.78
AX7665282	Retrofits	TC94-SWM AT VARIOUS LOCATIONS - GROUP 1	$691,768		$12,120	$703,888	12	0	26.9	0
AX7665582	Retrofits	AT VARIOUS LOCATIONS IN WA CO - GROUP 1	$144,833		$669,004	$813,837	5	0	17.43	0

Table 1-31: FY 2011 to 2017 Itemized Costs for Completed Projects

FMIS	BMP Type	Project Name	Planning, Engineering & Design	ROW Expenditures	Construction Expenditures	Total Expenditures to Date	No. of BMPs in Project	No. of BMPs Constructed to Date	Impervious Treatment for Project (AC)	Impervious Treated to Date (AC)
AX7665B82	Retrofits	AT VAR LOCATIONS IN AA COUNTY-GROUP 1A			$6,316	$6,316	5	0	21.22	0
AX9295182	SWM	TC70-SWM AT VARIOUS LOCATION IN DIST 3	$161,555		$2,474,194	$2,635,749	17	17	11.26	11.26
BA2015382	SWM	SWM-AT VARIOUS LOCATIONS - GROUP 1	$187,168		$11,929	$199,096	16	0	12.36	0
CE2725282	SWM	AT VARIOUS LOCATIONS - GROUP 1	$220,481	$52,745	$173,595	$446,822	12	0	5.82	0
CH2985182	SWM	SMALLWOOD STATE PARK	$140,512		$1,470	$141,982	5	0	6.17	0
DNR - Million Tree	Trees	TREE PLANTINGS FOR MILLION TREE INITIATIVE (PARTNERSHIP WITH DNR)	PE Unknown		$1,389,650	$1,389,650	119	119	202.78	202.78
FR5975182	Streams	LITTLE CATOCTIN CREEK	$279,853	$12,616	$3,622	$296,091	1	0	30.63	0
FR6635382	SWM	AT VARIOUS LOCATIONS - GROUP 1A	$487,086		$423	$487,509	13	0	8.24	0
HA4075182	Streams	PLUMTREE RUN STREAM RESTORATION	$127,012		$1,364,846	$1,491,858	1	1	21	21
HA4095182SBR	Streams	MD 23 MAGNESS FARM STREAM RESTORATION AT TRIBUTARY OF DEER CREEK	$107,549		$97,408	$204,957	1	1	11.6	11.6
HO1695182	Streams	FURNACE AVENUE TRIBUTARY			$314,782	$314,782	1	1	3	3

Table 1-31: FY 2011 to 2017 Itemized Costs for Completed Projects

FMIS	BMP Type	Project Name	Planning, Engineering & Design	ROW Expenditures	Construction Expenditures	Total Expenditures to Date	No. of BMPs in Project	No. of BMPs Constructed to Date	Impervious Treatment for Project (AC)	Impervious Treated to Date (AC)
HO2065182	Streams	UPPER LITTLE PATUXENT - TC 12	$239,689		$2,072,751	$2,312,440	1	1	45	45
HO3255124	Streams	DORSEY RUN	$766,658		$303,050	$1,069,708	1	1	19.73	19.73
HO4085174	Streams	MD 100 RED HILL BRANCH BRAMPTON HILLS	Breakdown Unknown			$579,272	1	1	4.17	4.17
PG0585182	SWM	ROSARYVILLE STATE PARK	$64,310		$2,407	$66,717	4	0	3.56	0
PG0735182	Outfalls	SRI-ALONG MD 210			$1,999,384	$1,999,384	6	6	10.75	10.75
PG1085182	SWM	WATER QUALITY SITES ON MD 4 AND MD 214			$1,784,755	$1,784,755	2	0	9.91	0
Various	Trees	TREE PLANTINGS ASSOCIATED WITH VARIOUS LANDSCAPE/SUSTAINABILITY PROJECTS	Exact Cost Unknown, Part of Larger Planting Contracts				393	393	118.23	118.23
WA2445182	SWM	SRI-PA STATE LINE TO FREDERICK COUNTY LI			$1,576,754	$1,576,754	70	70	31.97	31.97
WA2655482	SWM	AT VARIOUS LOCATIONS - GROUP 1B	$507,849	$7,068	$950	$515,868	13	0	9.34	0
WA2775182	Trees	TREE PLANTING AT VARIOUS LOCATIONS	$94,014		$533,044	$627,058	62	4	28.5	9.31
						Totals:	**2,464**	**2,093**	**1,912**	**1,636**

F. Assessment of Controls

SHA and ten other municipalities in Maryland have been conducting discharge characterization monitoring since the early 1990s. From this expansive monitoring, a statewide database has been developed that includes hundreds of storms across numerous land uses. Analyses of this dataset and other research performed nationally effectively characterize stormwater runoff in Maryland for NPDES municipal stormwater purposes. To build on the existing information and to better track progress toward meeting TMDLs, better data are needed on ESD performance and BMP efficiencies and effectiveness.

Assessment of controls is critical for determining the effectiveness of the NPDES stormwater management program and progress toward improving water quality. SHA shall use chemical, biological, and physical monitoring to assess watershed restoration efforts, document BMP effectiveness, or calibrate water quality models for showing progress toward meeting any applicable WLAs developed under EPA approved TMDLs identified above. Additionally, SHA shall propose a stream monitoring site to assess the implementation of the latest version of the 2000 Maryland Stormwater Design Manual.

F.1 Watershed Restoration Assessment

SHA is required to continue monitoring in the Montgomery County Seneca Creek watershed, or, select and submit for MDE's approval a new watershed restoration project for monitoring. Monitoring activities shall occur where the cumulative effects of watershed restoration activities can be assessed. One outfall and an associated in-stream station, or other locations based on a study design approved by MDE, shall be monitored. The minimum criteria for chemical, biological, and physical monitoring are as follows:

a) <u>Chemical Monitoring</u>:

i) Twelve (12) storm events shall be monitored per year at each monitoring location with at least three occurring per quarter. Quarters shall be based on the calendar year. If extended dry weather periods occur, baseflow samples shall be taken at least once per month at the monitoring stations if flow is observed;

ii) Discrete samples of stormwater flow shall be collected at the monitoring stations using automated or manual sampling methods. Measurements of pH and water temperature shall be taken;

iii) At least three (3) samples determined to be representative of each storm event shall be submitted to a laboratory for analysis according to methods listed under 40 CFR Part 136 and event mean concentrations (EMC) shall be calculated for:

1. *Biochemical Oxygen Demand*
2. *Total Kjeldahl Nitrogen (TKN)*
3. *Nitrate plus Nitrite*
4. *Total Suspended Solids*
5. *Petroleum Hydrocarbons (TPH)*
6. *E. coli or enterococcus*
7. *Total Lead*
8. *Total Copper*
9. *Total Zinc*
10. *Total Phosphorus*
11. *Hardness*

iv) Continuous flow measurements shall be recorded at the in-stream monitoring station or other practical locations based on the approved study design. Data collected shall be used to estimate annual and seasonal pollutant loads and reductions, and for the calibration of watershed assessment models. Pollutant load estimates shall be reported according to any EPA approved TMDLs with stormwater WLAs.

b) <u>Biological Monitoring</u>:

i) Benthic macroinvertebrate samples shall be gathered each Spring between the outfall and in-stream stations or other practical locations based on an MDE approved study design; and

ii) SHA shall use the EPA Rapid Bioassessment Protocols (RBP), Maryland Biological Stream Survey (MBSS), or other similar method approved by MDE.

c) <u>Physical Monitoring</u>:

i) A geomorphologic stream assessment shall be conducted between the outfall and in-stream monitoring locations or in a reasonable area based on the approved study design. This assessment shall include an annual comparison of permanently monumented stream channel cross-sections and the stream profile;

ii) A stream habitat assessment shall be conducted using techniques defined by the EPA's RBP, MBSS, or other similar method approved by MDE; and

iii) A hydrologic and/or hydraulic model shall be used (e.g., TR-20, HEC-2, HEC-RAS, HSPF, SWMM, etc.) in the fourth year of the permit to analyze the effects of rainfall; discharge rates; stage; and, if necessary, continuous flow on channel geometry.

d) Annual Data Submittal:

i) EMCs submitted on MDE's long-term monitoring database as specified in PART V below;

ii) Chemical, biological, and physical monitoring results and a combined analysis for the approved monitoring locations; and

iii) Any requests and accompanying justifications for proposed modifications to the monitoring program

The Stream Restoration of Little Catoctin Creek at MD 340 – Frederick County Project (MDOT SHA contract number FR5975182) advertised on June 6, 2017. The bids are scheduled to open on October 5 with anticipated construction notice to proceed for mid-December 2017. Advertised plans are included with this report on the compact disc.

Pre-construction monitoring falling under phases CHEM 1, BIO 1, and PHYS 1 has been performed and is discussed in detail within Appendix J of this annual report. CHEM 1 includes data for stage, discharge, velocity, continuous water quality measurements, and discrete water quality measurements. BIO 1 includes pre-construction monitoring of benthic invertebrates and stream habitat assessments. PHYS 1 includes a geomorphic assessment to establish a baseline for the pre-restoration project area. This assessment was performed at five cross sections throughout the project reach as well as upstream and downstream of the project limits. The cross-sections were monumented for future reference and comparison. Longitudinal profiles were also established upstream and downstream of each cross-section from riffle crest to riffle crest at a minimum of 60 feet. Construction monitoring will begin after NTP.

Over the past year MDOT SHA has been implementing the monitoring plan by establishing baseline pre-construction observations for chemical, biological, and physical changes throughout the implementation of the stream restoration at Little Catoctin Creek (LCC). The monitoring efforts during the first year represent pre-restoration conditions. A more thorough analysis of baseline, pre-restoration conditions will be completed in 2018, once Year-2 monitoring has concluded (Fall 2017). This analysis will be submitted along with next year's monitoring activities update.

F.1.a Chemical Monitoring

In September 2016, the U.S. Geological Survey Site 01636845 (Little Catoctin Creek Near Rosemont, MD; upstream) was established, which included a radar stage sensor and acoustic doppler velocity meter (ADVM) for continuous flow measurements. Since the installation of the equipment, 29 discharge measurements have been recorded. Current and historic observations can be found here:

https://nwis.waterdata.usgs.gov/md/nwis/uv/?site_no=01636845

In December 2016, U.S. Geological Survey Site 01636846 (Little Catoctin Creek at Rosemont, MD; downstream) was established and instrumented with an ADVM to measure stream velocity. Current and historic observations can be found here:

https://waterdata.usgs.gov/nwis/inventory/?site_no=01636846&agency_cd=USGS

Figure 1-36: Storm flow at U.S. Geological Survey Site 01636845 (Little Catoctin Creek Near Rosemont, MD; Upstream)

By December 2016, sondes were installed at both locations to continuously measure water quality data; Temperature, Specific Conductivity, pH, and Turbidity on a 5-minute interval.

From the period 01/24/2017 through 07/06/2017, a total of 8 complete sets of discrete storm samples were collected. Samples have been analyzed for nutrients, metals, VOC's, bacteria and 5-day biological oxygen demand. Upon completion of analyses, results are loaded into the U.S. Geological Survey's National Water Information Service (NWIS) and are available online.

Chemical monitoring methods, monitoring plan site map, and monitoring results can be found in Appendix J, Section 2.

F.1.b Biological Monitoring

Three stream reaches were identified for biological monitoring and are located within the restoration project area, upstream of the project area (control reach), and downstream of the project reach. Two sites were allocated at each reach and, when possible, coincide with the physical and chemical monitoring locations.

All the physical habitat and biological monitoring was done using the Maryland Biological Stream Survey (MBSS) sampling protocols. Taxa richness at each site ranged from 14 to 22, with taxa richness generally decreasing in an upstream direction throughout the study reaches. Benthic macroinvertebrate index scores ranged from Very Poor to Poor condition in the three study reaches. BIBI scores observed during the same time period at the reference sites ranged from Fair to Good. A total of 21 fish species representing seven families were collected from Little Catoctin Creek in 2016. Fish species richness at each site ranged from 13 to 18. Physical habitat index scores for each site showed a downstream to upstream pattern of decreasing habitat quality with highest index scores measured in the Downstream reach and lowest scores measured in the Control reach. Epifaunal substrate quality, a qualitative measure of habitat available to benthic macroinvertebrates, ranged from Sub-optimal to Optimal within the study area.

Biological monitoring methods, monitoring plan site map, monitoring results, photo log of sampling locations, and a discussion of next steps can be found in Appendix J, Section 3.

F.1.c Physical Monitoring

Physical monitoring began by setting a baseline for observing geomorphic changes in cross section, profile to determine energy/friction slope through the observed cross section (both in water surface elevations and riffle-to-riffle), and bed material. Monumented cross sections were established and surveyed along with profiles and Wolman pebble counts at each site. Photo documentation and field notes are kept along with the recorded data. The cross sections were established and surveyed on September 19, 2017.

The channel was classified using the Rosgen classification technique as type 'F' channel due to its low gradient, incised channel (see Figure 1-37), and entrenched ratio. Preliminary analysis of these results demonstrates the restoration reach is unstable with receding banks (especially at monitoring location P-4). Further discussion can be found in Appendix J, Section 4)

Figure 1-37: Exposed Bank at Section P-4 of the Physical Monitoring Locations

Preliminary findings of the physical monitoring, including comparisons of the cross-section data collected in 2017 with the topographical survey performed in 2015 can be found in Appendix J, Section 4.

F.1.d Annual Data Submittal

Pre-restoration chemical, biological, and physical monitoring has been performed at Little Catoctin Creek. MDOT SHA has prepared an implementation document, included with this annual report as Appendix J. This appendix describes in detail these monitoring activities. MDOT SHA has provided the monitoring program information in the following feature classes and tables as specified in the May 2017 MDE Geodatabase Guideline format.

- Monitoring Site feature class (MSI)
- Monitoring Drainage Area feature class (MDA)
- Chemical Monitoring table (CHE)
- Biological Monitoring (BIO)

F.2 Stormwater Management Assessment

MDOT SHA is required to select a site to monitor, develop a monitoring plan, and submit for MDE's approval within 1 year of permit issuance for determining the effectiveness of stormwater management practices for stream channel protection as implemented under the latest stormwater regulations. Physical stream monitoring protocols shall include:

a) An annual stream profile and survey of permanently monumented cross-sections at the approved monitoring site to evaluate channel stability in conjunction with surrounding and on-going development;
b) A comparison of the annual stream profile and survey of the permanently monumented cross-sections with baseline conditions for assessing areas of aggradation and degradation; and
c) A hydrologic and/or hydraulic model shall be used (e.g., TR-20, HEC-2, HEC- RAS, HSPF, SWMM, etc.) in the fourth year of the permit to analyze the effects of rainfall; discharge rates; stage; and, if necessary, continuous flow on channel geometry.

In order to meet this permit condition, MDOT SHA has proposed to monitor Interstate 70 (I-70) at the Marriottsville Road bridge in Howard County, Maryland. Stormwater controls are proposed along I-70 within the Marriottsville Road interchange and include: two grass swales, three bioswales, and one bioretention. All facilities are located within the Little Patuxent River watershed (LPW).

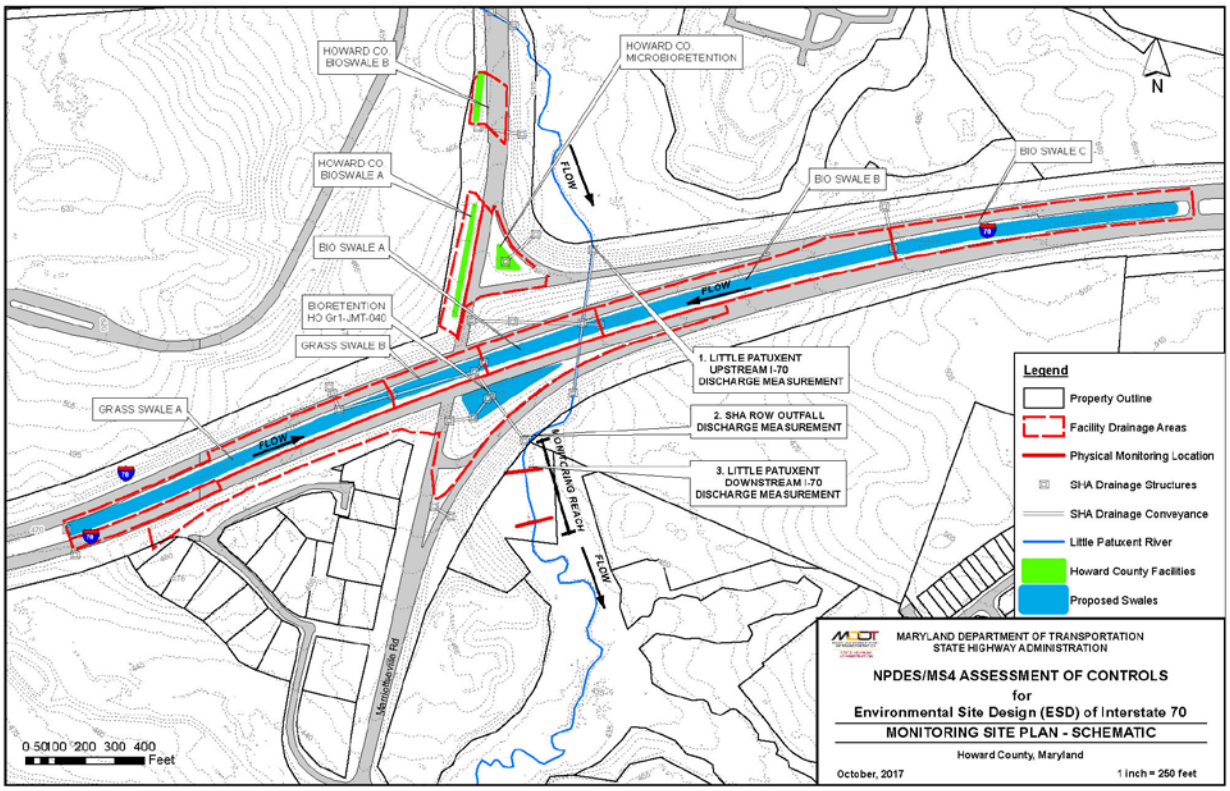


Figure 1-38: MDOT SHA and HO County ESD Facilities and Monitoring Sites

SHA submitted an updated monitoring plan for the I-70 sites to MDE on September 2, 2016. Coordination with MDE has progressed throughout the last year and the monitoring plan was updated by MDOT SHA and submitted to MDE on March 24, 2017. This updated version included additional county-level watershed information including results of a review of Howard County's LPW Assessment Report (dated November 30, 2015) and analysis of spatial data for County restoration practices within the watershed received March 10, 2017. It was determined that the proposed monitoring site is in the Northern Little Patuxent (NLP) drainage of the LPW.

Subsequent to the development of the March 2017 version of the monitoring plan, MDOT SHA became aware of a Howard County Bureau of Highways roadway/bridge widening project at the Marriottsville Road Interchange. The primary purpose of the project is to accommodate four travel lanes and two bike lanes (one bike lane on each side). The proposed construction is adjacent to the MDOT SHA proposed stormwater management facilities and this monitoring study area.

After coordination with Howard County personnel, MDOT SHA assessed changes to the monitoring plan to accommodate the proposed road and bridge widening and associated ESD facilities. MDOT SHA notified MDE of this change on July 24, 2017 via email. Coordination between the county and MDOT SHA will continue to combine the MDOT SHA facilities into the county design and construction contracts to eliminate any conflicts during construction and to benefit from combined permit reviews through the county. See Figure 1-38 for locations of MDOT SHA and Howard County proposed ESD facilities and monitoring sites.

On August 30, 2017, MDE granted MDOT SHA formal approval to conduct ESD monitoring at this

site contingent upon MDOT SHA submitting a revised monitoring plan to MDE that includes the combined plan with Howard County and TR-20 results for the existing and proposed conditions with and without proposed BMPs at the I-70/ Marriottsville Interchange as well as with and without all BMPs in the watershed.

MDOT SHA is including an updated assessment of controls monitoring plan as Appendix K of this annual report. The updated monitoring plan includes revised tables, treatment amounts, maps, and a new TR-20 run reflecting the addition of the proposed Howard County BMPs. The updated plan includes Howard County data, planning documents, and preliminary investigation plans.

G. Program Funding

The MS4 permit requires a fiscal analysis of capital and operations expenditure and budgets as well as watershed protection and restoration funds generated through stormwater fees or other means. MDOT SHA does not impose stormwater fees or generate funding for watershed protection and restoration outside of the State Transportation Trust Fund. This permit condition also requires that adequate program funding be made available to ensure compliance for the next fiscal year. MDOT SHA is committed to appropriating the full funding amount necessary to meet these permit requirements. Funding needs to meet all the permit requirements are split between capital and operations funding as described below.

Capital Funding

Capital funds are programmed to meet the needs of the MS4 program listed below. MDOT SHA OED currently maintains adequate capacity in architectural/engineering consultant contracts to support these activities. Additional procurements were brought on line during FY17 that total $72 Million for engineering and $4 Million for SWM BMP remediation.

Part IV.A Permit Administration
Part IV.B Legal Authority
Part IV.C Source Identification

Management Programs including:

Part IV.D.1.a and b Stormwater Management Reviews and Data tracking associated with MDOT SHA Delegation Authority approvals.

Review and approval expenditures and budget are included for restoration projects built in compliance with Part IV.E, Restoration Plans and TMDLs. Funds for new-and re-development roadway projects are not tracked and reported because these funds are included in each individual roadway project budget and cannot be readily extracted.

Part IV.D.1.c Stormwater Management for construction inspection and SW As-built Certification process.

Construction inspection and SW As-built Certification process expenditures and budget are included for restoration projects built in compliance with Part IV.E, Restoration Plans and TMDLs. Funds are not tracked and reported associated with construction inspection and SW As-built Certification process expenditures for roadway new- and re-development projects. These funds are included in each individual roadway project budget and cannot be readily extracted.

Part IV.D.1d Stormwater Management associated with preventive maintenance inspections and remediation.

Part IV.D.2 Erosion and Sediment Control

ESC expenditures and budget are included for restoration projects built in compliance with Part IV.E, Restoration Plans and TMDLs. ESC funds related to new-and re-development roadway projects are not tracked and reported because these funds are included in each individual roadway project budget and cannot be readily extracted.

Part IV.D.3 Illicit Discharge Detection and Elimination

Part IV.D.4 Trash and Litter Program

Program management related to MS4 reporting and tracking, and educational source control.

Part IV.D.5 Property Management and Maintenance

Program management expenditures and budget related to inlet cleaning and street sweeping for TMDL implementation plan development, tracking, and reporting are included. Funding related to minimizing chemical applications for vegetation management are not tracked and reported because these funds are included in each individual roadway project budget and cannot be readily extracted. Funds related to industrial site pollution prevention plan development and implementation, and staff good housekeeping training are included.

Part IV.D.6 Public Education
Part IV.E Restoration Plans and TMDLs
Part IV.F Assessment of Controls

Operations and Maintenance Funding

Operations and maintenance funds are budgeted for routine maintenance of structural stormwater control structures; street sweeping, inlet cleaning, chemical application and winter deicing training, and other activities to foster minimization; litter removal and education. As restoration practices increase, enhancements to the operations budget are sought through the legislature. During FY17 an additional $2.4 Million for operations and maintenance activities was sought for enhanced inlet cleaning.

Delivered Data

MDOT SHA has provided the fiscal program information in the Fiscal Analyses table (FIS) as specified in the May 2017 MDE Geodatabase Guideline format. The geodatabase documents budget and cost for operations and capital funding. These values are also summarized in Table 1-32 below. The FIS table includes a mandatory field for watershed protection and restoration funds generated for the current fiscal year. Since MDOT SHA does not generate these funds, this field is not applicable.

Table 1-32: MS4 Funding Budget and Expenditures

Fund	FY17 Expenditures (Millions)	FY18 Budget (Millions)*
Fund 82 – TMDL/MS4	$63.9	$128.8
Fund 74 – Drainage	$13.9	$23.2
Fund 49 – Industrial	$1.9	$5.4
Operations/ Maintenance	$13.2	$16.0
Totals	$92.9	$173.4

* Funding numbers are rounded to nearest $0.1 Million

Part Two

Drainage and Stormwater Asset Program

PART TWO

2. Drainage and Stormwater Asset Program

Introduction

The Maryland Department of Transportation State Highway Administration (MDOT SHA) owns, operates, and maintains an extensive roadway network that is served by a complex and expanding drainage and stormwater system. The Drainage and Stormwater Asset Management Program was established to construct, operate, maintain and remediate permanent drainage and stormwater assets that convey and treat highway runoff. The program goal is to inventory all drainage and stormwater assets to provide ongoing preventive and remedial solutions for any functional deficiencies that occur through routine operations. As of FY 2017, MDOT SHA manages nearly 4,900 permanent stormwater management facilities and ESD practices, nearly 171,000 hydraulic structures, and almost 140,000 conveyance features (nearly 9 million linear feet) statewide. This includes over 4,100 permanent stormwater management facilities and ESD practices, nearly 124,000 hydraulic structures and almost 100,000 conveyances (nearly 7 million linear feet) within the MS4 jurisdictions. Since 1999, MDOT SHA has had a comprehensive asset management program to locate, inspect, evaluate, and remediate these assets to sustain their functionality, improve water quality and stability, protect sensitive water resources, and provide an aesthetic and safe transportation system. MDOT SHA has developed a detailed inspection rating and work order development system to track, prioritize and plan the necessary activities for extending the life expectancy of drainage and stormwater assets.

The objective of the program is to have 90% of the assets functioning as originally designed and is directly tied to the MDOT SHA Business Plan goal of providing a positive contribution to the water quality of the Chesapeake Bay. Additionally, the Program has a secondary goal of strategically enhancing the overall function of existing facilities to meet the latest SWM design standards and regulatory requirements.

The Program is divided into five major components:

- Planning – Including inventory, inspections, performance ratings and data management
- Design – Including remediation/action ratings, work order generation and retrofit design
- Construction – Including area wide contracts across various MDOT SHA offices, Bid Build contracts, Innovative Contracting such as design build and immediate response
- Operations – Including minor maintenance, routine maintenance and inspection support
- Future Focus – Including business process improvement such as technology upgrades, new tools, software, standard procedures and research

MDOT SHA is working to improve the efficiency of the program as a whole. This is necessary to maintain aging infrastructure and position the program to manage more recently built BMPs. In addition to the increase in inventory, MDOT SHA is facing increasingly strict regulatory requirements to permit remediation activities that require additional time for the design and construction of maintenance activities.

While working through the new challenges, MDOT SHA continues to focus on public service and the SWM assets impact on the transportation network and the community. Many of these aspects are illustrated in Figure 2-1.

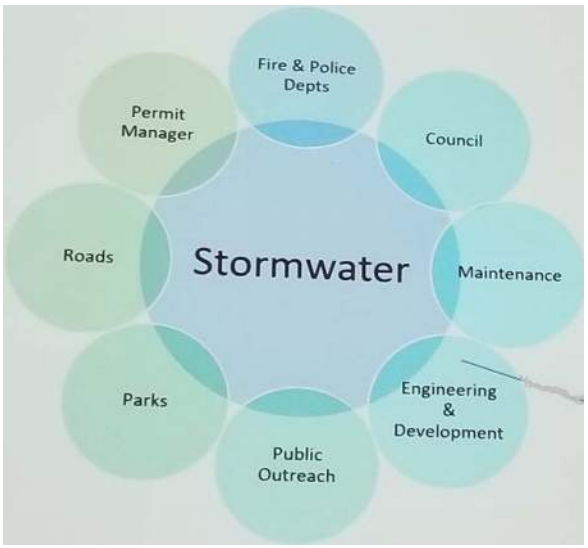


Figure 2-1: Stormwater Connections to Other Public Service Entities

It is helpful to remember this holistic connection when considering planning, design, construction, operations and the future.

A. Planning

The NPDES Municipal Separate Storm Sewer System (MS4) permit requires MDOT SHA to identify all storm drainage infrastructure that captures, treats and conveys stormwater runoff from MDOT SHA properties in the designated NPDES areas of the State. MDOT SHA inspects drainage assets (pipes, channels, inlets and manholes) and stormwater management assets (ponds, swales, infiltration and ESD facilities) for functionality. The overall goal is to have the most current inventory, conduct inspections and perform rating assessments based on the *MD SHA Stormwater NPDES Program Standard Procedures Manual.* This enables MDOT SHA to prioritize the repair, remediation and retrofit of MDOT SHA-owned SWM facilities and drainage infrastructure.

MDOT SHA has expanded its program to cover all areas of the State within its right-of-way. In the past couple of years, MDOT SHA has progressed efforts to collect data for SWM inventory of drainage infrastructure and to perform BMP inspections in all counties outside the NPDES Permit area. Allegany County was completed in June 2017 and Garrett County will be complete by November 2017. The drainage system asset inventory and inspection program includes hydraulic structures, pipe conveyances, and outfalls. Additionally, MDOT SHA has expanded the drainage system asset inspection program by adding video inspections to evaluate entire pipe lengths for a full determination of structural integrity. These types of in depth inspections are being performed primarily along roadways with aging drainage systems, and at MDOT facilities such as Welcome Centers, maintenance shops, parking lots, and Park and Rides.

Assets receive a performance rating once inspections have been performed and the database is updated. Ratings are related to the asset type and are assigned based on inspection results. Drainage system assets, such as pipes and outfalls are rated based on structural integrity, while SWM assets are rated based on the specific facility type and functionality.

A.1. Inventory

The MDOT SHA drainage system assets and SWM facility inventory includes all hydraulic structures, pipe conveyances, outfalls and SWM facilities that intercept and manage runoff from the MDOT SHA highway network and roadway-related assets. It includes SWM facilities not owned or maintained by MDOT SHA, but by other entities including but not limited to counties, municipalities, other state agencies, and private entities.

The facility inventory database is frequently updated as new facilities are brought online. Updates occur statewide for MDOT SHA's entire infrastructure in each Maryland county; including all Phase I and II MS4 locations, as well as locations outside these areas.

Compared to the previous reporting period, several counties show a decrease in the total number of SWM facilities managing runoff from MDOT SHA roadway networks and assets. In FY 2016, approximately 2800 grass swales were loaded to the database as the result of desktop studies and MDE coordination for credit reported on October 9, 2016: All were rated functionally adequate. A detailed review took place during this reporting period which resulted in a net loss

of 913 of these swales due to quality control evaluations of the data, additional baseline computations and MDE comments on the 2016 Annual Report. The adjustments were delivered in MDOT SHA's July 31, 2017 submission to MDE (*MDOT SHA Response to MDE Impervious Area Assessment Report Comments*).

Currently, 628 of these swales are shown as proposed in Table 2-1 (shown later in this report). Future analysis of all these facilities should recover credit and place them back in the database as requiring no action once complete. These are currently considered a 'temporary loss' until further analysis is complete.

New developments adjacent to MDOT SHA roadways, construction of major highway improvement projects and safety improvement / system preservations projects all serve to add to the drainage and SWM inventory. There has been an overall increase in the drainage inventory compared to FY 2016. Often, to meet regulatory requirements, these projects implement Environmental Site Design to the Maximum Extent Practicable (ESD to MEP) as well as require SWM treatment of any additional or reconstructed impervious surfaces. System preservation projects are ongoing, as MDOT SHA continually strives to provide a high-quality transportation system to all.

A.2. Inspection and Performance Ratings

Drainage system and SWM facility field inventories and inspections have been completed for all counties, both MS4 and non-MS4. The information is used to verify existing data in the MDOT SHA database as well as to determine the SWM facilities functional rating and serve as the foundation to recommend any necessary remedial actions. The statewide inventory is continuously updated on a county-by-county basis. A tracking system is in place and under constant improvement with emerging technologies to streamline planning efforts for future inspections for all counties in the state.

The inspection protocol is documented in Chapter 3 of *Maryland State Highway Administration Stormwater NPDES Program, Standard Procedures – Best Management Practice Field Inspections & Data Collection Procedures*

During initial field assessments, individual parameters of each SWM facility are scored on a scale of 1 to 5. Scores are then used to establish an overall SWM facility performance rating as follows:

A **No Issues.** The SWM facility is functioning as designed with no adverse conditions identified. There are no signs of impending deterioration.

Figure 2-2: Infiltration Trench Rated "A"

B **Minor Problems:** The SWM facility functions as designed, but minor issues are observed that may worsen to the next rating level if not repaired in a reasonable timeframe.

Figure 2-3: Infiltration Trench Rated "B"

C **Moderate Problems:** The SWM facility functions as designed, but efficiency,

performance, and function are at risk or somewhat compromised and may worsen to the next rating level if not repaired in a reasonable timeframe.

Figure 2-4: Infiltration Trench Rated "C"

D Major Problems: The SWM facility no longer functions as designed, and efficiency has been compromised. Repair or remediation should be performed.

Figure 2-5: Infiltration Trench Rated "D"

E Severe Problems: The SWM facility no longer functions as designed and efficiency as well as several critical parameters have been significantly compromised. The SWM facility shows signs of deterioration and/or failure, requiring immediate remedial action.

In FY 2017, MDOT SHA performed 4249 inspections of unique SWM facilities across Anne Arundel, Baltimore, Carroll, Charles, Frederick, Harford, Howard, Montgomery, Prince Georges, Washington Counties. In addition, the small cities of Cambridge, Salisbury and Cumberland were all inspected. A smaller number of facilities were re-inspected after minor maintenance or remediation efforts were initiated. Inspection efforts also expanded to include specially trained personnel to enter and inspect confined space, so all underground confined utilities that were due were also inspected. Inspections in some of these areas will continue into FY 2018 as part of the effort to launch updated inspection tools. All updates are included in this report.

The inventory inspections are used to develop action ratings and prioritize remediation efforts. The remedial inspection protocol describing field assessment methodologies used for determining the observed functionality of a SWM facility and providing guidance for remedial actions is included in Chapter 7 of the *Maryland State Highway Administration Stormwater NPDES Program Standard Procedures - Best Management Practice Assessment Guidelines for Maintenance and Remediation.* The assessments and recommended action ratings provide data that enables MDOT SHA to adequately allocate sufficient resources to ensure an appropriate schedule of remediation activities. The two-tiered rating system is used to prioritize maintenance activities, initiate remedial design, permitting and environmental clearance processes, develop and justify fiscal budget to requests for appropriate funding and to sufficiently plan areawide contracts procurement.

See Table 2-1 below for a summary of the Stormwater Asset Management Program within MS4 Counties.

Table 2-1: Stormwater Asset Management Program in MS4 Jurisdictions

County	No Action	Routine	Major Remedial	Retrofit Design	% Funct.	Total Invent.	Proposed/Grass Swale Programming
Anne Arundel	162	228	189	10	66.2%	589	203

Table 2-1: Stormwater Asset Management Program in MS4 Jurisdictions

County	No Action	Routine	Major Remedial	Retrofit Design	% Funct.	Total Invent.	Proposed/Grass Swale Programming
Baltimore	187	128	68	11	79.9%	394	0
Carroll	125	29	4	0	97.5%	158	3
Cecil	106	13	5	0	96.0%	124	32
Charles	176	103	24	2	91.5%	305	11
Frederick	356	69	43	1	90.6%	469	48
Harford	124	45	61	5	71.9%	235	8
Howard	274	247	80	5	86.0%	606	83
Montgomery	304	188	101	6	82.1%	599	72
Prince George's	474	153	47	1	92.9%	675	165
Washington	137	15	7	2	94.4%	161	0
Salisbury	5	6	0	0	100%	11	0
Cumberland	0	0	0	0	100%	0	0
Cambridge	0	1	0	0	100%	1	0
Totals	**2293**	**1209**	**622**	**41**	**84.08%**	**4165**	**625**

SHA conducts Stormwater Asset Management Statewide, however, the information in this table represents MS4 Phase I and II jurisdictions only. Approximately 718 additional facilities exist throughout the state.

A.3. Inspection Tools and Training

MDOT SHA currently uses two custom software programs to collect and store geospatial information in support of the stormwater inventory and inspection program: The Office Tool and the Field Tool. The Office Tool is used to input data as well as perform quality assurance (QA) reviews. The Field Tool is used with GPS coordinate units to collect and edit field data. During the past several years, inspectors have found it increasingly difficult to start inspection tasks and get all needed hardware and software to function properly. The custom designed Field Tool is running on software that is no longer supported by the current ESRI standards. This made configuring inspection machines as well as data management difficult. As a result, MDOT SHA began work on design and implementation of new inspection tools. It is anticipated that these new tools will be more efficient and accurate in capturing data. Details of the future launch of the tools are included in Section E.1 of this report.

To meet the increased demand of facility remediation work per the 2016 Annual Report, MDOT SHA has added additional resources. Four consultant staff joined the Asset Management team to keep up with demand. This new staff brought both experience in the field along with fresh ideas to the team. As the staff assigned the remediation action ratings, they often noted deficiencies in the field inspection data provided by inspection teams. It was quickly determined that retraining the inspectors was the best solution. MDOT SHA provided training to all anticipated SWM BMP Inspectors in April 2017. MDOT SHA offered two sessions of the 2-day training classes, conducted on April 4th and 5th; and April 19th and 20th. The first day of training was a full day of classroom training to cover the importance of

accurate inspection data in the general structure of the program, inventory and inspection procedures, step by step demonstrations of the inspection tool use, a review of SWM BMPs, conveyance and source identification aspects, and a visual guide to inspection parameters. The training classes were led by a combination of MDOT SHA staff and consultant staff involved in the program.

Figure 2-6: Inspection Training Day 1 (Classroom Examples)

While developing the training materials, rating teams created a brief visual guide to supplement the specific items called out in the Standard Operating Procedures. This visual guide will help to ensure inspection and rating consistency aligned with the protocols across the program and will minimize subjectivity. The guide was presented as part of the training and received exceptionally well by trainees. The full document was limited to about 30 pages to make it easy to keep with inspection teams for reference.

Figure 2-7: Image Guide to Structure Inspection Scoring Presentation Slide

The final day of training consisted of site visits to several BMP locations throughout Howard County. The purpose of the site visit day was to expose inspectors to a variety of SWM BMP types and review inspection and rating criteria in the field with MDOT SHA Rating Staff, Project Managers and Trainers. At each site, discussions were held about aspects of the inspection needed for each BMP type including the approach to performing the assessment and rating. In addition, inspectors did a training exercise to rate two side by side facilities using the paper inspection forms to ensure they covered all aspects of possible scenarios.

Figure 2-8: Inspection Training Day 2 (Field Exercises)

MDOT SHA has evidence of the success of the training, as the inspection results from FY17 were more detailed, accurate and complete. The results are reflected in finding many facilities that are not functioning to their intended design and, as a result, major remediation efforts are being targeted. This increase was anticipated based on current trends as many facilities begin to reach the end of their expected life cycle.

A.4. Data Management

MDOT SHA has developed an inventory of all SWM drainage infrastructure in each NPDES MS4 jurisdiction and performed SWM facility inspections in all twenty-three counties. The data collection effort is on-going in all the counties statewide, and involves continuous updates of the GIS data for source identification and database records of inspection and remediation activities.

MDOT SHA is preparing for an upgrade to the servers, the structure of the ESRI geodatabase and detailed schema. As a result, many new cells to data tables were created to better track project progress, data coordination efforts and inspection schedules. The structure allows for the establishment and enforcement of topologic and/or network rules as well as unique data entry while still helping project management with a comprehensive approach. The database format resulted in improved data intelligence and integrity. MDOT SHA integrates the geodatabase with other organizational applications for data sharing and viewing, such as eGIS, the new HHD Web Research App and iMAP (discussed below) to improve communication between offices. This is an ongoing process that continues to improve.

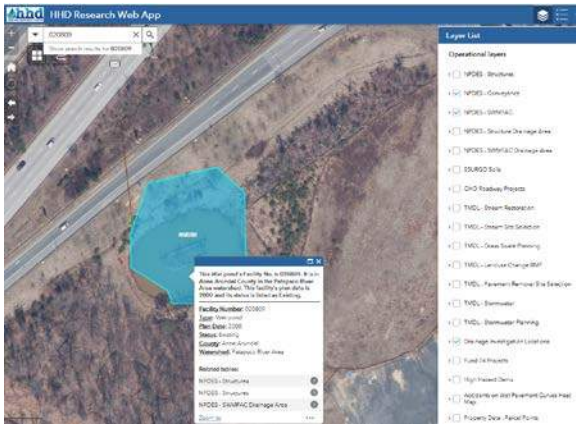


Figure 2-9: HHD Web Research App Sample Screen

The ways to view data were expanded in FY 2017. The launch of the HHD Web Research App provided the first cross jurisdiction viewing tool. In this tool, all stormwater facility data for can be viewed in conjunction with additional layers that allow staff to view restoration projects for planned improvements. This allows for a thorough analysis of the system needs when planning watershed restoration projects for permit restoration efforts. The tool also provides roadway and drainage improvement project data which may show that an existing facility will be upgraded with a roadway project. In addition, inventory of drainage data, flooding issues from customer complaints and accident data related to wet pavement can be found in the tool for all roadways. This comprehensive viewing tool was developed at the request of the program, but it is showing

vast application across several MDOT SHA offices for planning purposes.

B. Engineering

Assets with major deficiencies that entail more than minor maintenance require a detailed remedial assessment to determine specific causes of deficiencies and to develop a remedial action plan. Procedures have been created that assist with decisions on minor maintenance, remediation or full retrofit of drainage and SWM assets. These assessment guidelines document the methodologies to be used in the field for assessing and determining remedial actions necessary for restoring stability and functionality. In addition, the procedures provide information on field preparation, data management of collected information, as well as development of remedial assessment reports and work orders for contracting crews.

B.1. Remediation Rating System

Response actions are divided into various categories of activities: no response required, minor maintenance, major remediation, retrofit design, immediate response or abandonment. The following outlines the official ratings that help determine the next steps in the process.

I No Response Required - The asset is functioning as designed. Re-schedule for the next multi-year inspection assessment period or put on low priority minor maintenance list.

Figure 2-10: Infiltration Trench Rated "I"

II Minor Maintenance - The asset is functioning as designed, but routine and preventative action should be performed to sustain effective performance.

Figure 2-11: Infiltration Basin Rated "II" Requiring Vegetation and Inflow Repair

III Major Remediation - The asset has some compromised functionality and significant remediation is necessary to restore original functionality. The facility work can be performed within the existing facility footprint.

Figure 2-12: Infiltration Trench Rated "III" (excessive and debris blocking facility, monitoring well buried)

Figure 2.12 - Infiltration Trench Rated III (excessive and debris blocking facility, monitoring well buried)

IV Retrofit Design - The asset is no longer functioning as designed and cannot be restored to the original function without a complete re-design and re-construction of the facility with a larger footprint. Often reconstruction will also require a new facility type.

Figure 2-13: Infiltration Trench Rated "IV" (facility not functioning, sedimentation major concern for long term sustainability)

V Immediate Response - The SWM facility has catastrophically failed and public safety hazards exist that require immediate corrective action.

Figure 2-14: Infiltration Trench Rated "V" (severe flooding threatens roadway)

VI Abandonment - The SWM facility is unsustainable and no longer provides sufficient benefit to warrant remedial design.

Figure 2-15: Infiltration Trench Rated "VI" (Abandoned)

For the first time in many years, the remedial action rating system was expanded. As planning efforts for facility remediation expand it became clear that some inspections previously performed were inadequate because key attributes of facilities could not be accessed for rating purposes. MDOT SHA coordination efforts to get minor maintenance performed on a facility, usually in the form of brush clearing was needed to complete the inspection. The rating value of 'R' for 'Re-inspection' was created so the database could easily and quickly be sorted to find any inspections that still needed priority for the year. This method contributed to a more complete and accurate set of inspection data for FY 2017. Additional ratings are planned for the future and are discussed in Section E.1.

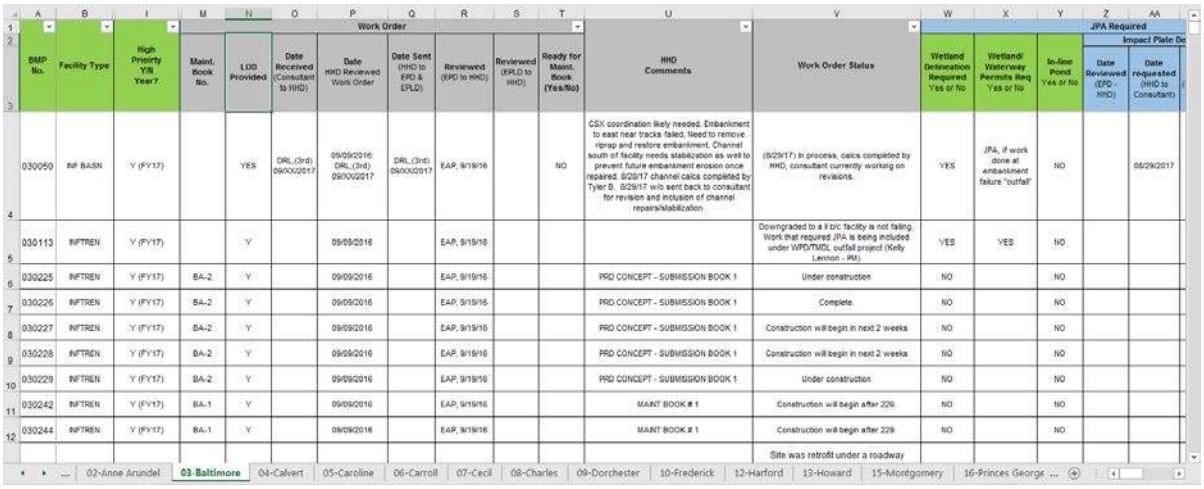
B.2. Work Order Generation

This section summarizes the status of MDOT SHA repair and remediation activities in response to identified deficiencies of SWM facilities. Since MDOT SHA has a goal to ensure functionality and efficiency of all its owned and maintained SWM facilities, deficiencies are corrected through development of remedial work orders for areawide contracts.

SWM facilities that require major remedial work are assigned an action rating of "III" by MDOT SHA and prioritized by urgency and location. Based on this rating, construction activities are defined in prescriptive work orders

and marked on the original design plans for the contractor to address identified issues.

The work typically falls under the General Approval for Erosion & Sediment control (ESC), The previous General Approval has expired and MDOT SHA applied for a new General Approval for Statewide Stormwater Facility Maintenance General Statewide Erosion and Sediment Control Approval in 2015. The permit is currently still under review by MDOT SHA Plan Review Division (PRD) as well as MDE. Until General Approval is received, major remediation efforts that disturb over 5,000 SF and 100 Cu. Yards of earth movement will require individual ESC approval for each site. This requires additional time and coordination to perform required major remedial work. As previously discussed, per direction from MDE, during FY 2016 a more cumbersome permitting process was put in place including additional screening for environmental features. The screening was to verify the need for a Joint Permit Application under the regulations of MDE for natural environmental features. This screening process can take several months to complete and because of this screening process, the number of work orders generated during FY 2016 saw a temporary decline. In response to this decline, MDOT SHA added several additional consultant staff to the Asset Management team. The additional resources are providing support to generate, check and submit work orders for the lengthy permitting process. The extra staff also brought the need for better and more efficient data tracking and coordination. A BMP Master List was created to track BMPs for priority, work order details such as limit of disturbance, dates of design and review activities, status, wetland permitting needs and several other aspects of the process. This list has allowed the sharing of data and project planning to improve along with the work order development process. An example of the key aspects is shown in Figure 2-16.



	A	B	I	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
1				Work Order										JPA Required				
2																	Impact Plate De	
3	BMP No.	Facility Type	High Priority Y/N Year?	Maint. Book No.	LOD Provided	Date Received (Consultant to HHD)	Date HHD Reviewed Work Order	Date Sent (HHD to EPD & EPLD)	Reviewed (EPD to HHD)	Reviewed (EPLD to HHD)	Ready for Maint. Book (Yes/No)	HHD Comments	Work Order Status	Wetland Delineation Required Yes or No	Wetland/ Waterway Permits Req Yes or No	In-line Pond Yes or No	Date Reviewed (EPD - HHD)	Date requested (HHD to Consultant)
4	030050	INF BASN	Y (FY17)		YES	DRL (3rd) 09/XX/2017	09/09/2016 DRL (3rd) 09/XX/2017	DRL (3rd) 09/XX/2017	EAP, 9/19/16		NO	CSX coordination likely needed. Embankment to east near tracks failed. Need to remove riprap and restore embankment. Channel south of facility needs stabilization as well to prevent future embankment erosion once repaired. 8/28/17 channel calcs completed by Tyler B. 8/29/17 w/o sent back to consultant for revision and inclusion of channel repairs/stabilization.	(8/29/17) In process, calcs completed by HHD, consultant currently working on revisions.	YES	JPA, if work done at embankment failure "outfall"	NO		08/29/2017
5	030113	INFTREN	Y (FY17)		Y		09/09/2016		EAP, 9/19/16				Downgraded to a II b/c facility is not failing. Work that required JPA is being included under WPD/TMDL outfall project (Kelly Lennon - PM)	YES	YES	NO		
6	030225	INFTREN	Y (FY17)	BA-2	Y		09/09/2016		EAP, 9/19/16			PRD CONCEPT - SUBMISSION BOOK 1	Under construction	NO		NO		
7	030226	INFTREN	Y (FY17)	BA-2	Y		09/09/2016		EAP, 9/19/16			PRD CONCEPT - SUBMISSION BOOK 1	Complete.	NO		NO		
8	030227	INFTREN	Y (FY17)	BA-2	Y		09/09/2016		EAP, 9/19/16			PRD CONCEPT - SUBMISSION BOOK 1	Construction will begin in next 2 weeks	NO		NO		
9	030228	INFTREN	Y (FY17)	BA-2	Y		09/09/2016		EAP, 9/19/16			PRD CONCEPT - SUBMISSION BOOK 1	Construction will begin in next 2 weeks	NO		NO		
10	030229	INFTREN	Y (FY17)	BA-2	Y		09/09/2016		EAP, 9/19/16			PRD CONCEPT - SUBMISSION BOOK 1	Under construction	NO		NO		
11	030242	INFTREN	Y (FY17)	BA-1	Y		09/09/2016		EAP, 9/19/16			MAINT BOOK # 1	Construction will begin after 229.	NO		NO		
12	030244	INFTREN	Y (FY17)	BA-1	Y		09/09/2016		EAP, 9/19/16			MAINT BOOK # 1	Construction will begin after 229.	NO		NO		
													Site was retrofit under a roadway					

02-Anne Arundel | 03-Baltimore | 04-Calvert | 05-Caroline | 06-Carroll | 07-Cecil | 08-Charles | 09-Dorchester | 10-Frederick | 12-Harford | 13-Howard | 15-Montgomery | 16-Princes George ...

Figure 2-16: Work Order Tracking Details

The extra staff and efficiency of new systems are expediting the work order process, however the ability to perform needed remediation by a contractor will rest on the speed with which permits are granted. The PRD worked with the Asset Management team to determine the most efficient system possible under the current MDE regulations. Changes to the regulatory process to allow faster review and comment on all environmental approval aspects of remediation would have a significant impact on maintaining the functionality required by the NPDES permit. The General Approval process acknowledges this need and the fact that these sites have been previously permitted.

In FY 2016 remedial work orders were developed and approved and MDOT SHA expended approximately $1.4 million to perform major remediation. By contrast in FY 2017, fewer remedial work orders were developed and approved resulting in

expenditures of only $460,000. A summary of these efforts is shown in Tables 2-2 and 2-3 below. An example of one of these projects follow in Figure 2-17.

Table 2-2: BMP Major Maintenance Summary

County	District	BMPs for Major Maintenance	BMPs Maintained 10/2016 10/2017
Prince George's County	3	48	28
Total		**48**	**7**

Table 2-3: Major Maintenance Cost Year 2016 / 2017

Funding Allocation	Funding Amount
Prince George's County	$460,000
Total Costs	**$460,000**

Figure 2-17: Major Maintenance of BMP 030225 - Infiltration Trench

Before – Major Erosion & Media Replacement Needed ***During Major Maintenance***

B.3. Retrofit Design for Functional Enhancement and Remediation Projects

SWM facilities not currently functioning as originally intended and requiring major repair that cannot remain in the original design footprint or location, are assigned an action rating of "IV" by MDOT SHA and are placed on a list for retrofitting. Engineering solutions need to be developed to restore the treatment levels that had been provided by the original facility. These retrofitted facilities often require a SWM facility type change and new environmental permits. These permits do not fall under the general permit; therefore, it can take years to get projects fully designed, permitted and constructed. The projects will involve detailed engineering design and coordination. In addition to SWM facilities, drainage assets deemed in need of major remediation must also be addressed.

MDOT SHA continuously plans, designs and constructs functional enhancements and retrofits

for SWM facilities. Projects are funded using state and federal funds. Site selection for enhancement projects are evaluated using several factors, including feasibility, permitting process complexity, and benefit analysis. MDOT SHA often seeks opportunities to improve the efficiencies of older SWM facilities that currently provide only minimum water quality treatment. This provides greater reduction of pollutant loads from highway runoff.

As a part of MDOT SHA's improvement efforts, projects to improve water quality can result in treatment of additional impervious areas as well as provide replacement or an upgrade to the existing drainage infrastructure. This approach maximizes the MDOT SHA investment in SWM facility maintenance efforts. Projects also include rehabilitation of degraded outfalls, channel restoration, and slope stabilization. Retrofit projects may include reconstruction of a facility to restore function based on the most recent design criteria or to replace the older facility with modern SWM BMP or ESD. For example, a non-functional infiltration trench may be retrofitted to a bioretention facility with an enhanced filter to increase pollutant removal efficiency. The Asset Management team coordinates closely with the permit restoration team to choose sites ideal for retrofitting. The permit restoration sites are the first to be screened out of the list. These sites will offer maximum benefit to permit restoration efforts and these candidate sites are considered for the design, permit and construction efforts. Remaining sites in disrepair are kept on the Asset Management team and processed as described. A summary of these efforts is shown in Table 2-4 below.

Table 2-4: BMP Enhancement and SWM Retrofit Projects Summary

No.	Project	County	No. of BMPs	Contract Number	Construction Cost Estimate	Status
1	MD 32: Infiltration Basins Retrofit	AA	9	AX9315174	Actual cost $1.9M	Construction completed in fall 2016
2	US 50: Infiltration Basins Retrofit	AA	3	AA822A21	Estimate $1.5M	Under design to be advertised in fall 2017
3	Enhancement of SWM Facility 150173 and Outfall Stabilization	MO	1	MO6735174	Actual cost $1.4M	Construction completed in spring 2017
4	I-270: SWM Facility 150556 Retrofit	MO	1	MO106A21	Estimate $0.5M	Under design
5	MD 235: SWM Retrofit and Drainage Improvement	SM	1	SM3565174	Estimate $0.5M	Under construction (completion date spring 2018)
6	I-695: Minebank Run Stream Restoration, Drainage and Water Quality Improvements	BA	1	BA7125174	Estimate for SWM portion $2.0M	Under design to be advertised in fall 2017
	Total		**16**		**$7.8M**	

C. Construction

Major remediation and retrofit activities are performed to address significant deficiencies of SWM facilities. During FY 2017, MDOT SHA Office of Highway Development, which houses the Drainage SWM Asset Management Program, made significant changes to their

office policy on construction activities. The contracting mechanisms previously set up to expedite repair activities were abruptly eliminated at the start of the construction season. This limited the amount of work completed during the FY 2017 construction season as the team focused on pursuing new contracting routes thru District Construction or Maintenance teams and other avenues.

Activity schedules are determined by an internal priority list based on the last inspection date combined with the length of time the function of the facility has been at risk. In addition, geospatial data is also used to help combine activities together so they can be performed on multiple facilities in proximity to one another. This allows work to be completed with greater efficiency and lower cost. The purpose of the construction activities is to restore the performance of the asset as well as prevent failure of specific functional elements. Actions may include dredging, sediment removal, and obstruction removal within pipes. Work also may include removal of sediment from facilities to maintain the required water volume. Often larger scale activities include total reconstruction to upgrade a facility in an attempt to enhance function and increase treatment capacity.

Figure 2-18: SWM Retrofit Construction of SWM Facility 150173

Before Construction –Failed Infiltration Basin

During Construction

After Construction – Submerged Gravel Wetland Newly Inspected 2017

C.1. Area Wide Contracts

Many drainage systems and stormwater facilities remediation activities are performed through open-end construction contracts. Historically MDOT SHA administered concurrently 2-4 area wide (AW) contracts to address deficiencies of stormwater facilities, drainage system repairs or outfall channel stabilization. Over the years, this construction mechanism had been proven to be the most efficient and effective construction method to timely address urgent drainage and stormwater needs. The annual expenditures of the AW contracts vary from $5 to $7 million.

Because of the changes to MDOT SHA Contracting mechanisms previously mentioned, the Asset Management team made several presentations to staff who would be assigned to administering these contracts. Presentations were given at both the State-Wide Quality Council Meeting on May 11, 2017 and at the District 1 Team Leader Day on June 16, 2017 to introduce the new contracting options now available.

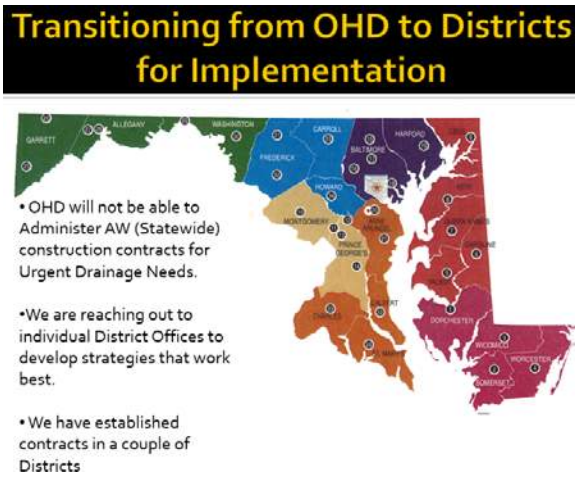


Figure 2-19: Construction Contract Transition Illustration

Discussions and review of various contract types occurred at each presentation and were followed by smaller meetings with key personnel to begin to coordinate specifics for each new contract. The Open-End Drainage/SWM Asset Remediation contracts were customized for each area's preferences. Those with contracts will be able to do remediation work on drainage assets such as pipes, conveyances and structures and to also work on the remediation efforts needed on SWM facilities.

Figure 2-20: Open End Contract Introduction

In the past year, MDOT SHA performed major remediation of 7 stormwater management facilities in Prince Georges County, the total construction cost of SWM facilities major remediation under areawide contracts was $460,000. Planning for new contracts through various sources have been put in motion and are discussed in the Future Focus Section E of this report.

C.2. Immediate Response

In the event of an emergency, MDOT SHA immediately performs work to ensure public safety. MDOT SHA responds to any outfall, pipe or SWM facility failure that requires immediate repair and remediation. These situations are rarely found during routine inspection of the SWM facilities, but can be more prevalent with drainage structures. Roadways are closed as necessary and detour routes are implemented as needed. Maintenance crews will usually perform emergency stabilization immediately. Site assessment and investigation occurs at the subject location within hours by a multi-disciplinary team. Plan development is initiated within 24-hours and a contractor is mobilized within a few days.

C.3. Bid-Build Contracts

Most of the SWM major retrofit projects have been implemented through traditional bid-build contracts. In the Fall of 2016, nine SWM facilities retrofits were completed along MD 32 in Anne Arundel County. One additional project in this county to restore the functionality of 3 facilities is under design to be advertised in the Fall of 2017. Within Montgomery County, one project was completed Spring 2017 and one last project is under design. Baltimore and Saint Mary's Counties each have projects under design or construction and are anticipated to be completed sometime during 2018. Table 2.4 shows a summary of all of these projects and is shown earlier in this report.

MDOT SHA continues to search for potential SWM sites to provide treatment of currently untreated impervious surface and maintain positive balance in the MDOT SHA Water Quality Bank. Several suitable sites have been identified, retrofit projects are in the planning stage and the design will be initiated in the upcoming years.

D. Operations

District operations are key in preventive maintenance of the SWM facilities to assure long term sustainability. A systematic approach over time is continually being developed. This system shifts the overall approach from one of reaction to drainage complaints and emergencies to one of proactive asset management. Catching problems before they arise or become severe reduces costs, allows planning for better spending and ensures higher degrees of public safety. MDOT SHA increased coordination efforts during FY 2017 and established meetings involving teams from Office of Maintenance, Districts and the Asset Management team. This coordination effort included meetings with Resident Maintenance Engineers, Assistant District Engineers, Directors of Office of Maintenance and Team Leaders and other workers. This increased communication showed a positive trend in the increase in awareness as well as training about the maintenance of drainage and SWM assets.

D.1. Minor Maintenance

SWM facilities requiring minor upkeep are assigned "II" rating by MDOT SHA. Minor repair activities are performed by District Operational staff or their contractors to help ensure that facilities remain functioning as designed. New procedures and support software are currently being explored at MDOT SHA to better address the various routine maintenance needs of the growing inventory. Routine upkeep or minor and preventive repairs are generally activities that address minor deficiencies and may include actions such as mowing, brush cutting, vegetative thinning, unwanted woody vegetation removal, invasive weed removal, and trash or debris removal. The purpose of the maintenance activities is to maintain the performance of the SWM facilities and prevent or eliminate conditions that deteriorate function. SWM facilities that are functioning as designed are kept on a schedule with District Maintenance in order to maintain their assigned "I" rating.

D.2. Minor Maintenance Procedures

MDOT SHA completed an operational manual for stormwater and drainage assets during FY 2016. The first edition of this manual was completed and distributed to all shops in the MS4 jurisdictions. The practices outlined in each manual are specific to facility type and input from several offices and divisions was pooled to provide valuable information on the proper procedures and equipment needed. This same format was used for the additional shops statewide that have begun receiving updated manuals. Table 2-5 shows the summary of shops and manual distribution dates. Minor updates to the manual were implemented based on feedback and additional proofreading. Meetings with the shops are being scheduled for the winter 2017 to determine any needed information that make an update necessary at this time. The manuals contain maps of the locations of all SWM facilities within the area of influence of the shop so maps will also require updates to keep shops aware of the growing number of facilities. This will ensure that newly constructed facilities are maintained

and retain their functional capacity in the long term.

Table 2-5: Shop Manual Distribution Summary

District	Shop Name	Distribution Timeframes
1	Cambridge	October 2017
1	Princess Anne	October 2017
1	Salisbury	September 2017
1	Snow Hill	October 2017
2	Centerville	October 2017
2	Chestertown	October 2017
2	Denton	October 2017
2	Easton	October 2017
2	Elkton	April 2016
3	Fairland	April 2016
3	Gaithersburg	April 2016
3	Laurel	April 2016
3	Marlboro	April 2016
4	Churchville	April 2016
4	Golden Ring	April 2016
4	Hereford	April 2016
4	Owings Mills	April 2016
5	Annapolis	April 2016
5	Glen Burnie	April 2016
5	La Plata	April 2016
5	Leonardtown	October 2017
5	Prince Frederick	July 2017
6	Hagerstown	April 2016
6	Keysers Ridge	October 2017
6	La Vale	October 2017
7	Dayton	April 2016
7	Frederick	April 2016
7	Westminster	April 2016

E. Future Focus

As MDOT SHA moves forward, the environmental regulations continue to evolve and include additional environmental stewardship. This pushes the program design and management to continually improve. This includes continuing to expand the size of the

NPDES programming resources. Accomplishing this requires that the program is focused on the future at all times and undergoes continuous planning efforts which include business process improvement, research and additional program support.

Future inspections activities for SWM facilities, IDDE screenings and Source ID are in the planning stages. These plans look several years into the future and are included in Part 1 of this report. In addition to the planning based on inspection records, retention of baseline credit is used to prioritize work performed on the SWM BMPs. A summary of this decision-making process is included in Table 2-6 below:

Table 2-6: Example Triennial Inspection Ratings and MDOT SHA Actions

SWM BMP Rated	Inspection Dates 1/15/2004	1/15/2007	1/15/2010	Scheduled Remediation Completion Date	Actual Remediation Completion Date
I	**PASS**– WQ treatment kept in reported data	**FAIL** – Minor remediation or major maintenance needed, WQ treatment kept in reported data	**PASS** – WQ treatment kept in reported data		
II	**PASS**– WQ treatment kept in reported data	**FAIL** -- Initial failed rating, WQ treatment kept in reported data	**FAIL** -- Major remediation needed; Remediation schedule provided to MDE, WQ treatment kept in reported data	**PASS** – WQ treatment kept in reported data	
III	**PASS**– WQ treatment kept in reported data	**FAIL** -- Initial failed rating, WQ treatment kept in reported data	**FAIL** -- Major remediation needed; Remediation schedule provided to MDE, WQ treatment kept in reported data	**FAIL** – WQ treatment removed from baseline treatment or restoration credit	**PASS** – WQ treatment added back into reported data

E.1. Business Process Improvement

The future focus of the program includes strategic planning efforts to improve business processes such as design, permitting, communication and tracking these improvements to better serve our customers and develop new technological resources. The following includes plans for future development, improvement and expansion of the existing program.

Technology Upgrades on Both Hardware and Software for database, inspections and ratings

The servers housing the NPDES GIS data are undergoing an upgrade. This upgrade is currently scheduled for November 2017 and will include software upgrades to more current technologies. At the time, GIS Data management procedures and database schema will be examined to increase efficiency and decrease potential conflicts or errors. Additional fields may be added or removed as the program continues to evolve.

The Inspection Tools for SWM facilities will be modernized and upgraded to optimize the program. During FY 2017, the MDOT SHA has been working on the design of the upgraded field inspection tool. This tool will be an integration of two Commercial-Off-the-Shelf (COTS) products made by ESRI. An integrated tandem interface of Survey 1-2-3 and

ArcCollector will be used as the new Inspection Tool and will include several upgraded features, including the following:

- Improved real time data management,
- Flexible hardware / device requirements
- Additional inspection forms for underground facilities,
- Tool tips for inspection parameters that reference and allow access to the Visual Guide for BMP inspection created during the inspector training in April 2017
- Required photograph for documentation of poor ratings for individual BMP components

Along with the server, software and Inspection Tool upgrades, a new Rating Tool is also under development. The new Rating Tool has been designed as an extension of the existing eGIS software architecture. The Asset Management team has worked closely with the design team on the look, feel and function of the new rating tool. It will provide features to make the rating process more efficient including side by side viewing of the inspection data and rating data, larger photo format and additional commenting ability and viewing. The tool will also feature additional ratings beyond those explained in Section B.1. The new ratings are outlined in Table 2.7 and will allow for enhanced tracking and coordination of inspections, retrofit work and treatment provided. The new tool will also generate reports directly from the database once ratings have been loaded and quality control performed.

Table 2-7: Future Remediation Ratings System

Rating	Description
I	No Maintenance
II	Minor Maintenance
III	Major Maintenance
IV	Retrofit/Functional Enhancement Recommended
IVA	Retrofit/Functional Enhancement in Progress (TMDL)
IVB	Retrofit/Functional Enhancement in Progress (HHD)
V	Immediate Response
VI	Abandon
X	Not SHA Facility (No SHA impervious treated)
XX	All Others Categories / Temporary Rating for Business Plan
T	Not SHA Facility (SHA impervious treated / MDE Tracking purposes only)
R	Re-Inspection Needed

While all of the technological works are separate, they are also interdependent so a schedule was developed incorporating all the above-mentioned aspects of the program. This schedule is subject to change as development, testing and implementation unfold. This tentative schedule is featured in Table 2-8 below.

Table 2-8: Estimated Upgrade Schedule for Database, Inspection, Rating Tools

Description	Target Start Date	Target End Date
Survey 1-2-3 Configuration	September 2017	October 2017
Arc Collector Configuration	September 2017	October 2017
System Assumptions and Constraints Analysis	September 2017	September 2017
Data Extraction from Original Database and Load to New	October 2017	December 2017
Web App Configuration for Inspections and Ratings	October 2017	November 2017
Internal Testing of Full System Upgrade	October 2017	November 2017

Table 2-8: Estimated Upgrade Schedule for Database, Inspection, Rating Tools

Description	Target Start Date	Target End Date
External and Field Testing	November 2017	January 2018
Updates to Standard Operating Procedures	November 2017	December 2017
Launch of New Ratings Tools	January 2018	
Inspection and Rating Training on New Software	February 2018	March 2018
Full Launch of New Inspection Tools	March 2018	
Known Risks Include: • Architecture Constraints affecting Scope and Schedule, • ESRI technology evolution effecting Scope, and • Competing Priorities effecting schedules.		

DoIT Investigation into Asset Management Software for MDOT

During FY18 MDOT SHA will be investigating asset management software solutions to improve our business process workflows and maintenance tracking and reporting efforts.

Updated Specifications and Documentation

As part of the forward thinking development of the Drainage and SWM Asset Management program, design procedures are also examined. Well-designed facilities make routine maintenance easier. Routine maintenance is the key to keeping the majority of facilities functioning as designed. One place where information has been lacking is when remediation efforts are made; good documentation of what has been done is prepared in order to support future inspections. For remediation work, no As-Built Certification is necessary because plans of original function construction are marked up and used as the guide for remediation efforts. As the BMPs were rated during FY 2017, it was often noted that determining how well the facility was performing was difficult because of a lack of documentation. The Asset Management team along with designers and specification writers have started working on a brief As Built specification and checklist to be included on FY 2018 remediation projects. This is expected to be included in the contracts Advertising in December 2017 with Notice to Proceed in March 2018. The Asset Management team will track the effectiveness of the specification in how much data they receive back from contractors as projects are completed. If followed, the inspection and subsequent checklist will significantly reduce the amount of time spent on inspections post-construction. During FY 2017, the As-Built process for new construction projects that include BMPs was updated and this has influenced the development of the process for remediation work.

E.2. Additional Program Support

Through all the work that the Drainage and SWM Asset Management Program completes in a year, it receives a lot of support from others. During FY 2017, this support was expanded in the places listed below:

PRD Support while Awaiting Approval of MDE General Permit for Remediation

Historically, the work completed for major remediation efforts fell under a General Permit for Maintenance and Remediation. This permit allowed for faster review times for remediation work that will return the facilities to fully functioning. This work is designed to restore what was originally built so detailed plans are not put together, but rather marked on the original plan set to show deficiencies and a punch list of work is provided. The approval

process for the General Permit through MDE has been delayed thru FY 2017 so individual submissions for each design have been required. To help support the program goals to restore any impaired BMPs to functioning in a timely manner Asset Management team members met with PRD and Environmental Permitting staff to create a system to help expedite work order approval. The group worked together to look at the General Permit submissions that have been made as well as any included MDE comments to address. These comments were addressed and some information the PRD requested was added and this updated document is making its way thru the approval process at this time. Once approved, this concept will then be used as a template for future contracts and work order reviews so they may be reviewed quickly at the Site Development and Final Stages instead. This approach will help the Asset Management team process and produce more work orders during FY 2018.

Contracting Changes and Expanded Remediation and Retrofitting Capacity

As previously mentioned, during FY 2017 the contracting mechanisms previously set up to expatiate repair activities were abruptly eliminated from the Office of Highway Development which houses the Asset Management team. While this limited the amount of work that was completed during the FY 2017 construction season it also created the opportunity to pursue new contracting routes thru several different avenues. The District Construction and Maintenance teams were the first place that contracts should logically be administered. The Asset Management team delivered presentations and held meetings with all 7 Districts to collaborate on the best way to support them in setting up these contracts. In addition, a project for The Secretary's Office is in the process of re-advertising for contractors and has been enhanced with remediation work in the immediate vicinity. This will allow for additional work on the program to be completed with other needed upgrades that were otherwise not attracting adequate contractor interest to be completed well.

Another avenue that has been investigated and is in development is a Turn Key Design Build Contract System that would create a framework for contractors and consultants to work together in a Design/Build style mechanism to fully both retrofit and remediate an area based on geography. This prototype is being developed and tested in Montgomery County.

The final new mechanism for contracting that will be put in place during FY 2018 as a more urgent needs system will be administered through the Office of Environmental Design. This system will run very similarly to the Innovative Contracting Division previously within Office of Highway Development.

The expansion of these contracting mechanisms may prove to be a huge benefit to the efficiency and speed with which facilities can be returned to functioning as designed. Throughout FY 2018 this will be tracked and reported for the program. Current planning is for approximately $37 million over the next 3 to 5 years for these various approaches.

F. Summary

The NPDES MS4 permit requires MDOT SHA to identify all infrastructure that captures, treats, and conveys stormwater runoff from all its facilities including hydraulic structures and stormwater management facilities that fall within the 11 designated MS4 jurisdictions. During FY 2017, MDOT SHA performed many inspections of unique SWM facilities were performed with additional re-inspections as needed. Through working in the Drainage and Asset Management comprehensive inspection and rating system to prioritize and plan remedial preventive maintenance activities, MDOT SHA worked on the associated permit conditions and MDOT SHA Business Plan goals. The key goal for this program is to maintain 90 percent of all MDOT SHA-owned SWM facilities at full functionality. During FY 2017 several internal changes to how MDOT SHA does business slowed the work on this goal and a functionality rating of just 84.08% was reached within the NPDES jurisdictions. Figure 2-19 on the following page shows the functional ratings and

the projected overall SWM inventory growth and trend.

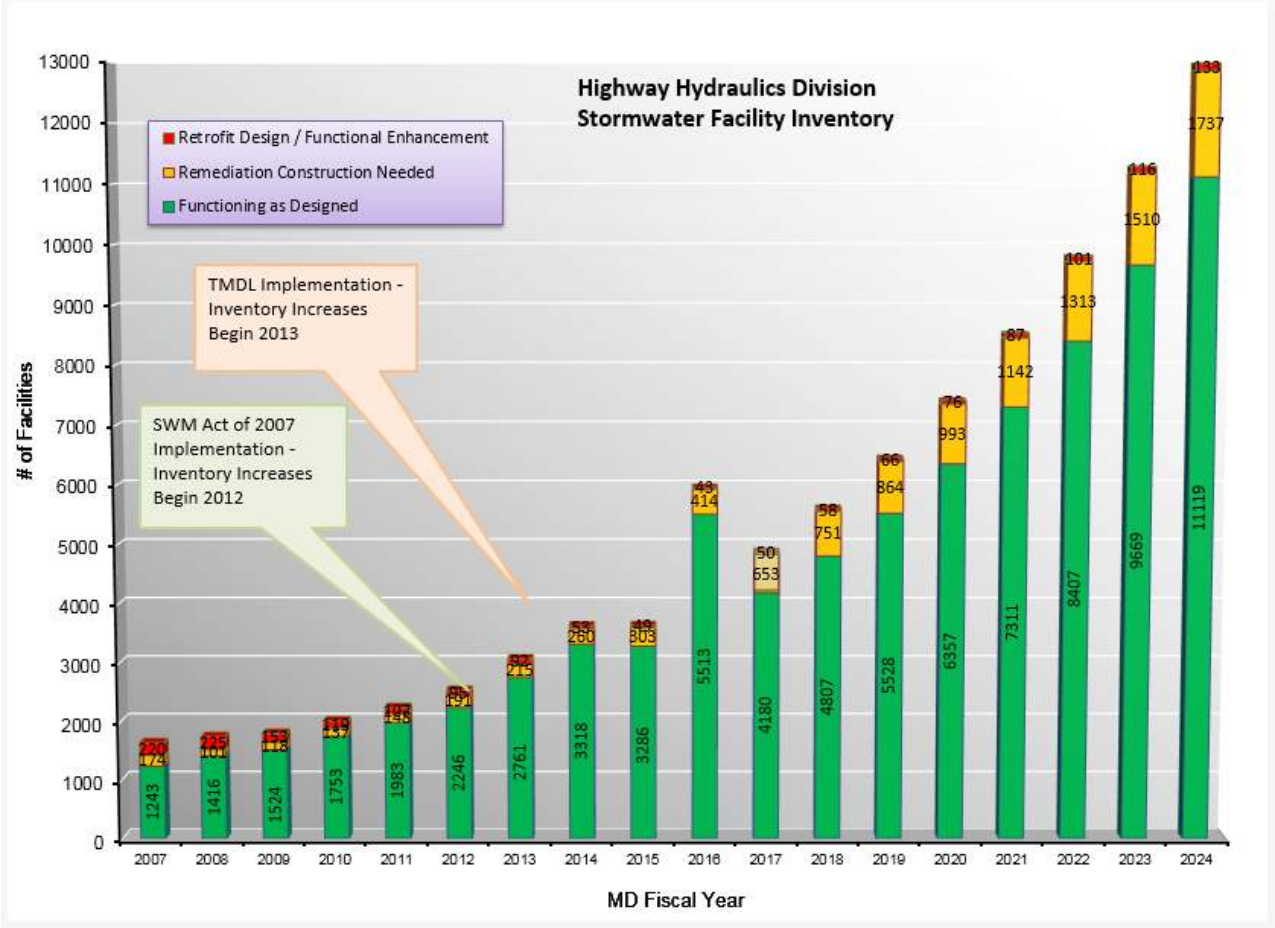


Figure 2-21: Statewide SWM Inventory Functional Rating and Projected Trend

While certain aspects of the program were seeing a temporary slowdown because of changes, preparation for expansion in capacity to remediate, maintain and retrofit facilities as well as organization and data management for both facility action rating and work order development were expanded. This expansion in resources led to several improvements in the overall process including retraining inspectors, creating a visual guide for inspection team reference resulting in higher quality inspection data submittals enabling improvements to future planning activities. This accompanied by major data management changes that have been planned and are underway. The upgrades to the GIS data servers, database schema, inspection tools, rating tools and the possible introduction of a full-scale asset management software program will provide significantly better data, tracking and communication and are all anticipated to have continued positive impacts on the program.

As the internal processes of the program were expanding, it was also reaching out to other Offices within MDOT SHA and expanding in those areas as well. Meetings, presentations for staff education and coordination on the part of many involved in the MS4 permit compliance teams resulted in a much higher degree of communication for minor maintenance activities. Innovation is beginning to be presented from maintenance personnel to help

facilitate this work and the tracking of these needs.

In conclusion, the program is poised for ongoing changes in the upcoming year. All plans are subject to change, delay and update, but team members remain optimistic about reaching these goals.

Appendix A

Restoration Accounting Methodology

Appendix A

Restoration Accounting Methodology

MARYLAND DEPARTMENT OF TRANSPORTATION™

STATE HIGHWAY ADMINISTRATION

Table of Contents

Table of Contents 1
1.0 Introduction 2
1.1 Purpose 2
1.2 Restoration Treatment Timeframe Determination 2
1.3 Restoration Impervious Accounting 3
2.0 Stormwater 5
2.1 Stormwater BMPs - Restoration IAC Calculation 5
2.2 Total Stormwater Restoration BMPs IAC Sum 36
3.0 Stream Restoration 41
3.1 Stream Restoration IAC Calculation 41
3.2 Total Stream Restoration IAC Sum 56
4.0 Outfall Stabilizations 58
4.1 Outfall Stabilization IAC Calculation 58
4.2 Total Outfall Stabilization IAC Sum 69
5.0 Tree Plantings 72
5.1 Tree Planting IAC Calculation 72
5.2 Total Tree Planting IAC Sum 89
6.0 Impervious Area Removal 93
6.1 Impervious Area Removal IAC Calculation 93
6.2 Total Impervious Area Removal IAC Sum 104
7.0 Inlet Cleaning 107
7.1 Inlet Cleaning IAC Calculation 107
7.2 Total Inlet Cleaning IAC Sum 112
8.0 Street Sweeping 114
8.1 Street Sweeping IAC Calculation 114
8.2 Total Street Sweeping IAC Sum 118
9.0 Redevelopment Credit 122
9.1 Redevelopment Credit IAC Calculation 122

1.0 Introduction

1.1 Purpose

The vision of this document is to detail the technical process of calculating restoration impervious area credit (IAC) using the MDE MS4 geodatabase, so that MDOT SHA can provide a clear basis of understanding for how the IAC value is calculated for restoration treatment across each of the implemented strategies. The MDE MS4 geodatabase does not explicitly provide a method to report the IAC *and* all core input values for each strategy.

The process and methodology to calculate IAC for each strategy, based on parameters reported within the MDE MS4 geodatabase, is the subject of this document.

1.2 Restoration Treatment Timeframe Determination

MDOT SHA's jurisdiction is linear in nature, which means that it crosses many other jurisdictions and watersheds, which limits the ability to have consistency in the imagery and datasets used to compile the impervious surface data. The information available varies by jurisdiction and quality. MDOT SHA has a variable baseline year across the jurisdictions where our right-of-way is located. The baseline years are presented in the table below for reference:

County	Baseline Date
Anne Arundel	12/31/2005
Baltimore	12/31/2005
Carroll	12/31/2005
Cecil	12/31/2005
Charles	12/31/2004
Frederick	12/31/2005
Harford	12/31/2004
Howard	12/31/2002
Montgomery	12/31/2004
Prince George's	12/31/2005
Washington	12/31/2005

MDOT SHA determined restoration treatment provided after the baseline year based upon the following fields within the MDE MS4 geodatabase for each strategy that MDOT SHA has implemented:

Strategy	MDE MS4 Geodatabase Feature Class	Baseline/Restoration Determining Field
Outfall Stabilization	AltBMPLine	IMPL_COMP_YR
Stream Restoration	AltBMPLine	IMPL_COMP_YR
Tree Planting	AltBMPPoly	IMPL_COMP_YR
Impervious Removal	AltBMPPoly	IMPL_COMP_YR
Street Sweeping	AltBMPPoly	IMPL_COMP_YR
Inlet Cleaning	AltBMPPoly	IMPL_COMP_YR
Stormwater*	BMP RestBMP	BMP.BUILT_DATE RestBMP.INSTALL_DATE

**By nature of the MDE MS4 geodatabase entity in which it is located, a Stormwater BMP can be determined to be baseline or restoration. The focus of this document will be on the RestBMP feature class.*

To quickly identify restoration treatment for each BMP in the MDE MS4 geodatabase, MDOT SHA has used comment and description fields available within the MDE MS4 geodatabase to insert text that identifies the feature as restoration. The process to identify restoration credit and calculate the impervious credit provided is detailed for each strategy below.

1.3 Restoration Impervious Accounting

In July 2017, MDOT SHA delivered to MDE a complete reassessment of the baseline impervious accounting, 20 percent impervious restoration goal, and detailed responses to the specific comments included in MDE Attachment II. MDOT SHA tracks restoration progress achieved by implementation strategy and reports the impervious treatment credit (acres) accomplished during the reporting period in the Annual Report and the MDE MS4 geodatabase. The restoration progress is tracked annually in accordance with compliance to the MDOT SHA 2016 Implementation Plan.

The restoration treatment (acres) accomplished by strategy type for the timeframes between the variable baseline year though FY2017 is presented in Table 1-26 in Section E.4.a within Part One of the Second Annual Report dated October 9, 2017. The table is provided below for reference. The goal of this document will be to guide MDE to replicate each of the impervious credit numbers presented below using the MDE MS4 Geodatabase and GIS step-by-step procedures to generate the same results.

Strategy	Variable Baseline Year - 2015	2016	2017	Total
	(acres)	(acres)	(acres)	(acres)
Impervious Surface Elimination (to Pervious)	0.49	0.00	1.89	2.38
New Stormwater	87.41	53.53	54.77	195.71
Grass Swales	0.00	9.07	11.60	20.67
Outfall Stabilization	0.00	2.00	16.25	18.25
Retrofit	0.00	94.43	4.78	99.21
Stream Restoration	444.04	137.24	67.00	648.28
Tree Planting	598.27	66.65	22.09	687.01
Redevelopment Credit	0.00	0.00	81.00	81.00
Inlet Cleaning	0.00	0.00	150.00	150.00
Street Sweeping	0.00	0.00	33.00	33.00
Totals	**1,130**	**363**	**442**	**1,936**
20% Restoration Target				**4709**

Note: This Table can be found in Section E.4.a within Part One of MDOT SHA's 2017 MS4 Annual Report as Table 1-26

The procedures for performing this restoration impervious accounting are detailed below.

2.0 Stormwater

Calculating the impervious treatment credit for Stormwater BMPs requires three (3) primary inputs:

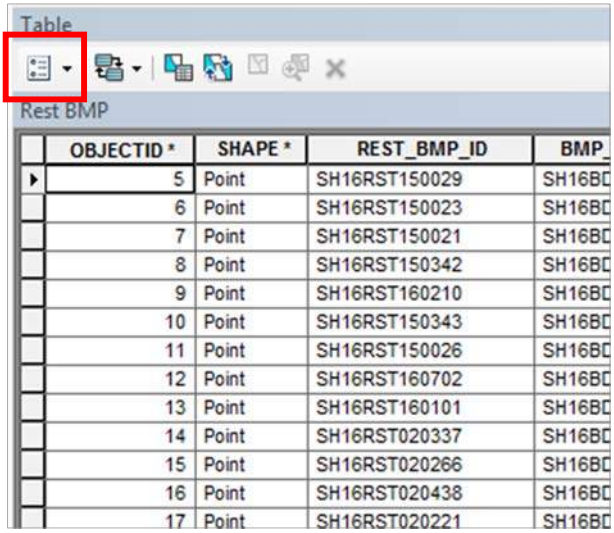
- Impervious acres, from within the MDE MS4 geodatabase (RestBMP feature class' IMP_ACRES field)
- PE treated factor, from within the MDE MS4 geodatabase (RestBMP feature class' PE_ADR field)
- Impervious Area equivalent factor, from Table 7 of MDE's August 2014 guidance (1.0 for stormwater BMPs)

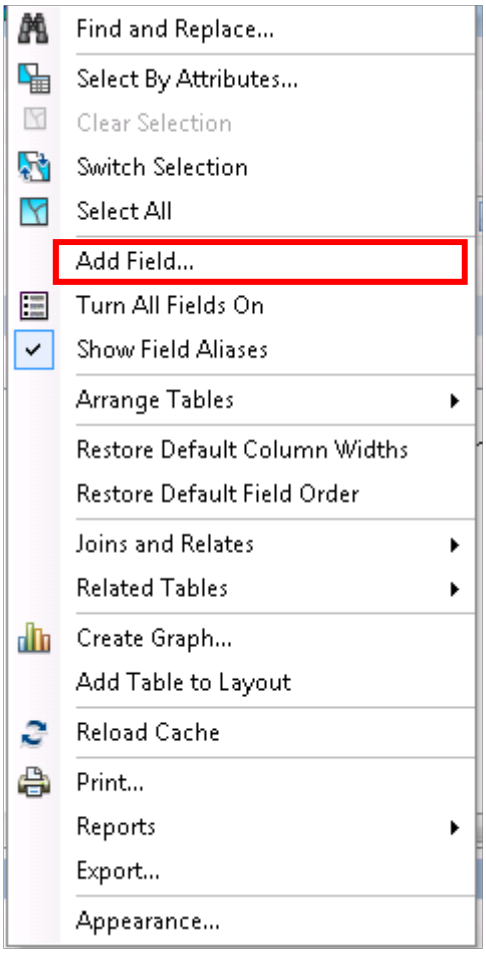
2.1 Stormwater BMPs - Restoration IAC Calculation

Because multiple inputs and a complex equation are required to calculate IAC for restoration stormwater BMPs, this example will add a new, temporary field to the RestBMP feature class. This process could also be done in Excel after exporting the RestBMP feature class (the calculation of IAC in Excel is not described within this document).

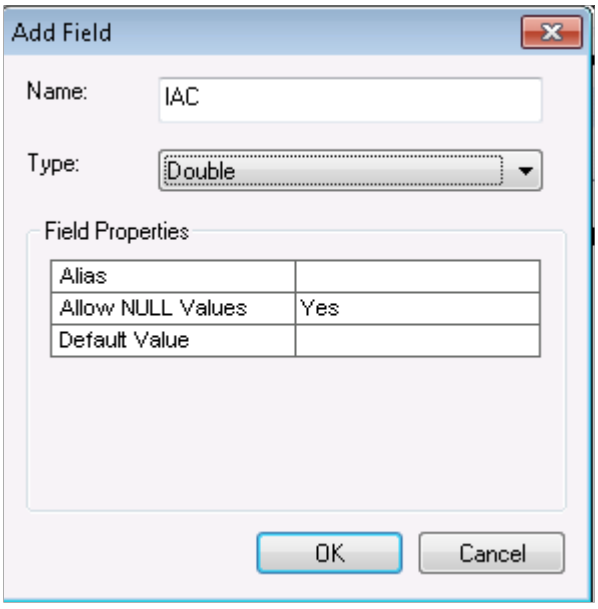
2.1.1 Add New IAC Field

- Within the RestBMP attribute table, click the Table Options button, and select "Add Field…"





- Within the Add Field dialog window, enter the new field name – "IAC". Set Type = Double. Accept the default Allow Nulls setting. Click "OK".



2.1.2 Calculate IAC Where Pe <= 1

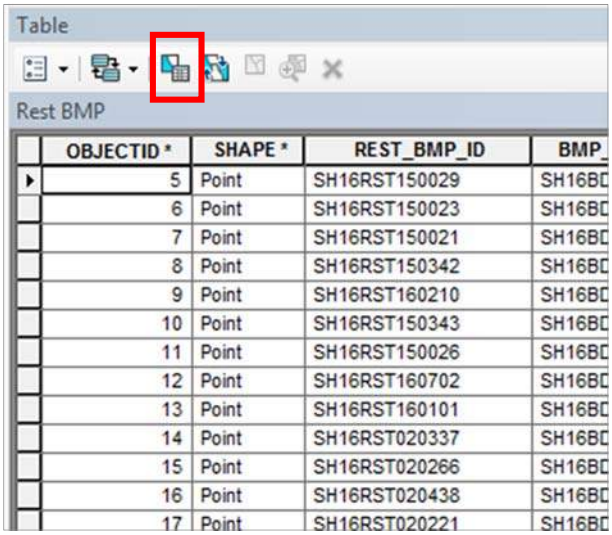
Because the IAC calculation differs where the Pe value is less than or equal to 1, from when the Pe value is greater than 1, the calculation of IAC will be performed twice – once for each Pe range.

The IAC formula where Pe <= 1 is as follows:

IAC = Pe x IA

Select where Pe <= 1

- Within the RestBMP attribute table, click the Select by Attributes button. The Select Attributes window will appear.

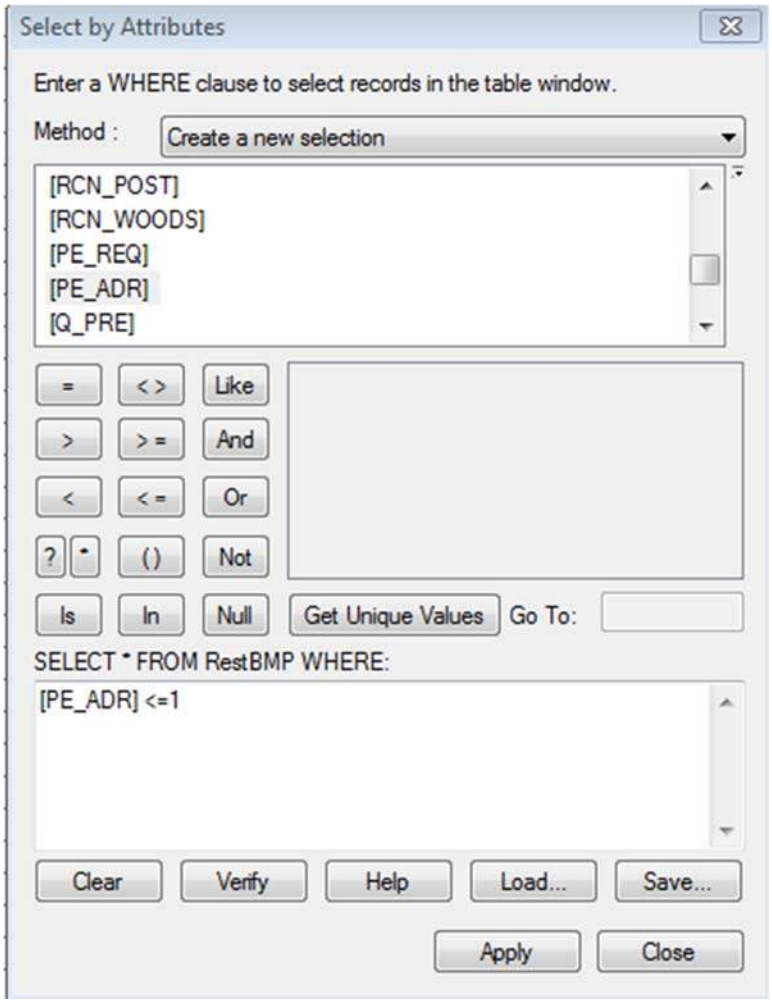


OBJECTID *	SHAPE *	REST_BMP_ID	BMP_
5	Point	SH16RST150029	SH16BD
6	Point	SH16RST150023	SH16BD
7	Point	SH16RST150021	SH16BD
8	Point	SH16RST150342	SH16BD
9	Point	SH16RST160210	SH16BD
10	Point	SH16RST150343	SH16BD
11	Point	SH16RST150026	SH16BD
12	Point	SH16RST160702	SH16BD
13	Point	SH16RST160101	SH16BD
14	Point	SH16RST020337	SH16BD
15	Point	SH16RST020266	SH16BD
16	Point	SH16RST020438	SH16BD
17	Point	SH16RST020221	SH16BD

- Within the Select by Attributes dialog window, enter the following selection statement to identify BMPs where the Pe addressed is less than or equal to 1, and click “Apply”:

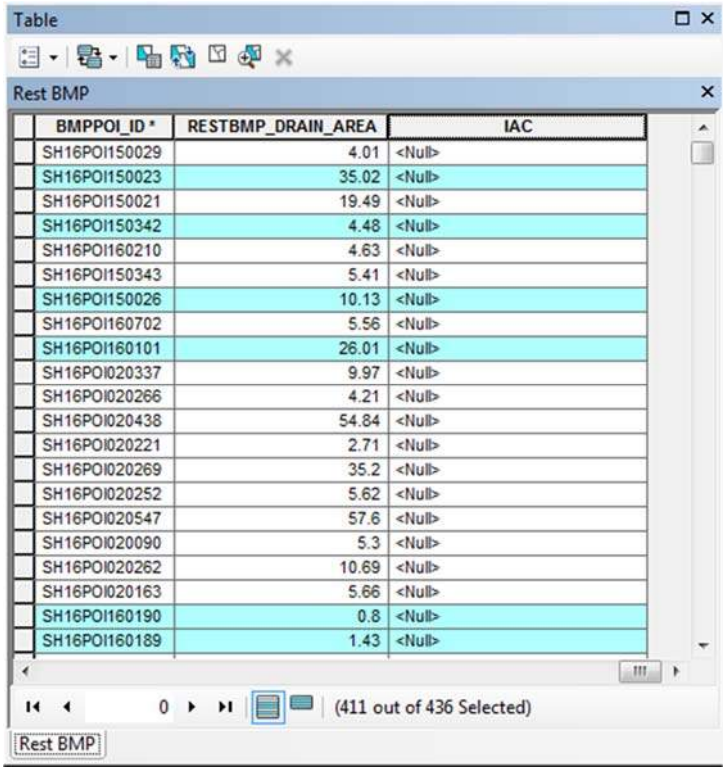
  [PE_ADR] <= 1

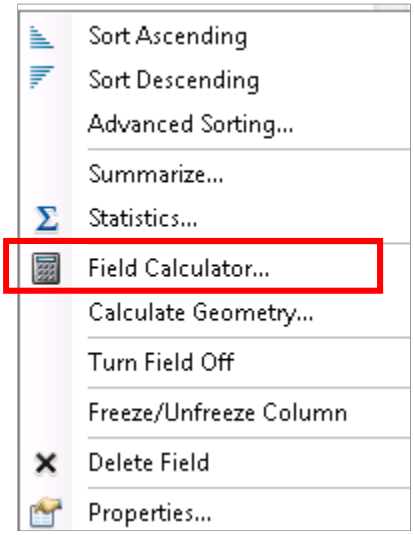
  Selecting these records will ensure that when the IAC calculation is applied, it is done so for the correct BMPs, based upon Pe value.



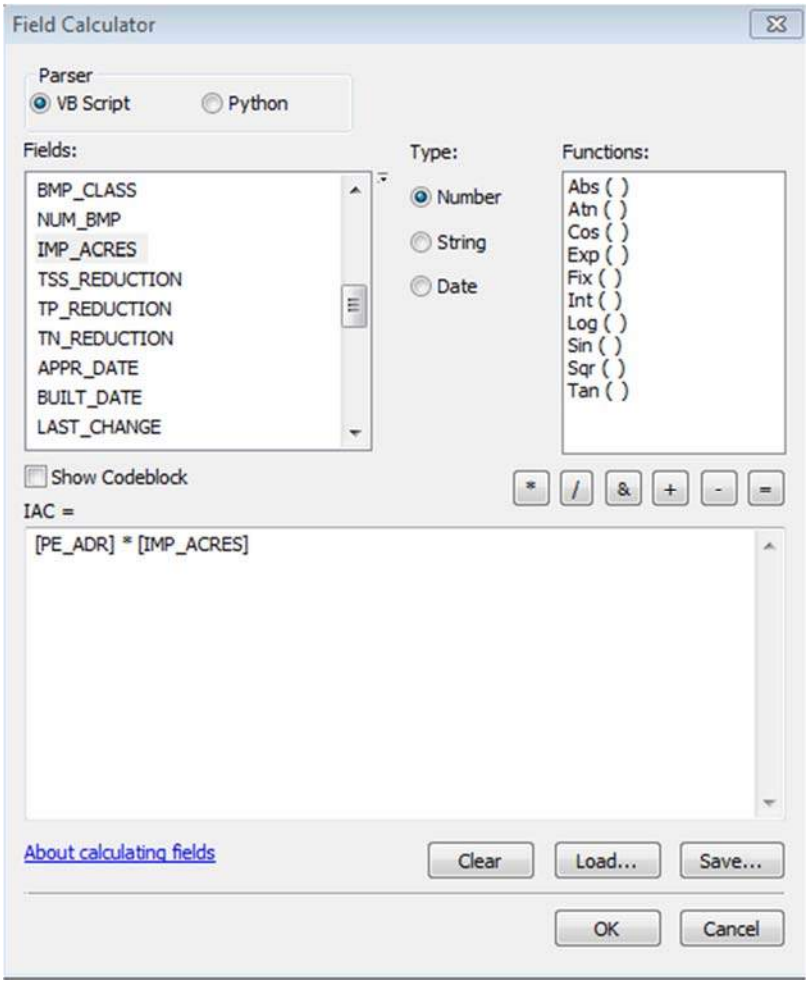
Calculate IAC for Pe <= 1

- Ensuring that the selection is retained, right click on the new IAC field, and select “Field Calculator…”





- Within the Field Calculator dialog window, enter the following calculation, and click “OK”:
  [PE_ADR] * [IMP_ACRES]



2.1.3 Calculate IAC Where Pe > 1

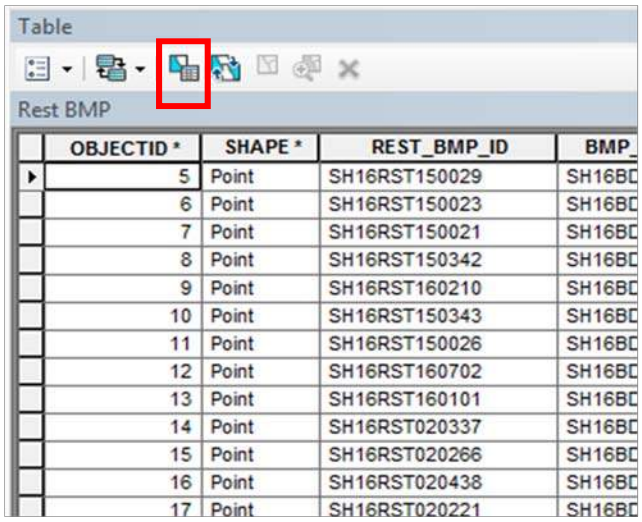
Because the IAC calculation differs where the Pe value is less than or equal to 1, from when the Pe value is greater than 1, the calculation of IAC will be performed twice – once for each Pe range.

The IAC formula where Pe > 1 is as follows:

IAC = IA x [((Pe – 1)/0.4) x 0.1] + IA

Select where Pe > 1

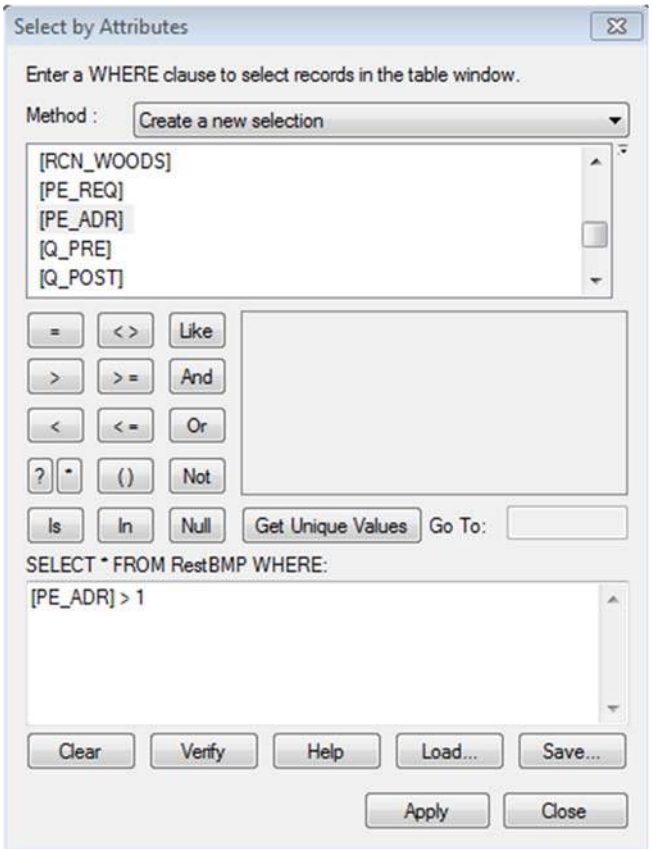
- Within the RestBMP attribute table, click the Select by Attributes button.



- Within the Select by Attributes dialog window, enter the following selection statement to identify BMPs where the Pe addressed is greater than 1, and click “Apply”:

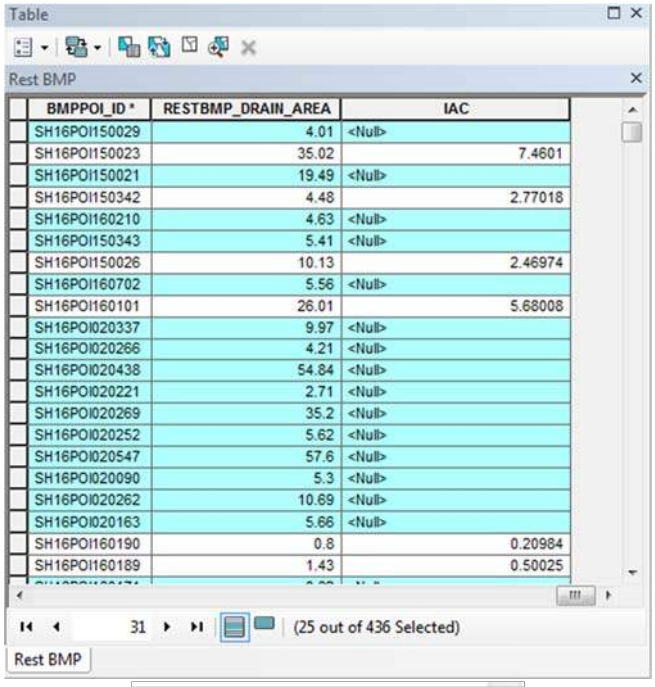
  [PE_ADR] > 1

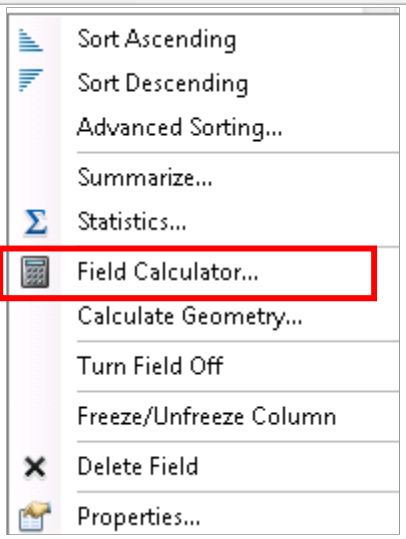
  Selecting these records will ensure that when the IAC calculation is applied, it is done so for the correct BMPs, based upon Pe value.



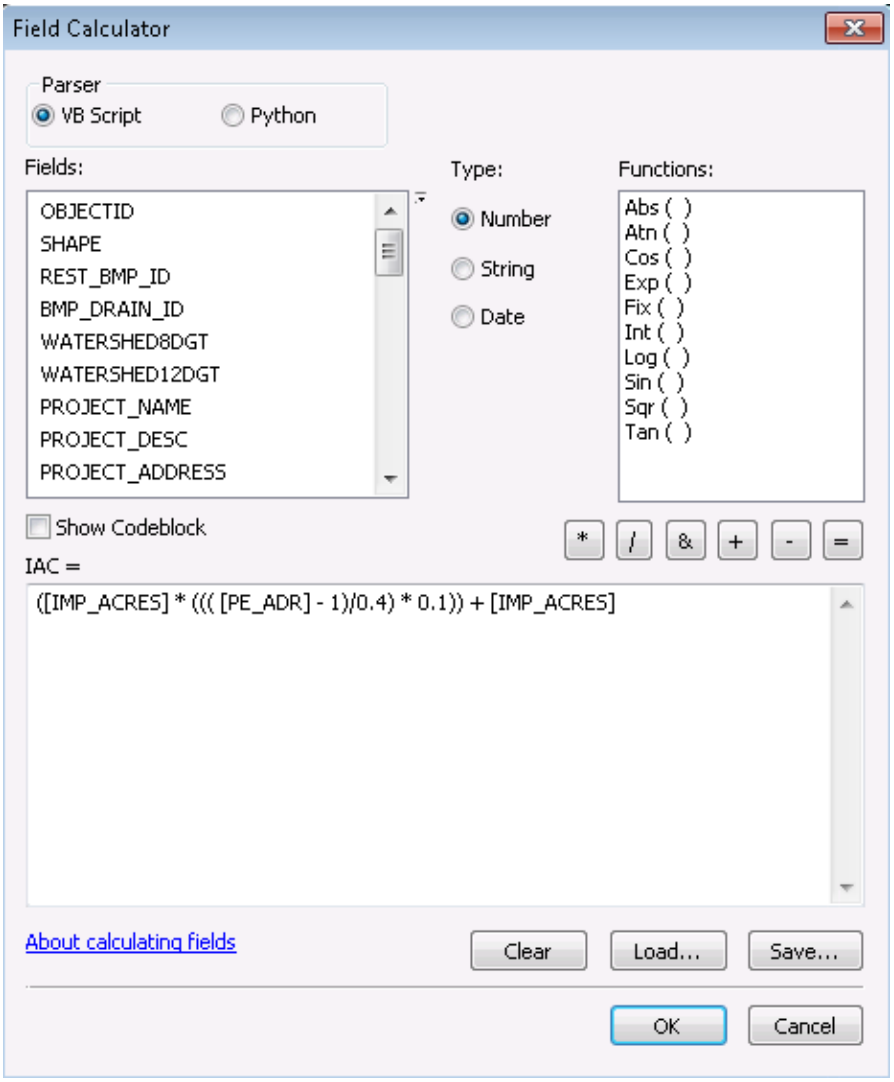
Calculate IAC for Pe > 1

- Ensuring that the selection is retained, right click on the new IAC field, and select "Field Calculator…"





- Within the Field Calculator dialog window, enter the following calculation, and click "OK":
  ([IMP_ACRES] * ((([PE_ADR] - 1)/0.4) * 0.1)) + [IMP_ACRES]

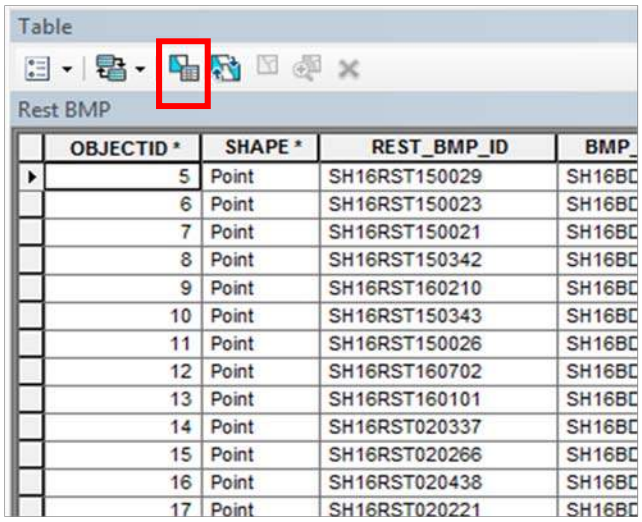


2.1.4 Restoration BMPS IAC by Fiscal Year and Strategy

The IAC values for stormwater restoration BMPs by fiscal year and strategy can be summed using the process below.

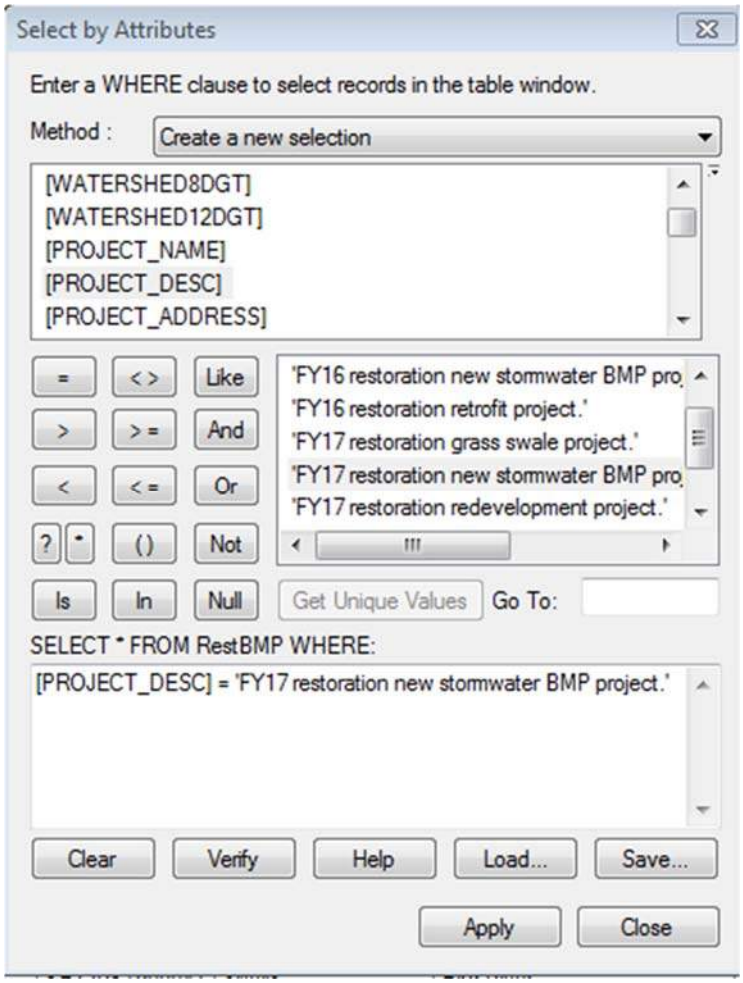
2.1.4.1 Restoration BMPS IAC for New Stormwater FY 2017

- Within the RestBMP attribute table, click the Select by Attributes button.

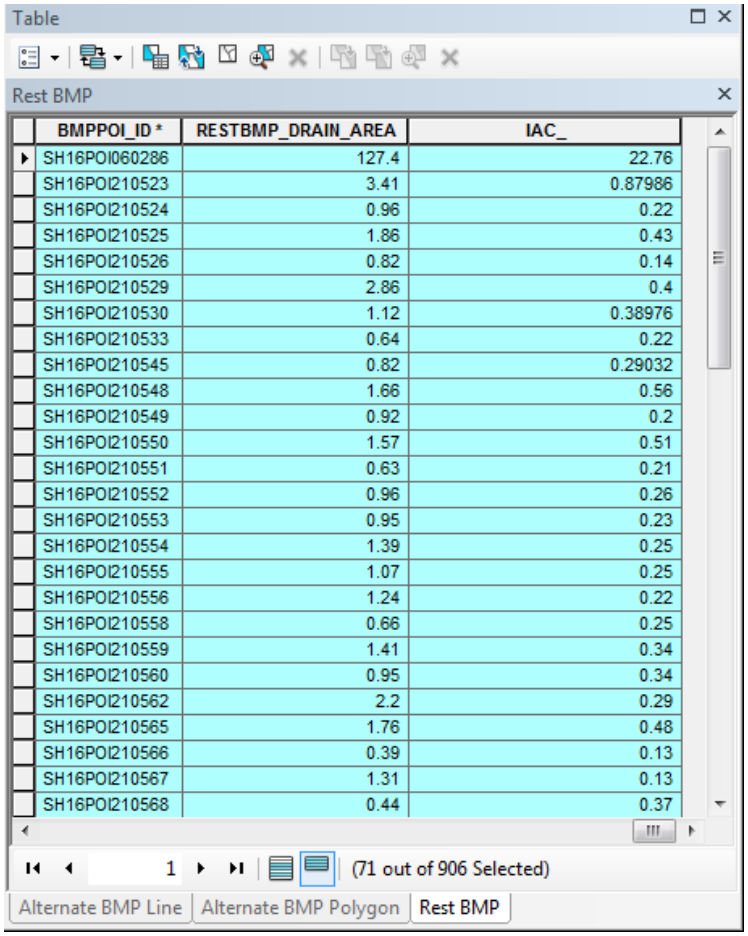


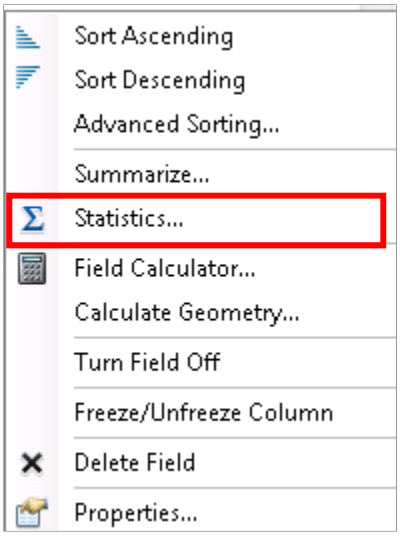
- Within the Select by Attributes dialog window, enter the following selection statement to identify New Stormwater BMPs for FY 17, and click “Apply”:

  [PROJECT_DESC] = 'FY17 restoration new stormwater BMP project.'

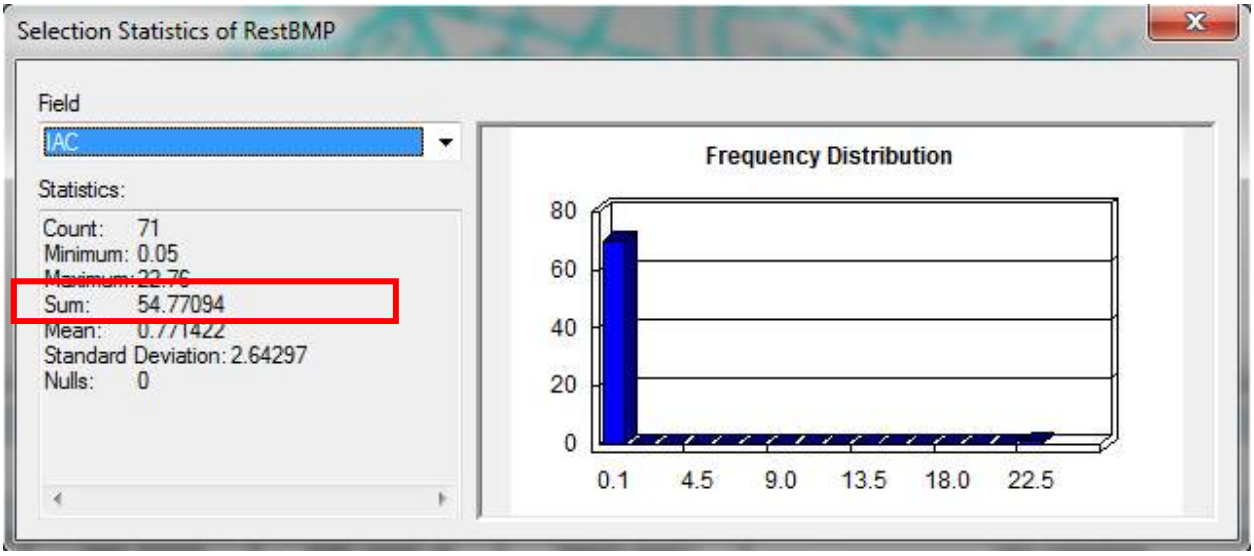


- Ensuring that the selection is retained, right click on the new IAC field, and select “Statistics…”





- View the “Sum” field to view the total stormwater restoration treatment credit claimed for new stormwater FY 17.

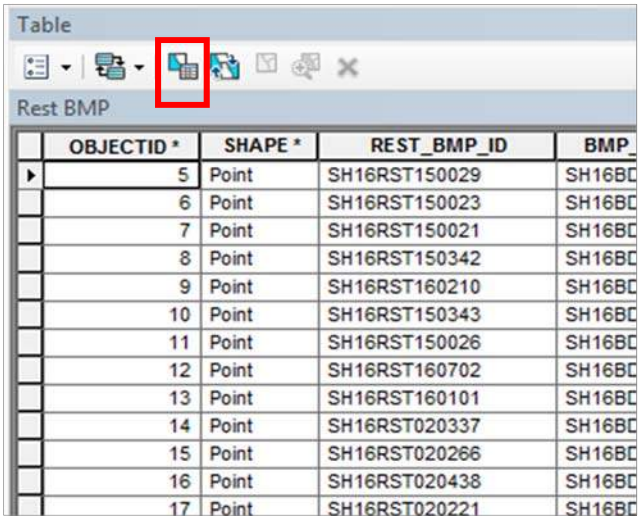


The total restoration new stormwater treatment credit for FY17 is 54.77 acres.

Strategy	Variable Baseline Year - 2015	2016	2017	Total
	(acres)	(acres)	(acres)	(acres)
Impervious Surface Elimination (to Pervious)	0.49	0.00	1.89	2.38
New Stormwater	87.41	53.53	54.77	195.71
Grass Swales	0.00	9.07	11.60	20.67
Outfall Stabilization	0.00	2.00	16.25	18.25
Retrofit	0.00	94.43	4.78	99.21
Stream Restoration	444.04	137.24	67.00	648.28
Tree Planting	598.27	66.65	22.09	687.01
Redevelopment Credit	0.00	0.00	81.00	81.00
Inlet Cleaning	0.00	0.00	150.00	150.00
Street Sweeping	0.00	0.00	33.00	33.00
Totals	**1,130**	**363**	**442**	**1,936**
20% Restoration Target				**4709**

2.1.4.2 Restoration BMPS IAC for New Stormwater FY 2016

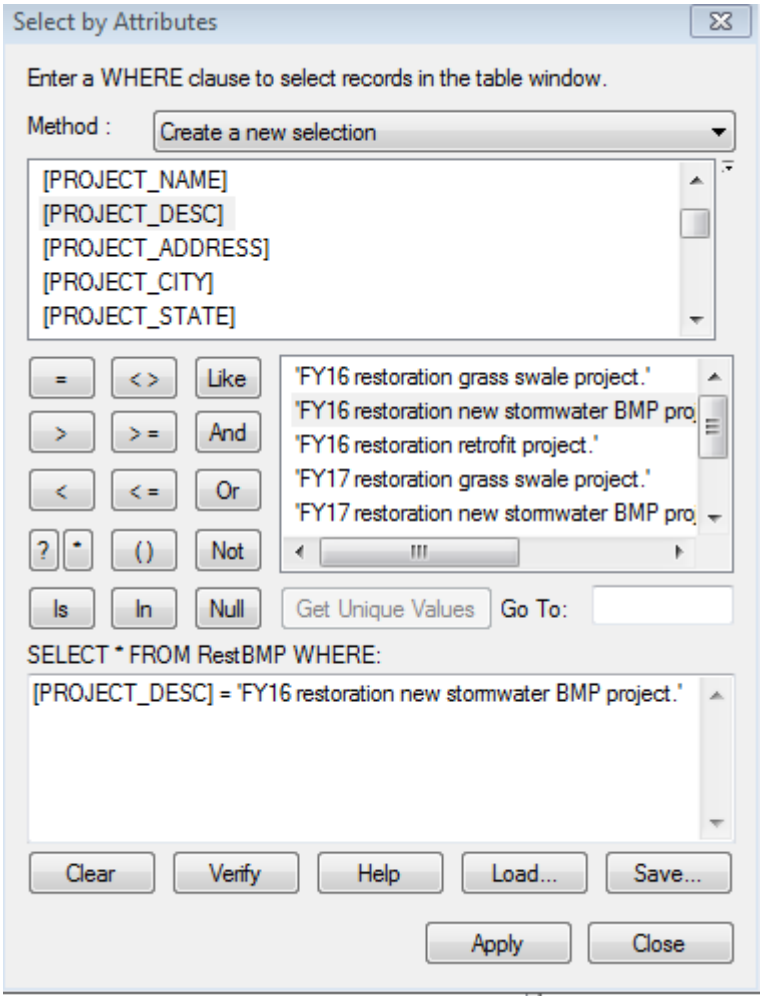
- Within the RestBMP attribute table, click the Select by Attributes button.



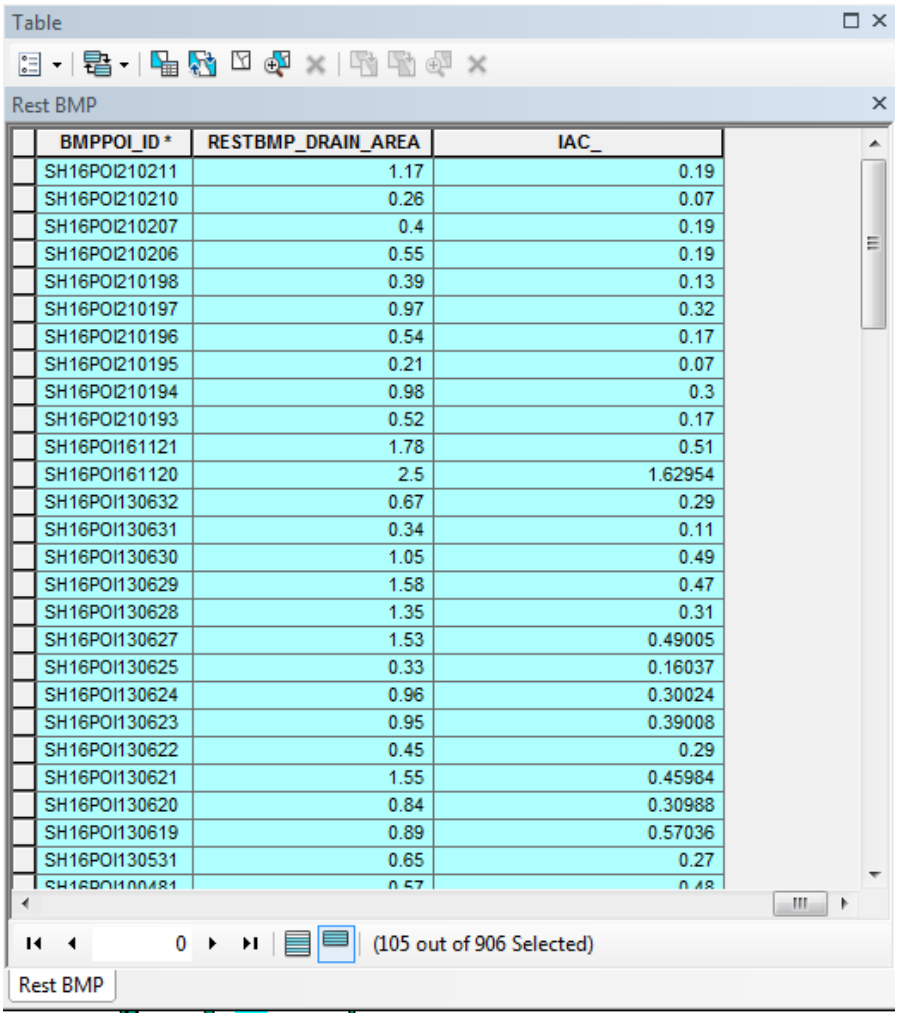
OBJECTID *	SHAPE *	REST_BMP_ID	BMP_
5	Point	SH16RST150029	SH16BD
6	Point	SH16RST150023	SH16BD
7	Point	SH16RST150021	SH16BD
8	Point	SH16RST150342	SH16BD
9	Point	SH16RST160210	SH16BD
10	Point	SH16RST150343	SH16BD
11	Point	SH16RST150026	SH16BD
12	Point	SH16RST160702	SH16BD
13	Point	SH16RST160101	SH16BD
14	Point	SH16RST020337	SH16BD
15	Point	SH16RST020266	SH16BD
16	Point	SH16RST020438	SH16BD
17	Point	SH16RST020221	SH16BD

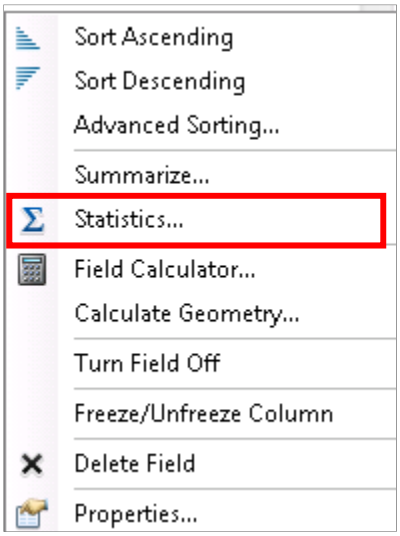
- Within the Select by Attributes dialog window, enter the following selection statement to identify New Stormwater BMPs for FY 16, and click “Apply”:

  [PROJECT_DESC] = 'FY16 restoration new stormwater BMP project.'

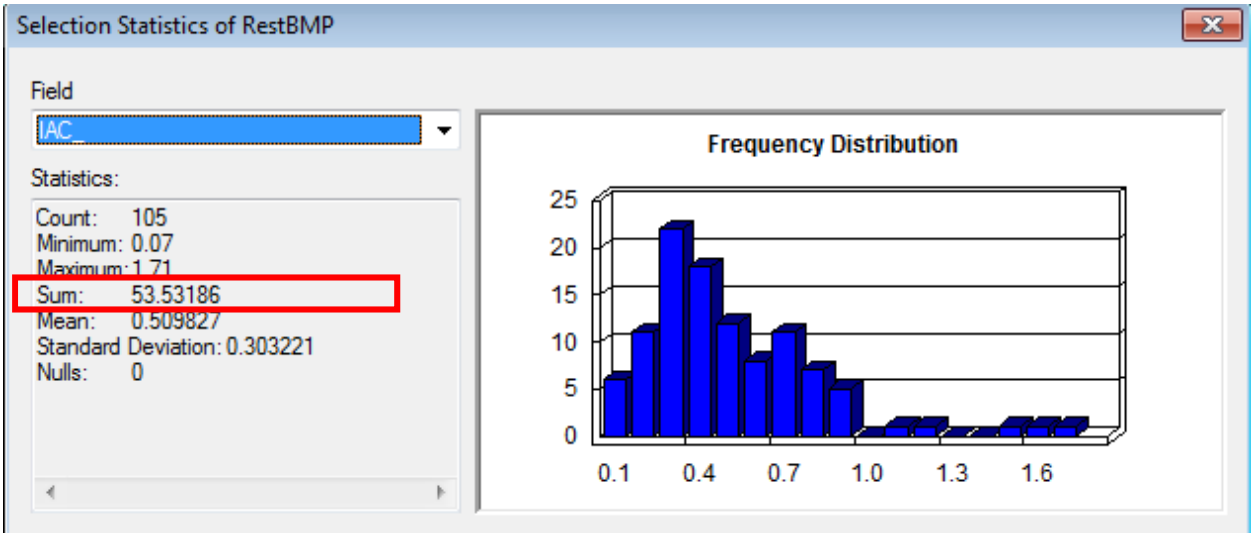


- Ensuring that the selection is retained, right click on the new IAC field, and select “Statistics…”





- View the “Sum” field to view the total stormwater restoration treatment credit claimed for new stormwater FY 16.

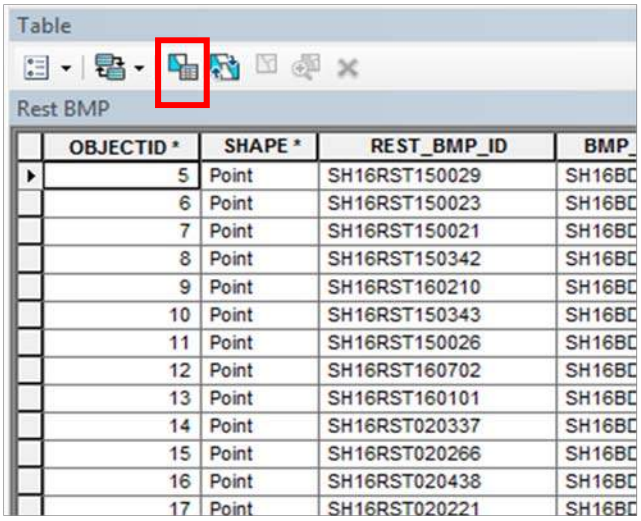


The total restoration new stormwater treatment credit for FY16 is 53.53 acres.

Strategy	Variable Baseline Year - 2015	2016	2017	Total
	(acres)	(acres)	(acres)	(acres)
Impervious Surface Elimination (to Pervious)	0.49	0.00	1.89	2.38
New Stormwater	87.41	53.53	54.77	195.71
Grass Swales	0.00	9.07	11.60	20.67
Outfall Stabilization	0.00	2.00	16.25	18.25
Retrofit	0.00	94.43	4.78	99.21
Stream Restoration	444.04	137.24	67.00	648.28
Tree Planting	598.27	66.65	22.09	687.01
Redevelopment Credit	0.00	0.00	81.00	81.00
Inlet Cleaning	0.00	0.00	150.00	150.00
Street Sweeping	0.00	0.00	33.00	33.00
Totals	**1,130**	**363**	**442**	**1,936**
20% Restoration Target				**4709**

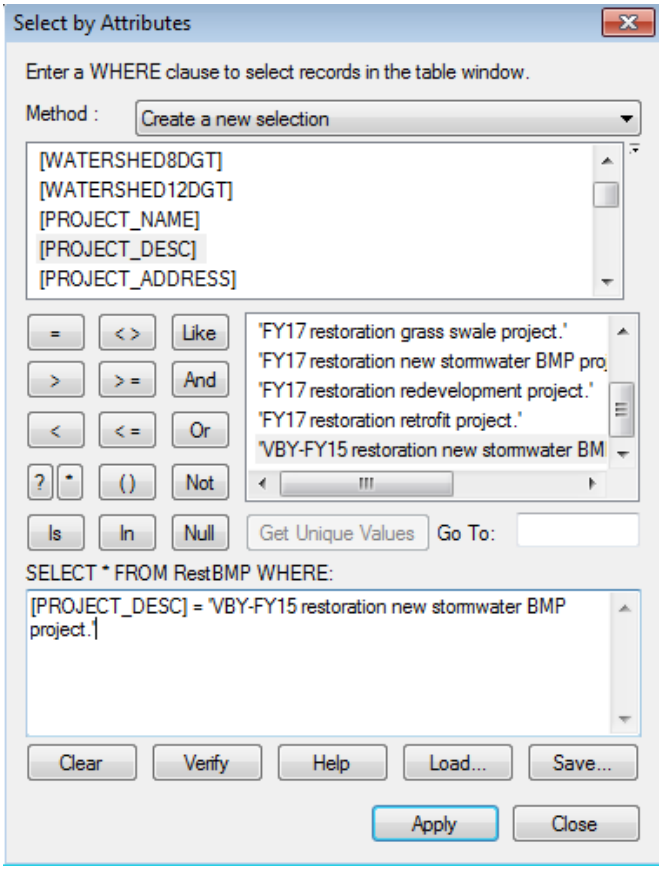
2.1.4.3 Restoration BMPS IAC for New Stormwater VBY-2015

- Within the RestBMP attribute table, click the Select by Attributes button.

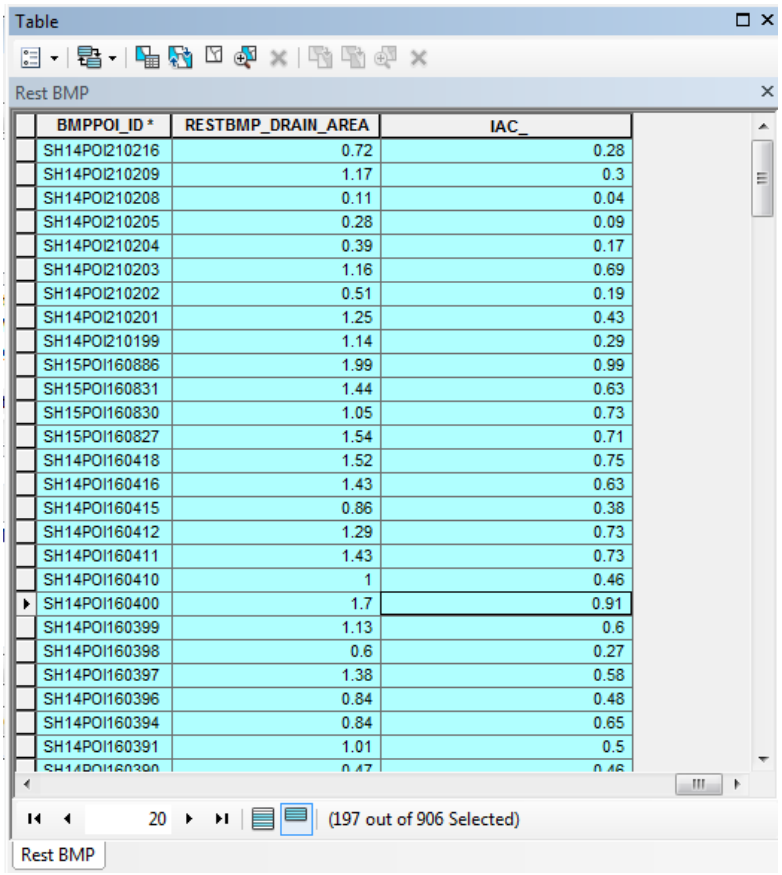


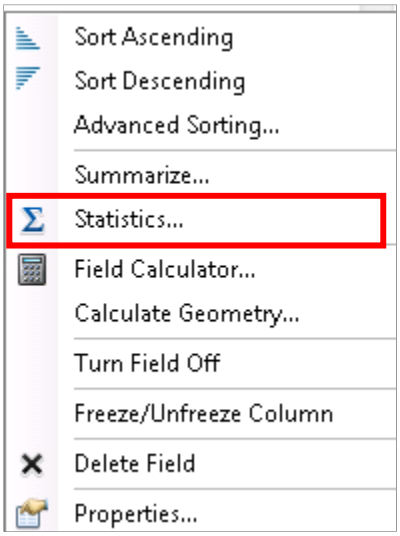
- Within the Select by Attributes dialog window, enter the following selection statement to identify New Stormwater BMPs for VBY-2015, and click “Apply”:

  [PROJECT_DESC] = 'VBY-FY15 restoration new stormwater BMP project.'

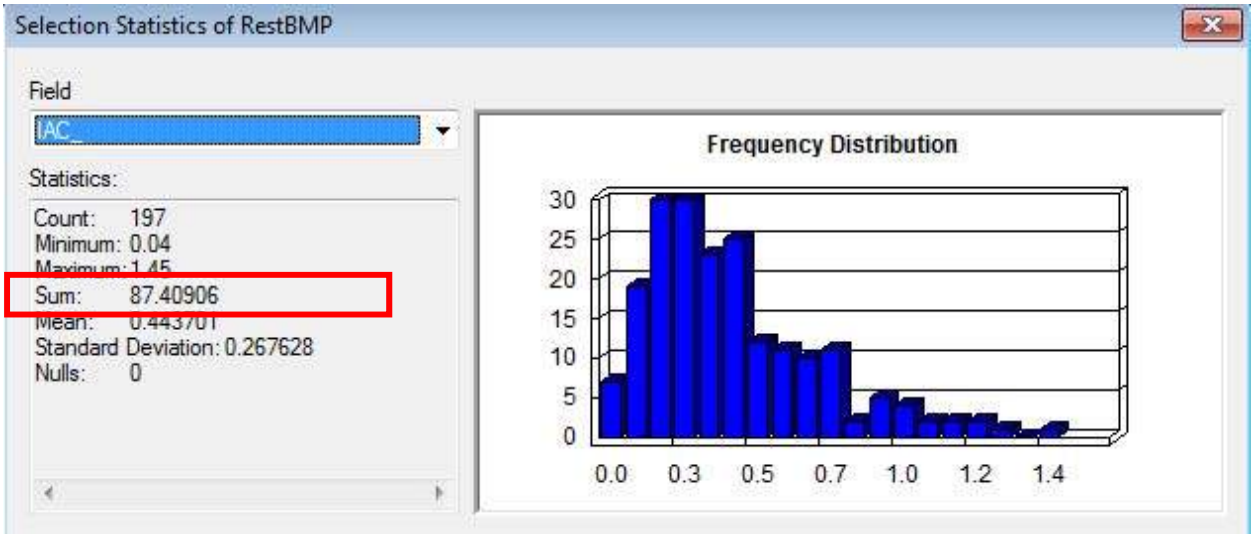


- Ensuring that the selection is retained, right click on the new IAC field, and select “Statistics…”





- View the “Sum” field to view the total stormwater restoration treatment credit claimed for new stormwater VBY-2015.

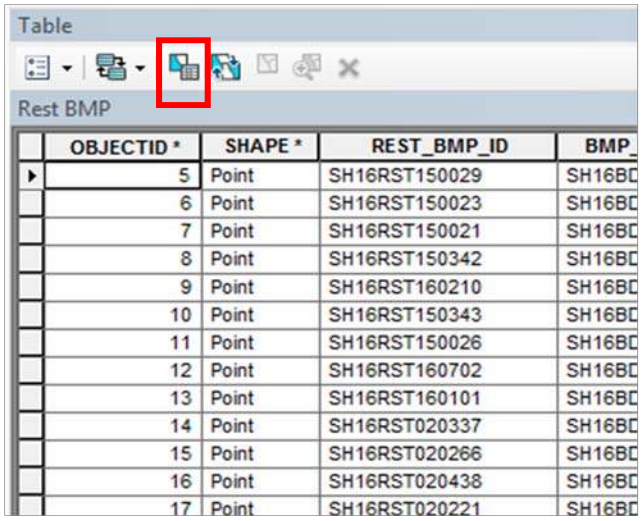


The total restoration new stormwater treatment credit for VBY-2015 is 87.41 acres.

Strategy	Variable Baseline Year - 2015	2016	2017	Total
	(acres)	(acres)	(acres)	(acres)
Impervious Surface Elimination (to Pervious)	0.49	0.00	1.89	2.38
New Stormwater	87.41	53.53	54.77	195.71
Grass Swales	0.00	9.07	11.60	20.67
Outfall Stabilization	0.00	2.00	16.25	18.25
Retrofit	0.00	94.43	4.78	99.21
Stream Restoration	444.04	137.24	67.00	648.28
Tree Planting	598.27	66.65	22.09	687.01
Redevelopment Credit	0.00	0.00	81.00	81.00
Inlet Cleaning	0.00	0.00	150.00	150.00
Street Sweeping	0.00	0.00	33.00	33.00
Totals	**1,130**	**363**	**442**	**1,936**
20% Restoration Target				**4709**

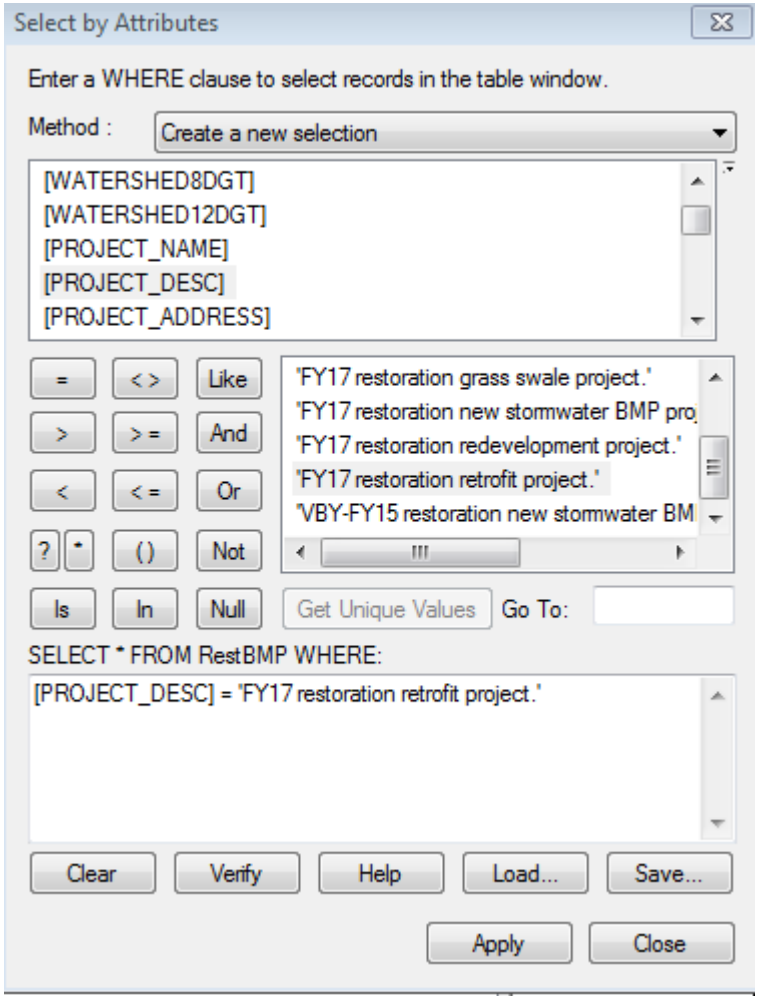
2.1.4.4 Restoration BMPS IAC for Retrofits FY 2017

- Within the RestBMP attribute table, click the Select by Attributes button.

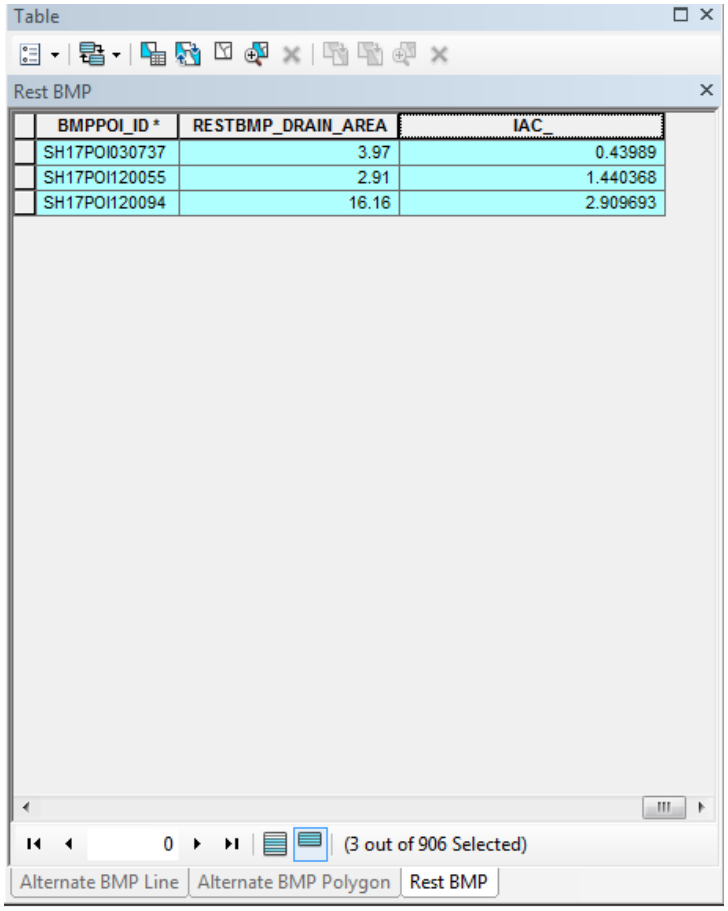


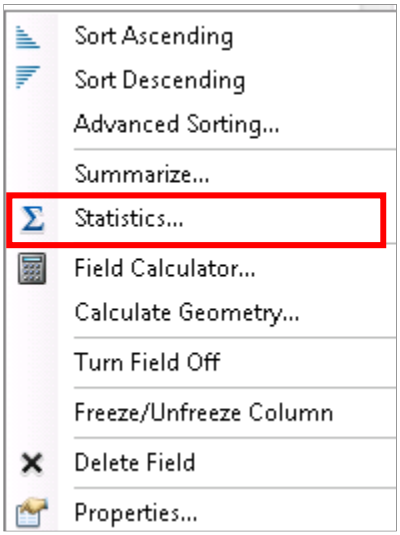
- Within the Select by Attributes dialog window, enter the following selection statement to identify Retrofit BMPs for FY 17, and click “Apply”:

  [PROJECT_DESC] = 'FY17 restoration retrofit project.'

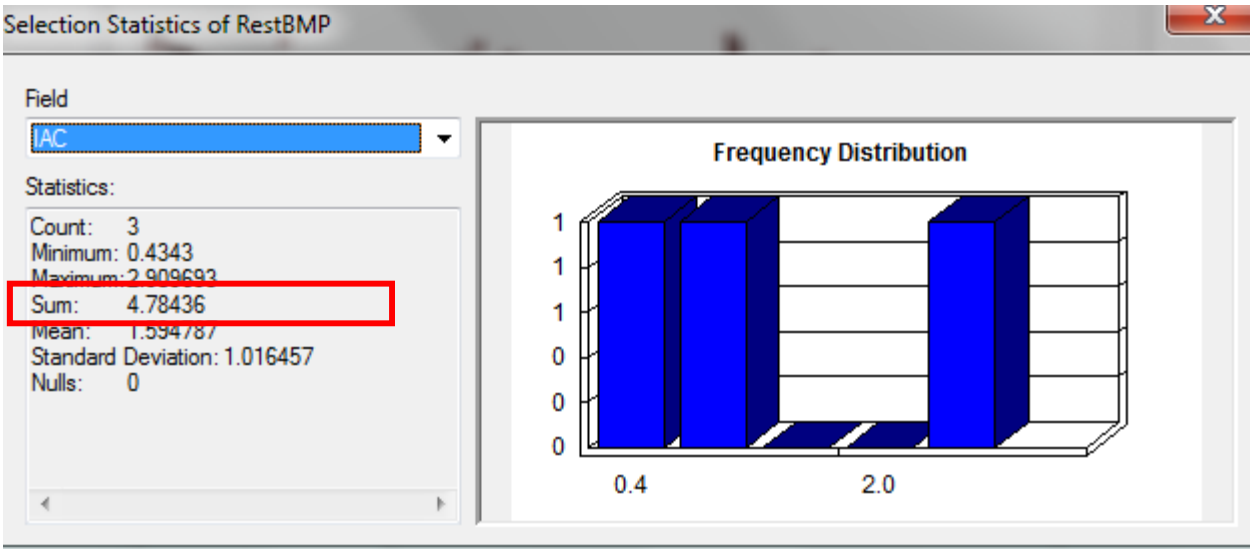


- Ensuring that the selection is retained, right click on the new IAC field, and select “Statistics…”





- View the “Sum” field to view the total restoration treatment credit claimed for retrofits FY 17.

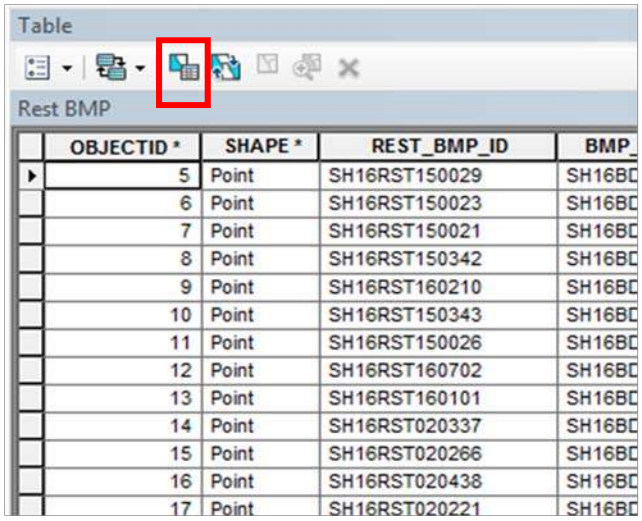


The total restoration retrofit treatment credit for FY17 is 4.78 acres.

Strategy	Variable Baseline Year - 2015	2016	2017	Total
	(acres)	(acres)	(acres)	(acres)
Impervious Surface Elimination (to Pervious)	0.49	0.00	1.89	2.38
New Stormwater	87.41	53.53	54.77	195.71
Grass Swales	0.00	9.07	11.60	20.67
Outfall Stabilization	0.00	2.00	16.25	18.25
Retrofit	0.00	94.43	4.78	99.21
Stream Restoration	444.04	137.24	67.00	648.28
Tree Planting	598.27	66.65	22.09	687.01
Redevelopment Credit	0.00	0.00	81.00	81.00
Inlet Cleaning	0.00	0.00	150.00	150.00
Street Sweeping	0.00	0.00	33.00	33.00
Totals	**1,130**	**363**	**442**	**1,936**
20% Restoration Target				**4709**

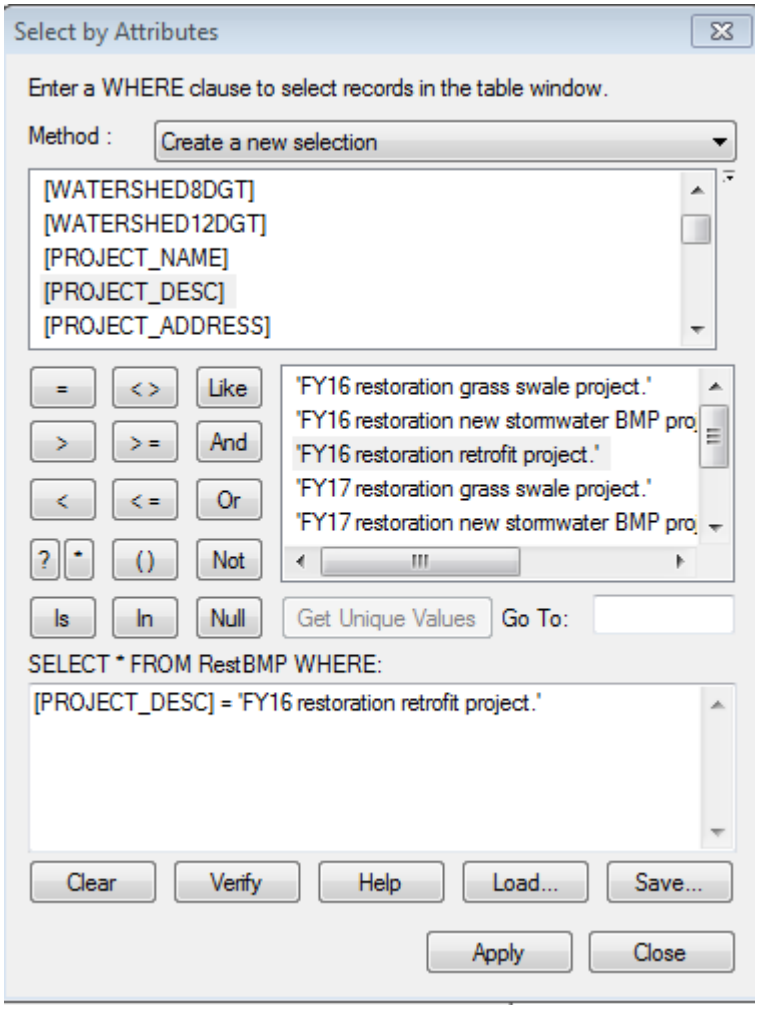
2.1.4.5 Restoration BMPS IAC for Retrofits FY 2016

- Within the RestBMP attribute table, click the Select by Attributes button.

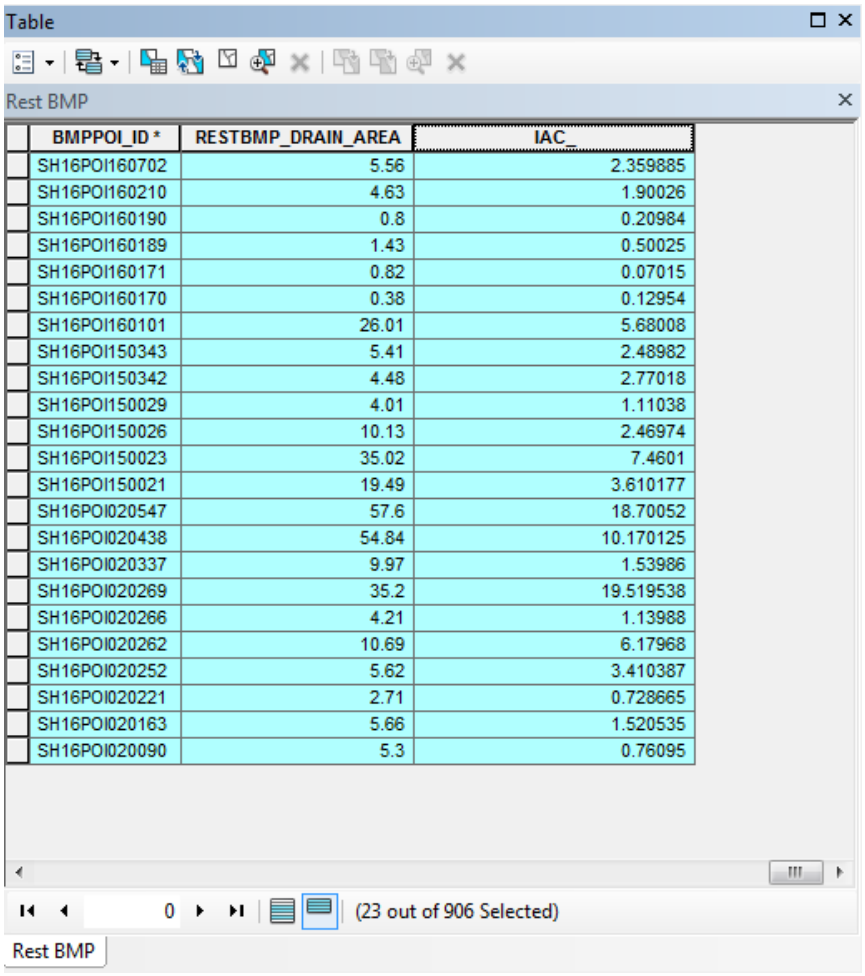


- Within the Select by Attributes dialog window, enter the following selection statement to identify Retrofits for FY 16, and click “Apply”:

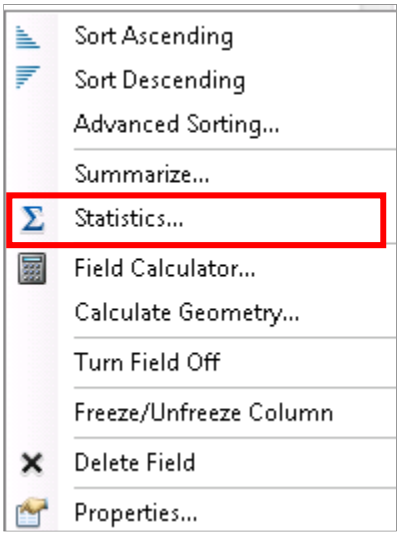
  [PROJECT_DESC] = 'FY16 restoration retrofit project.'



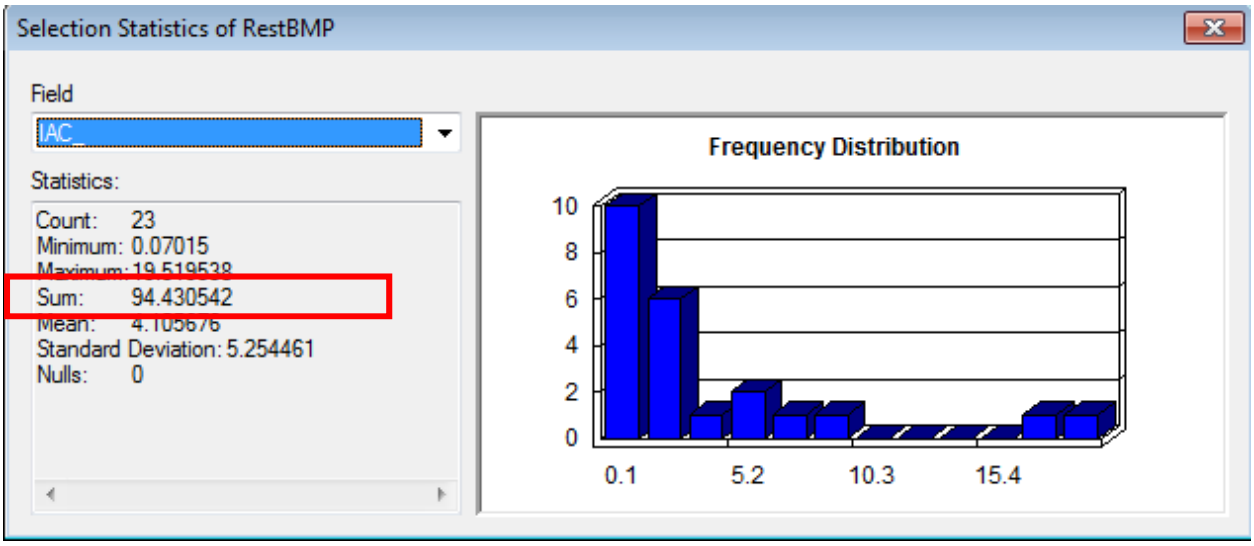
- Ensuring that the selection is retained, right click on the new IAC field, and select “Statistics…”



BMPPOI_ID *	RESTBMP_DRAIN_AREA	IAC_
SH16POI160702	5.56	2.359885
SH16POI160210	4.63	1.90026
SH16POI160190	0.8	0.20984
SH16POI160189	1.43	0.50025
SH16POI160171	0.82	0.07015
SH16POI160170	0.38	0.12954
SH16POI160101	26.01	5.68008
SH16POI150343	5.41	2.48982
SH16POI150342	4.48	2.77018
SH16POI150029	4.01	1.11038
SH16POI150026	10.13	2.46974
SH16POI150023	35.02	7.4601
SH16POI150021	19.49	3.610177
SH16POI020547	57.6	18.70052
SH16POI020438	54.84	10.170125
SH16POI020337	9.97	1.53986
SH16POI020269	35.2	19.519538
SH16POI020266	4.21	1.13988
SH16POI020262	10.69	6.17968
SH16POI020252	5.62	3.410387
SH16POI020221	2.71	0.728665
SH16POI020163	5.66	1.520535
SH16POI020090	5.3	0.76095



- View the “Sum” field to view the total restoration treatment credit claimed for retrofits FY 16.



The total restoration retrofit treatment credit for FY16 is 94.43 acres.

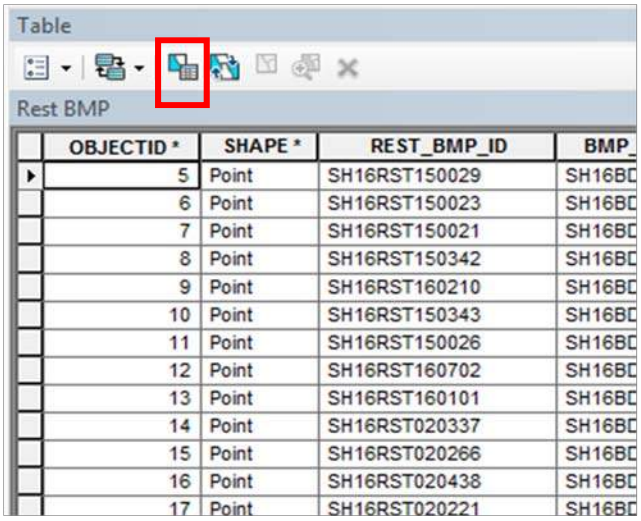
Strategy	Variable Baseline Year - 2015	2016	2017	Total
	(acres)	(acres)	(acres)	(acres)
Impervious Surface Elimination (to Pervious)	0.49	0.00	1.89	2.38
New Stormwater	87.41	53.53	54.77	195.71
Grass Swales	0.00	9.07	11.60	20.67
Outfall Stabilization	0.00	2.00	16.25	18.25
Retrofit	0.00	94.43	4.78	99.21
Stream Restoration	444.04	137.24	67.00	648.28
Tree Planting	598.27	66.65	22.09	687.01
Redevelopment Credit	0.00	0.00	81.00	81.00
Inlet Cleaning	0.00	0.00	150.00	150.00
Street Sweeping	0.00	0.00	33.00	33.00
Totals	**1,130**	**363**	**442**	**1,936**
20% Restoration Target				**4709**

2.1.4.6 Restoration BMPS IAC for Retrofits VBY-2015

There are no retrofit BMPS for VBY-2015.

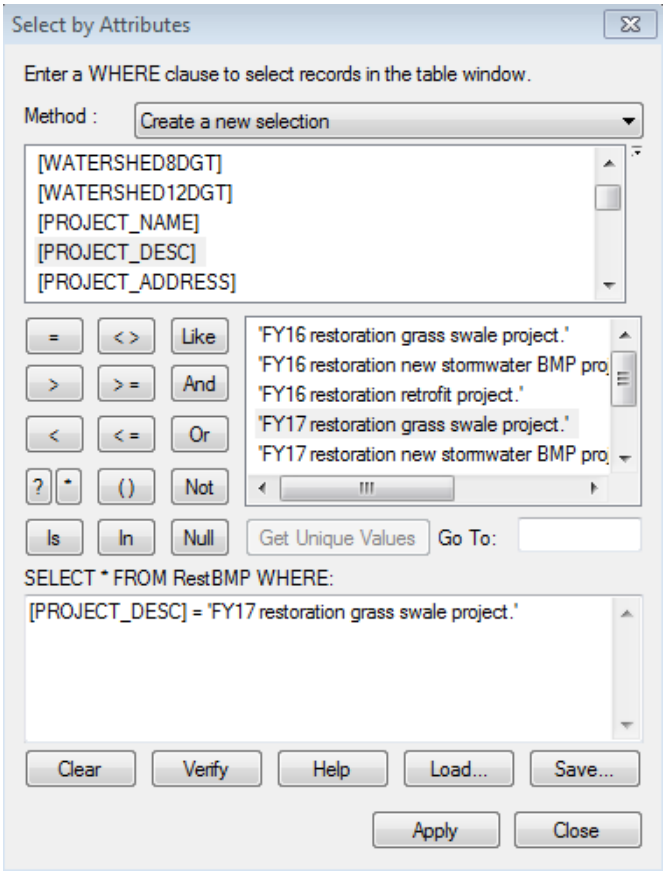
2.1.4.7 Restoration BMPS IAC for Grass Swales FY 2017

- Within the RestBMP attribute table, click the Select by Attributes button.

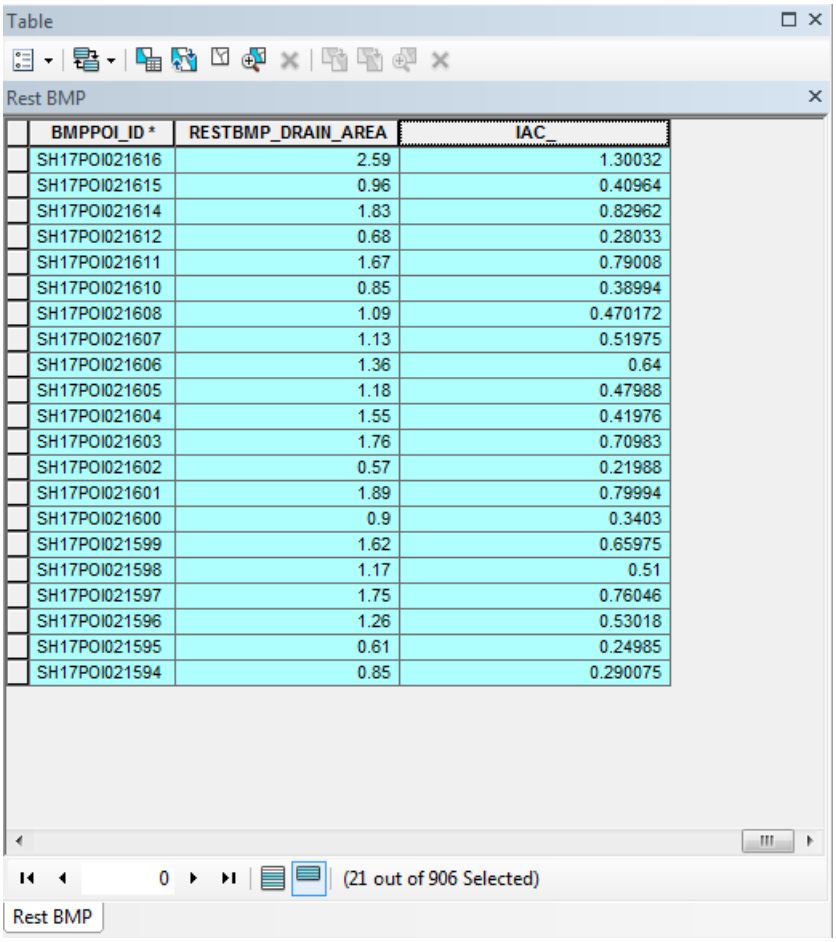


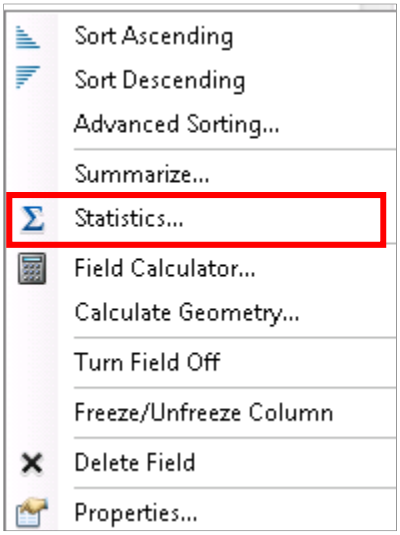
- Within the Select by Attributes dialog window, enter the following selection statement to identify Grass Swale BMPs for FY 17, and click “Apply”:

  [PROJECT_DESC] = 'FY17 restoration grass swale project.'

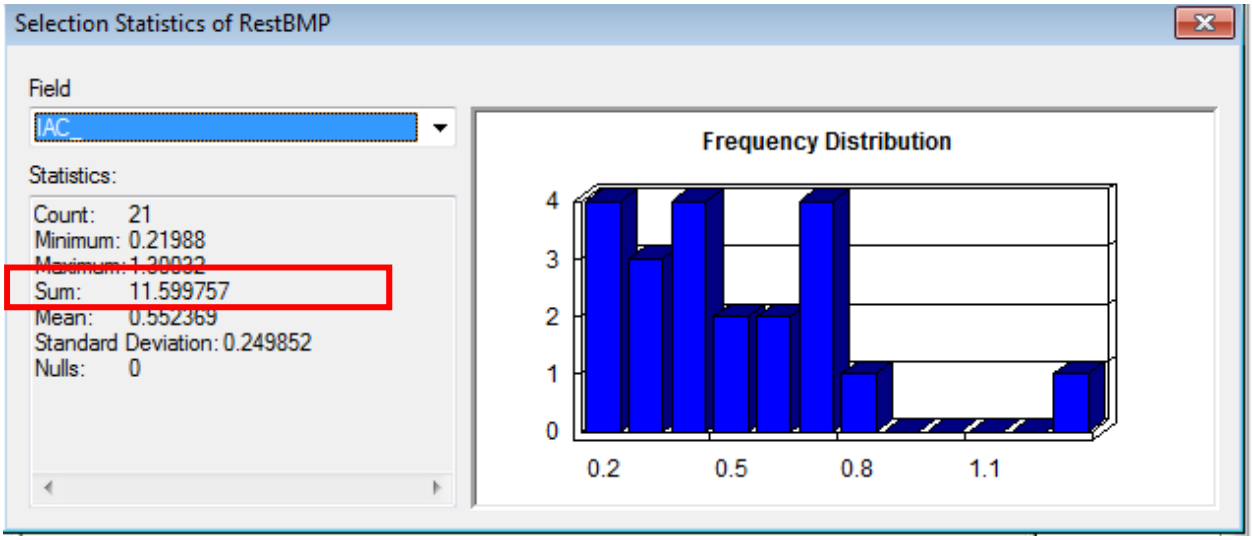


- Ensuring that the selection is retained, right click on the new IAC field, and select “Statistics…”





- View the “Sum” field to view the total restoration treatment credit claimed for grass swales FY17.

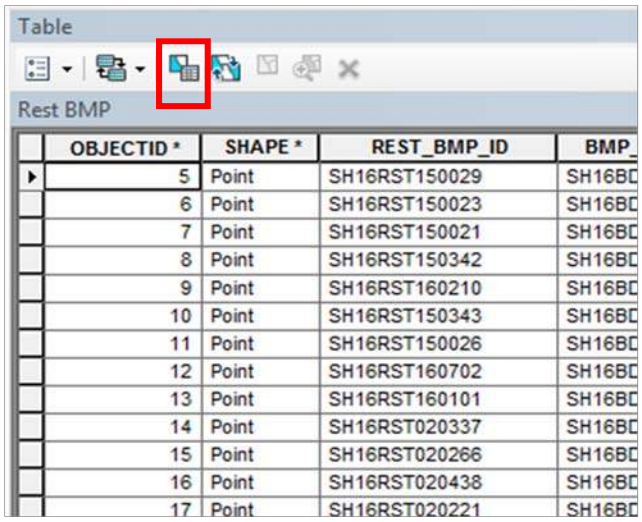


The total restoration grass swale treatment credit for FY17 is 11.60 acres.

Strategy	Variable Baseline Year - 2015	2016	2017	Total
	(acres)	(acres)	(acres)	(acres)
Impervious Surface Elimination (to Pervious)	0.49	0.00	1.89	2.38
New Stormwater	87.41	53.53	54.77	195.71
Grass Swales	0.00	9.07	11.60	20.67
Outfall Stabilization	0.00	2.00	16.25	18.25
Retrofit	0.00	94.43	4.78	99.21
Stream Restoration	444.04	137.24	67.00	648.28
Tree Planting	598.27	66.65	22.09	687.01
Redevelopment Credit	0.00	0.00	81.00	81.00
Inlet Cleaning	0.00	0.00	150.00	150.00
Street Sweeping	0.00	0.00	33.00	33.00
Totals	**1,130**	**363**	**442**	**1,936**
20% Restoration Target				**4709**

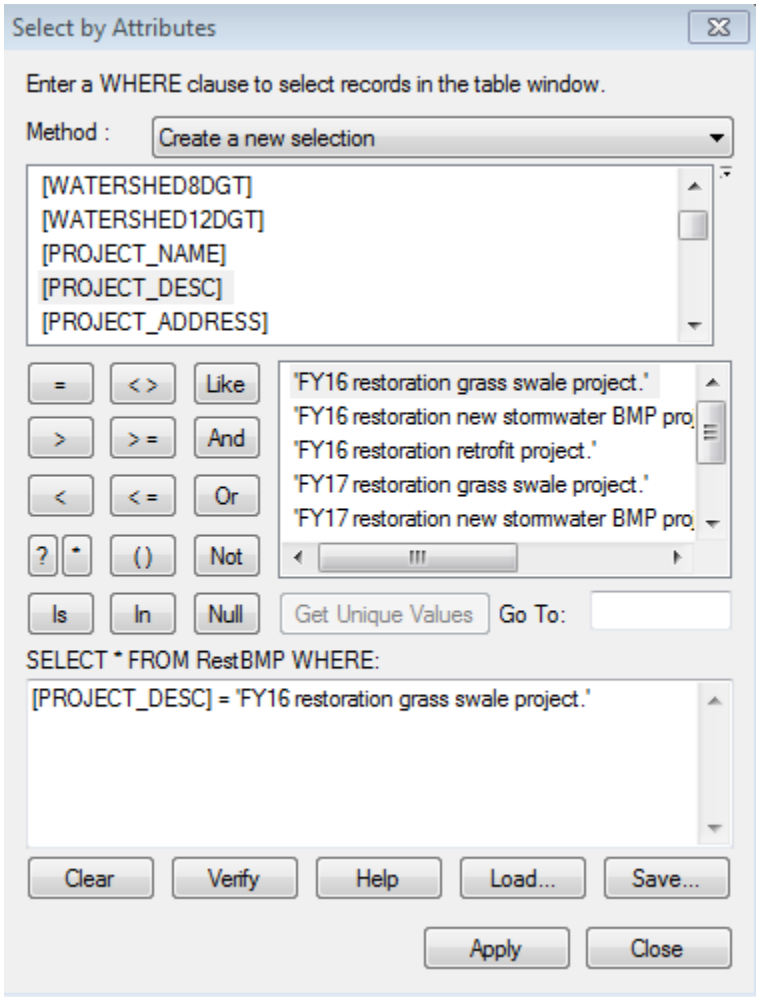
2.1.4.8 Restoration BMPS IAC for Grass Swales FY 2016

- Within the RestBMP attribute table, click the Select by Attributes button.

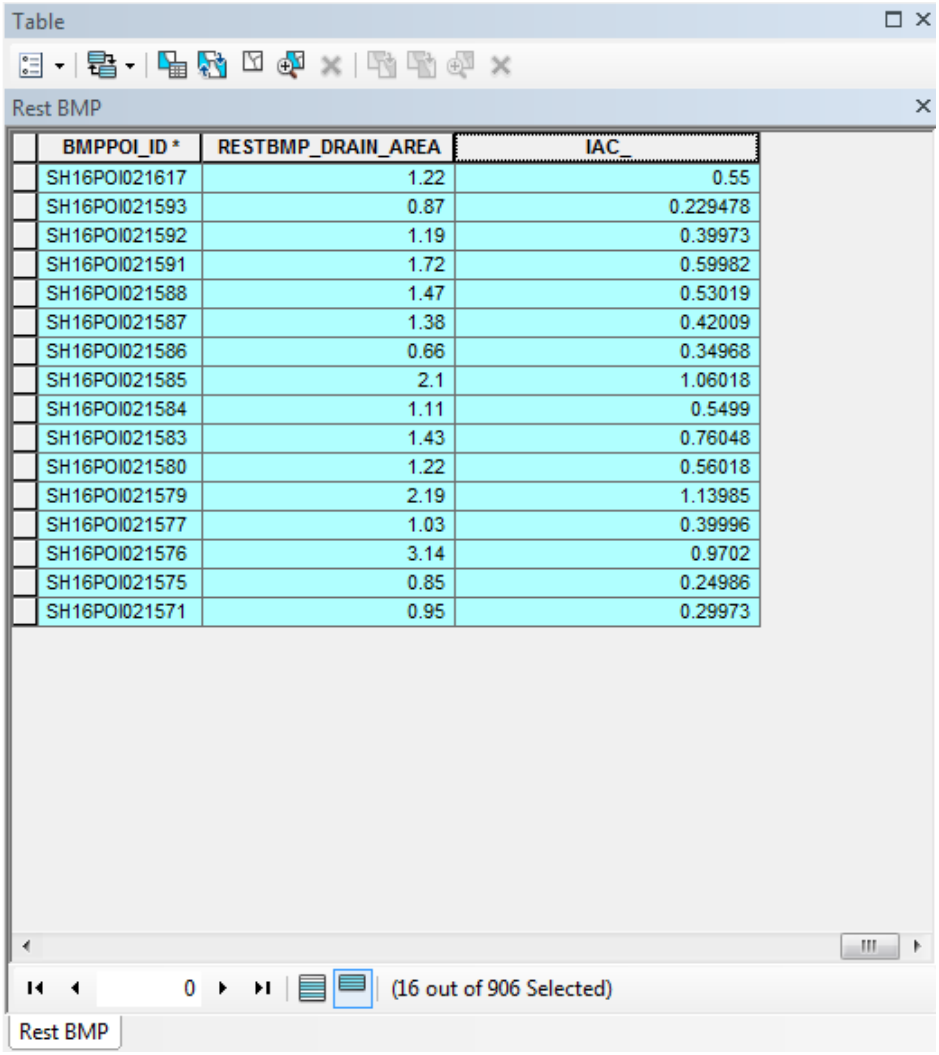


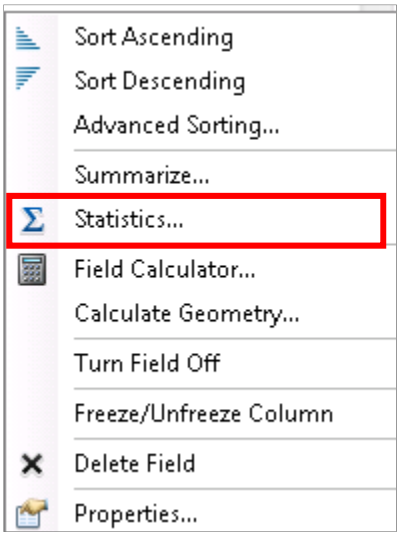
- Within the Select by Attributes dialog window, enter the following selection statement to identify Grass Swales for FY 16, and click “Apply”:

  [PROJECT_DESC] = 'FY16 restoration grass swale project.'

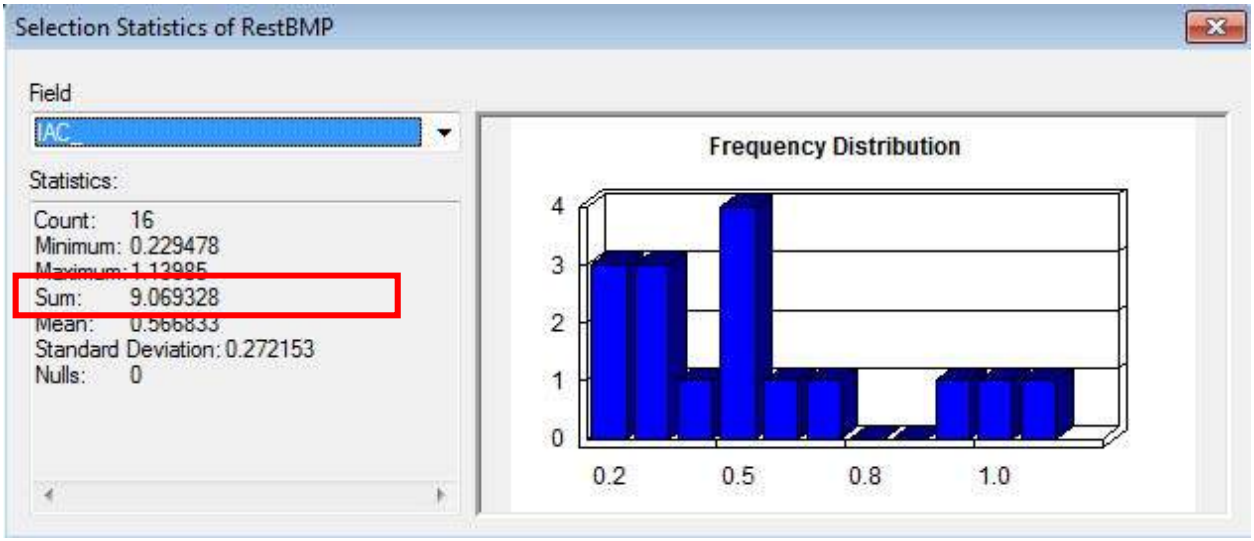


- Ensuring that the selection is retained, right click on the new IAC field, and select “Statistics…”





- View the “Sum” field to view the total restoration treatment credit claimed for grass swales FY 16.



The total restoration grass swale treatment credit for FY16 is 9.07 acres.

Strategy	Variable Baseline Year - 2015	2016	2017	Total
	(acres)	(acres)	(acres)	(acres)
Impervious Surface Elimination (to Pervious)	0.49	0.00	1.89	2.38
New Stormwater	87.41	53.53	54.77	195.71
Grass Swales	0.00	9.07	11.60	20.67
Outfall Stabilization	0.00	2.00	16.25	18.25
Retrofit	0.00	94.43	4.78	99.21
Stream Restoration	444.04	137.24	67.00	648.28
Tree Planting	598.27	66.65	22.09	687.01
Redevelopment Credit	0.00	0.00	81.00	81.00
Inlet Cleaning	0.00	0.00	150.00	150.00
Street Sweeping	0.00	0.00	33.00	33.00
Totals	**1,130**	**363**	**442**	**1,936**
20% Restoration Target				**4709**

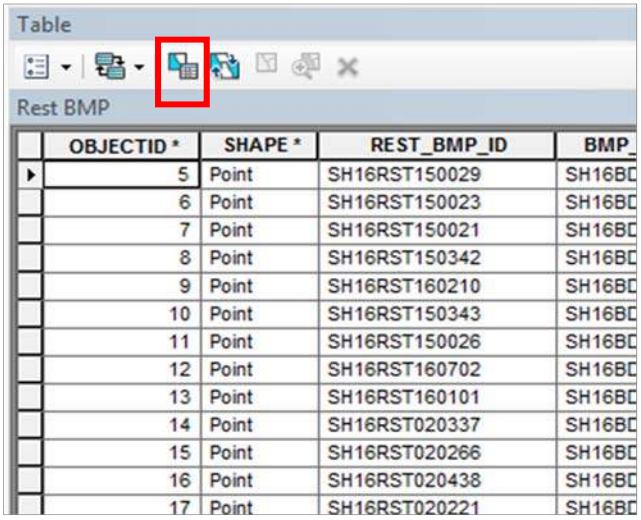
2.1.4.9 Restoration BMPS IAC for Grass Swales VBY-2015

There are no grass swale BMPS for VBY-2015

2.2 Total Stormwater Restoration BMPs IAC Sum

The IAC values for restoration BMPs can be summed using the process below.

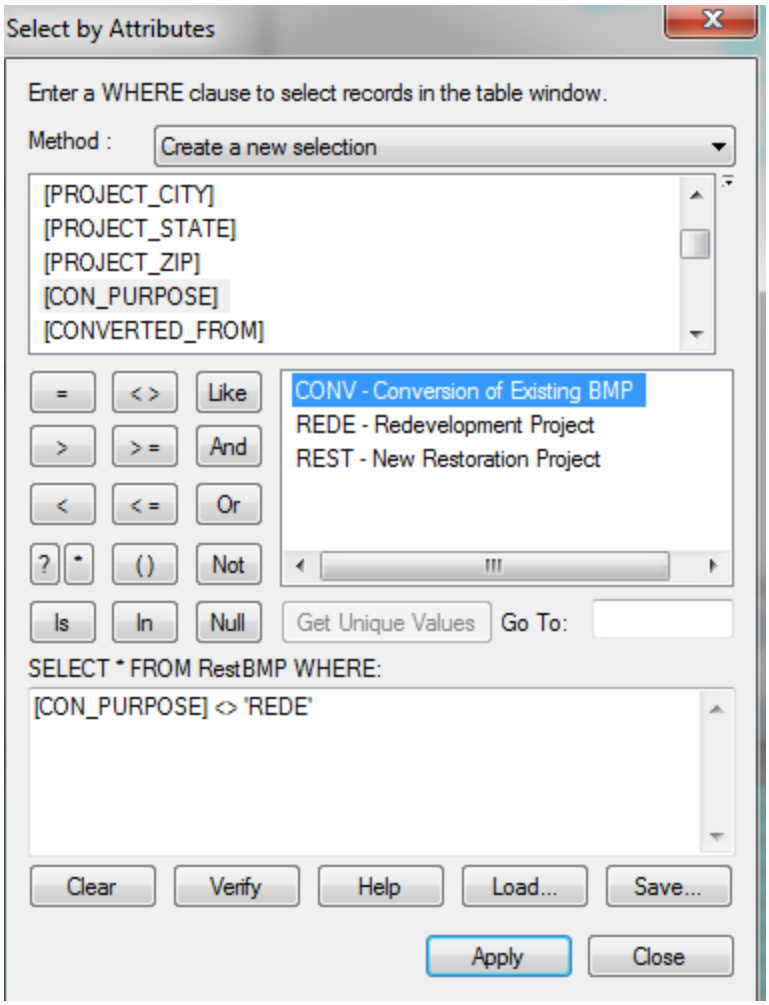
- Within the RestBMP attribute table, click the Select by Attributes button.



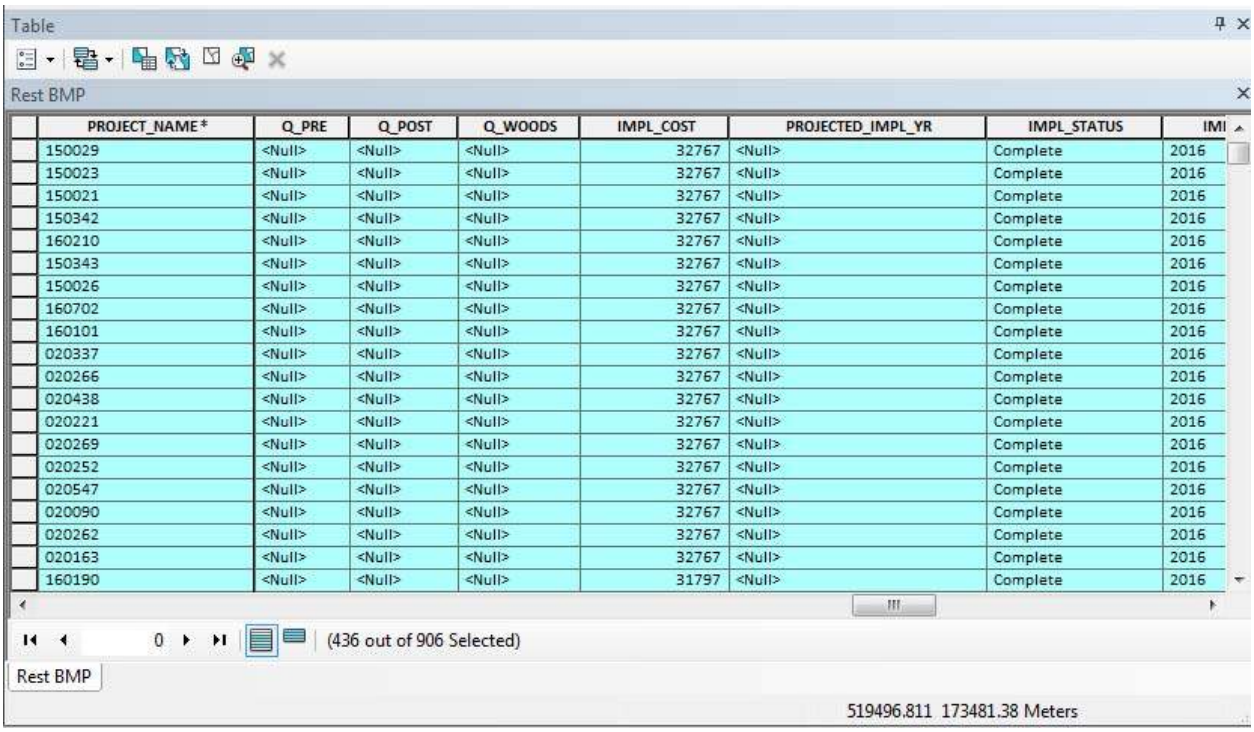
OBJECTID *	SHAPE *	REST_BMP_ID	BMP_
5	Point	SH16RST150029	SH16BD
6	Point	SH16RST150023	SH16BD
7	Point	SH16RST150021	SH16BD
8	Point	SH16RST150342	SH16BD
9	Point	SH16RST160210	SH16BD
10	Point	SH16RST150343	SH16BD
11	Point	SH16RST150026	SH16BD
12	Point	SH16RST160702	SH16BD
13	Point	SH16RST160101	SH16BD
14	Point	SH16RST020337	SH16BD
15	Point	SH16RST020266	SH16BD
16	Point	SH16RST020438	SH16BD
17	Point	SH16RST020221	SH16BD

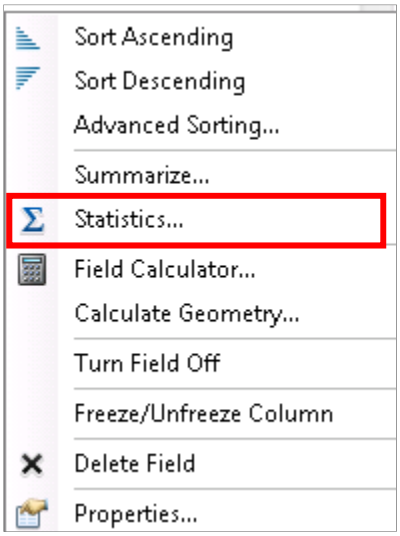
- Within the Select by Attributes dialog window, enter the following selection statement to identify all stormwater projects across all years, and click “Apply”:

[CON_PURPOSE] <> 'REDE'

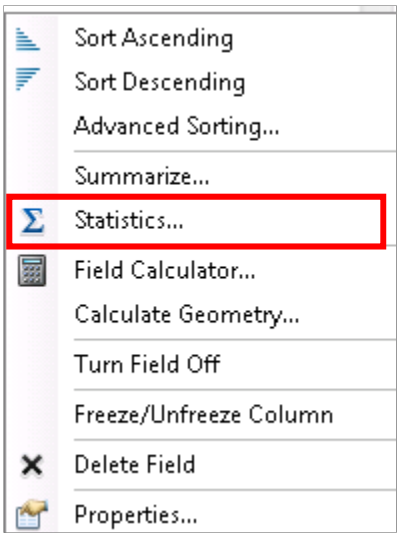


- Ensuring that the selection is retained, right click on the new IAC field, and select “Statistics…”

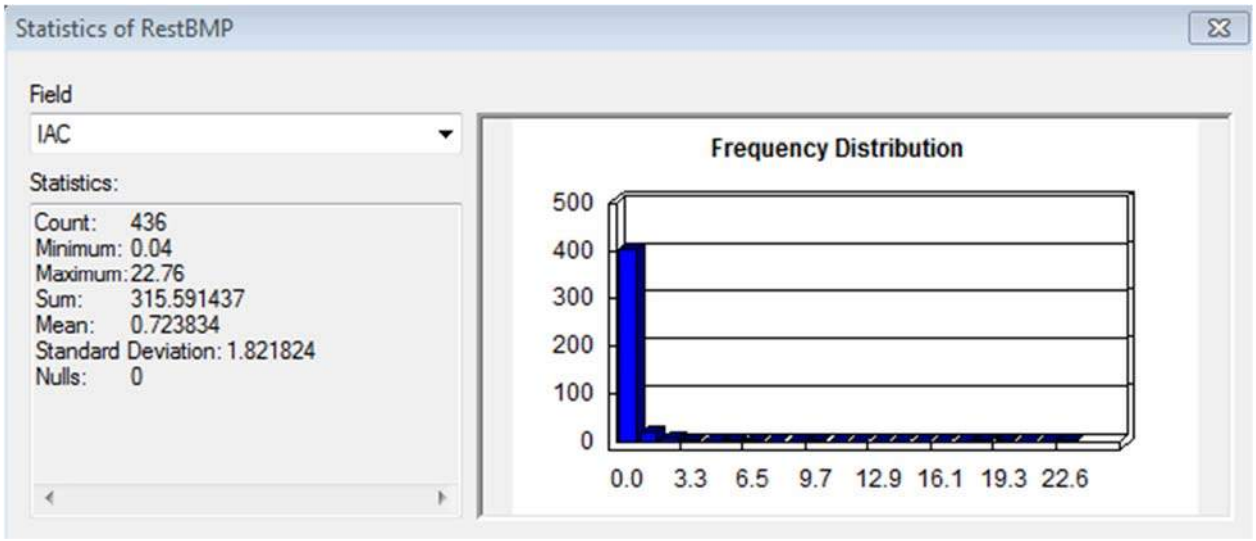




- Right click on the new IAC field, and select “Statistics…”



- View the "Sum" field to view the total stormwater restoration treatment credit claimed.



The total restoration stormwater treatment credit is 315.55 acres. This will match the sum of the values in the *Total (acres)* field for New Storwmwater, Grass Swales, and Retrofit.

Strategy	Variable Baseline Year - 2015	2016	2017	Total
	(acres)	(acres)	(acres)	(acres)
Impervious Surface Elimination (to Pervious)	0.49	0.00	1.89	2.38
New Stormwater	87.41	53.53	54.77	195.71
Grass Swales	0.00	9.07	11.60	20.67
Outfall Stabilization	0.00	2.00	16.25	18.25
Retrofit	0.00	94.43	4.78	99.21
Stream Restoration	444.04	137.24	67.00	648.28
Tree Planting	598.27	66.65	22.09	687.01
Redevelopment Credit	0.00	0.00	81.00	81.00
Inlet Cleaning	0.00	0.00	150.00	150.00
Street Sweeping	0.00	0.00	33.00	33.00
Totals	**1,130**	**363**	**442**	**1,936**
20% Restoration Target				**4709**

3.0 Stream Restoration

Calculating the impervious treatment credit for Stream Restoration requires two (2) primary inputs:

- Length of Restoration, from within the MDE MS4 geodatabase (AltBMPLine feature class' LENGTH_REST field)
- Impervious Acre Equivalent factor, from Table 7 of MDE's August 2014 guidance (0.01 for stream restoration)

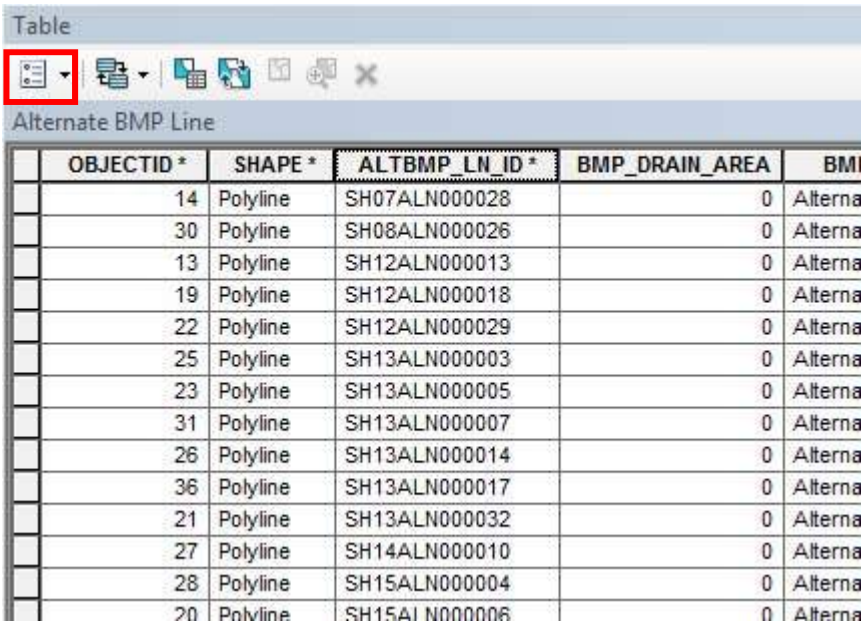
3.1 Stream Restoration IAC Calculation

The AltBMPLine feature class contains a field to explicitly capture IAC ("EQU_IMP_ACR"). To verify the IAC, this example will add a new, temporary field to the AltBMPLine feature class. This new field will hold the results of the IAC calculation, so once calculated, will equal the existing MDE field "EQU_IMP_ACR". This field is added as a way to re-calculate the IAC, and ensure values align with the MDE field.

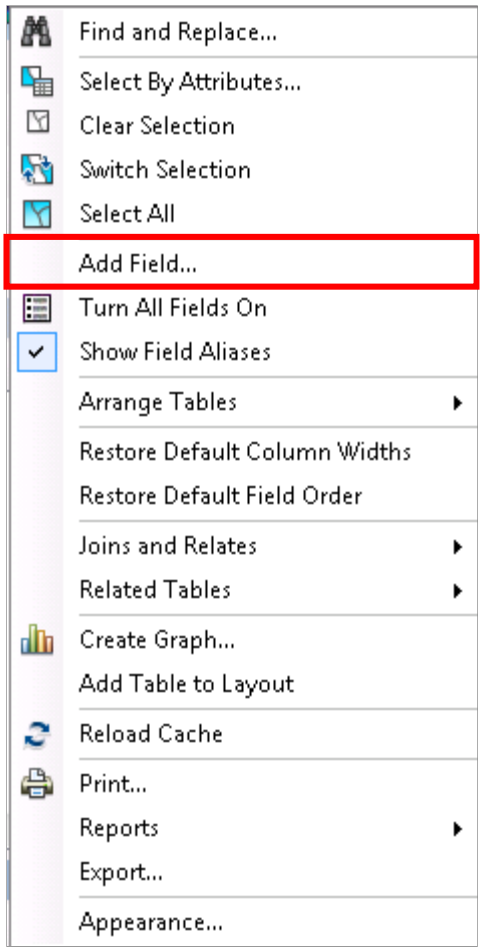
This process could also be done in Excel after exporting the AltBMPLine feature class (the calculation of IAC in Excel is not described within this document).

3.1.1 Add New IAC Field

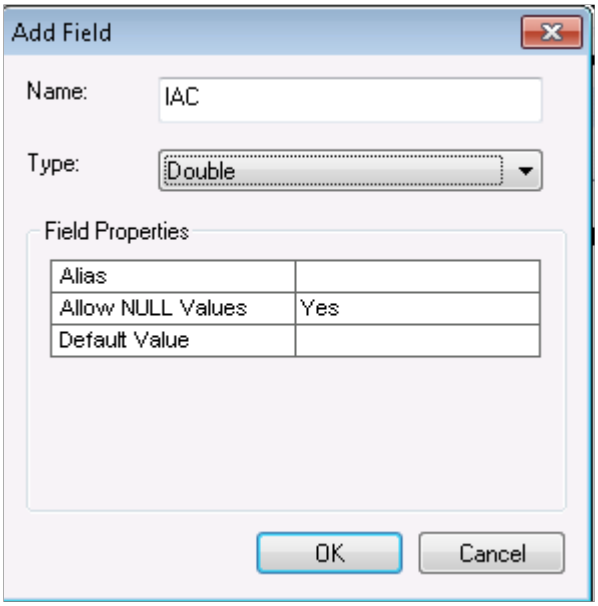
Within the AltBMPLine attribute table, click the Table Options button, and select "Add Field…"



OBJECTID *	SHAPE *	ALTBMP_LN_ID *	BMP_DRAIN_AREA	BMI
14	Polyline	SH07ALN000028	0	Alterna
30	Polyline	SH08ALN000026	0	Alterna
13	Polyline	SH12ALN000013	0	Alterna
19	Polyline	SH12ALN000018	0	Alterna
22	Polyline	SH12ALN000029	0	Alterna
25	Polyline	SH13ALN000003	0	Alterna
23	Polyline	SH13ALN000005	0	Alterna
31	Polyline	SH13ALN000007	0	Alterna
26	Polyline	SH13ALN000014	0	Alterna
36	Polyline	SH13ALN000017	0	Alterna
21	Polyline	SH13ALN000032	0	Alterna
27	Polyline	SH14ALN000010	0	Alterna
28	Polyline	SH15ALN000004	0	Alterna
20	Polyline	SH15ALN000006	0	Alterna

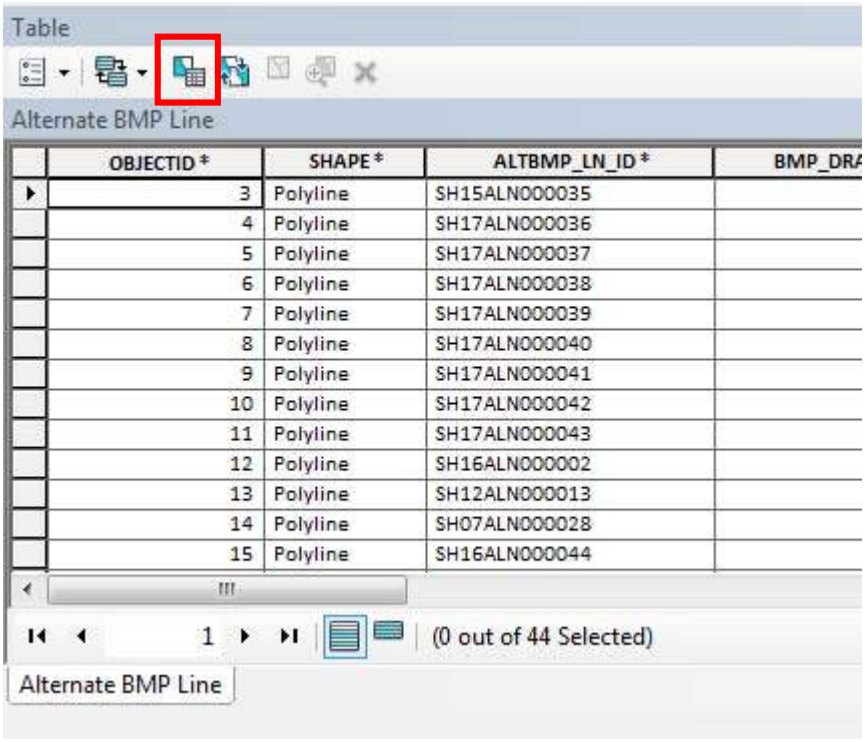


- Within the Add Field dialog window, enter the new field name – "IAC". Set Type = Double. Accept the default Allow Nulls setting. Click "OK".



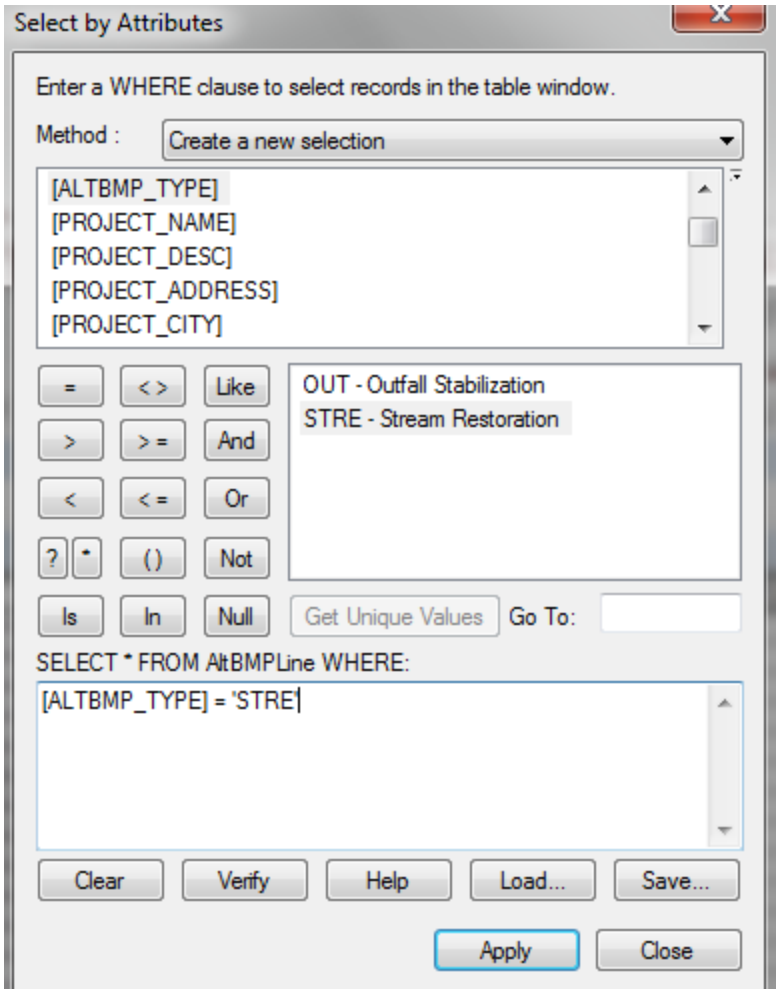
3.1.2 Calculate IAC

- Because several strategies are contained within the AltBMPLine feature class, it is necessary to select Stream Restoration strategy features first.
- Within the AltBMPLine attribute table, click the Select by Attributes button.

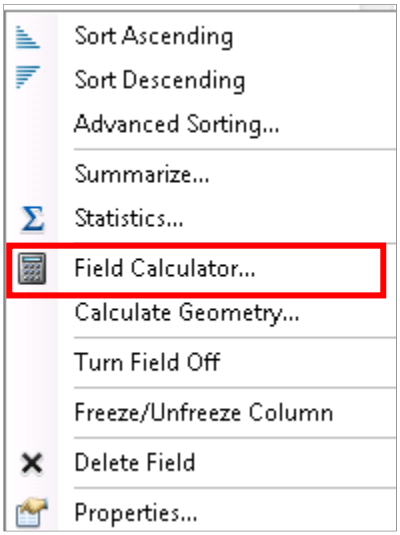


- Within the Select by Attributes dialog window, enter the following selection statement to identify stream restoration projects, and click “Apply”:

  [ALTBMP_TYPE] = 'STRE'

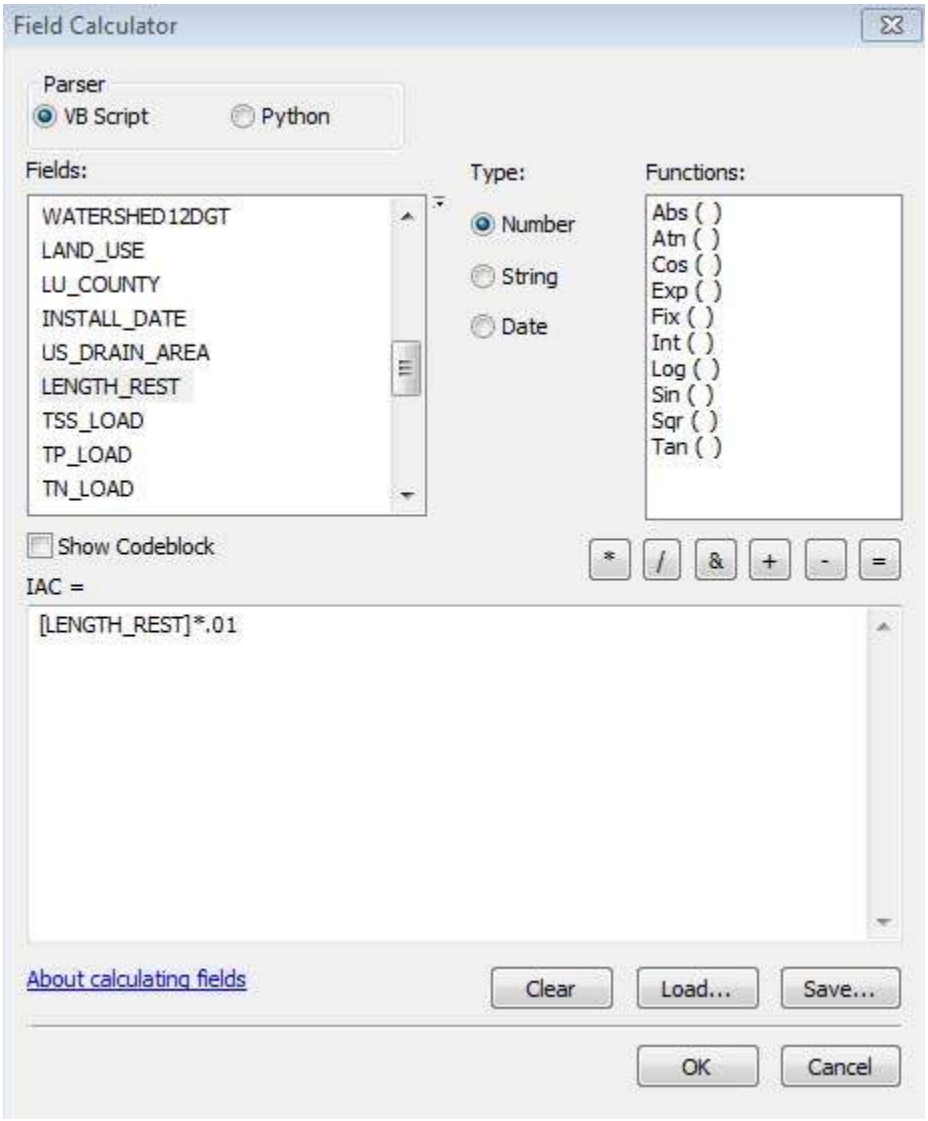


- Ensuring that the selection is retained, right click on the new IAC field, and select "Field Calculator…"



- Within the Field Calculator dialog window, enter the following calculation and click "OK":

[LENGTH_REST] * 0.01

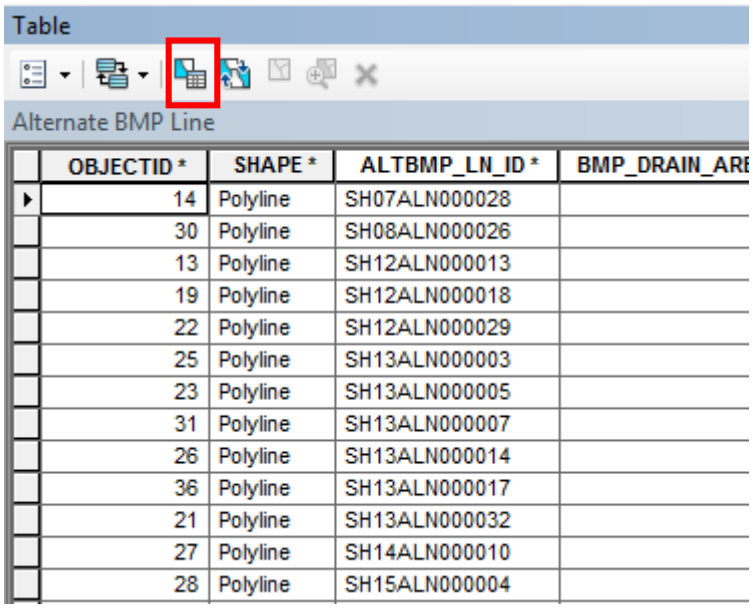


3.1.3 Stream Restoration IAC by Fiscal Year

The IAC values for stream restoration by fiscal year and strategy can be summed using the process below.

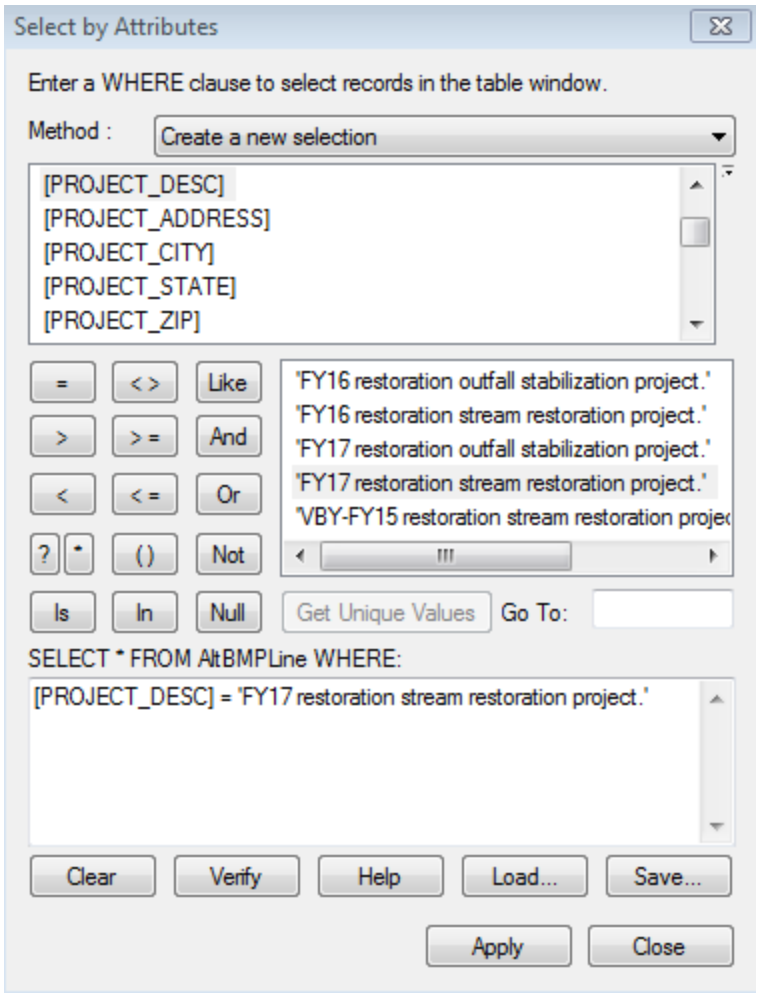
3.1.3.1 Stream Restoration IAC for FY 2017

- Within the AltBMPLine attribute table, click the Select by Attributes button.

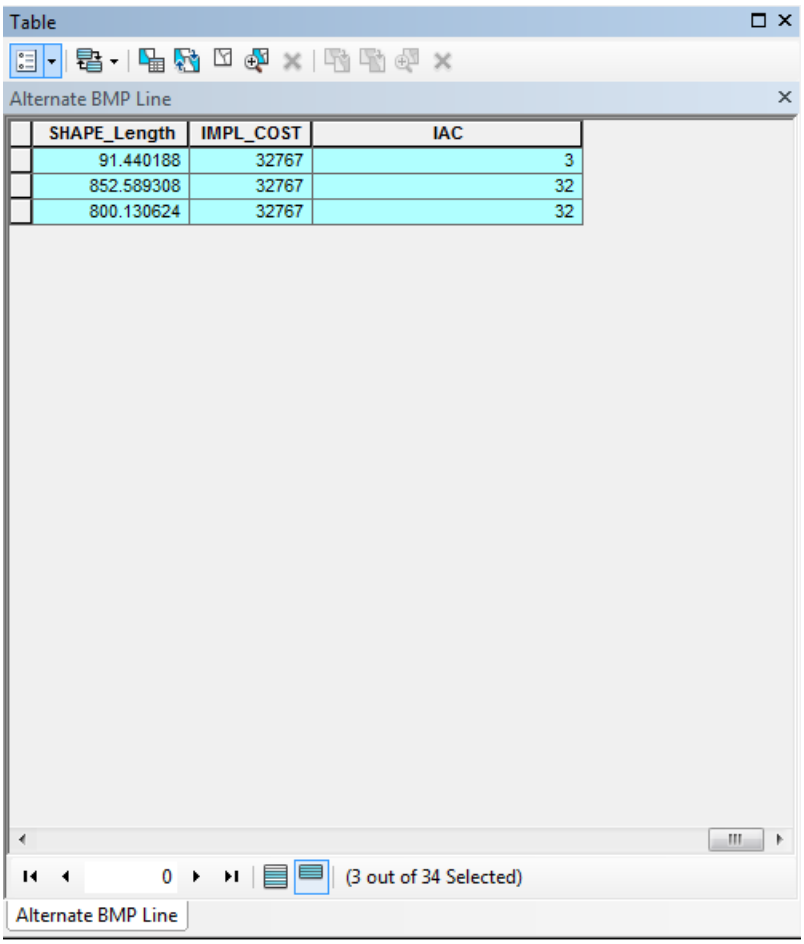


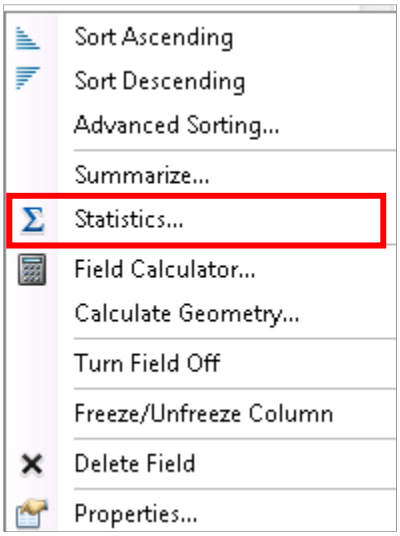
- Within the Select by Attributes dialog window, enter the following selection statement to identify stream restoration for FY 17, and click “Apply”:

  [PROJECT_DESC] = 'FY17 restoration stream restoration project.'

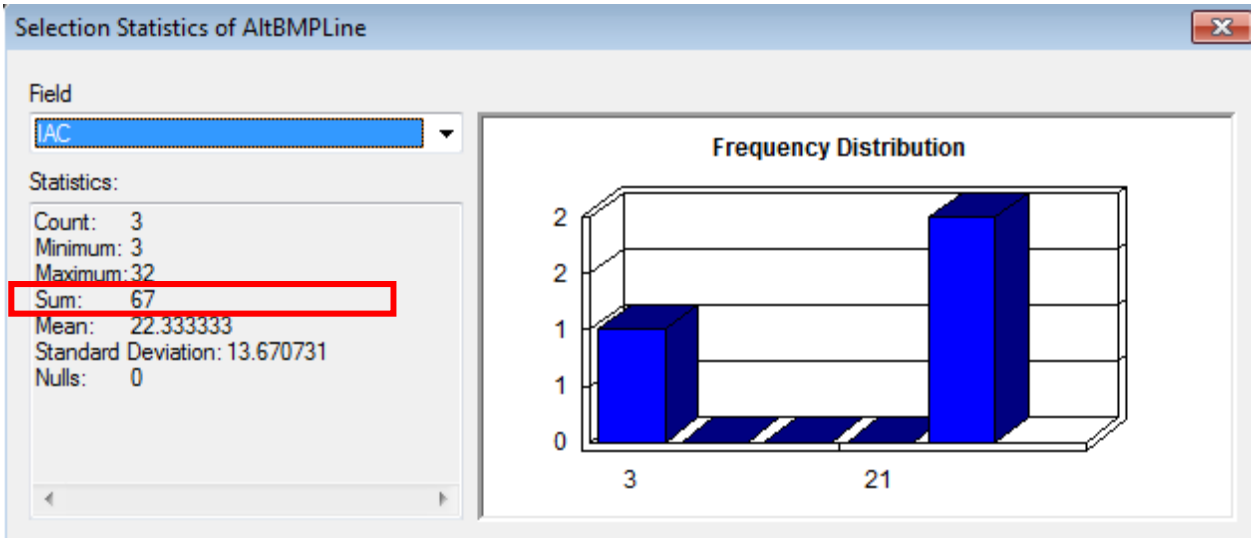


- Ensuring that the selection is retained, right click on the EQU_IMP_ACR field, and select "Statistics…"





- View the “Sum” field to view the total restoration treatment credit claimed for stream restoration FY 17.

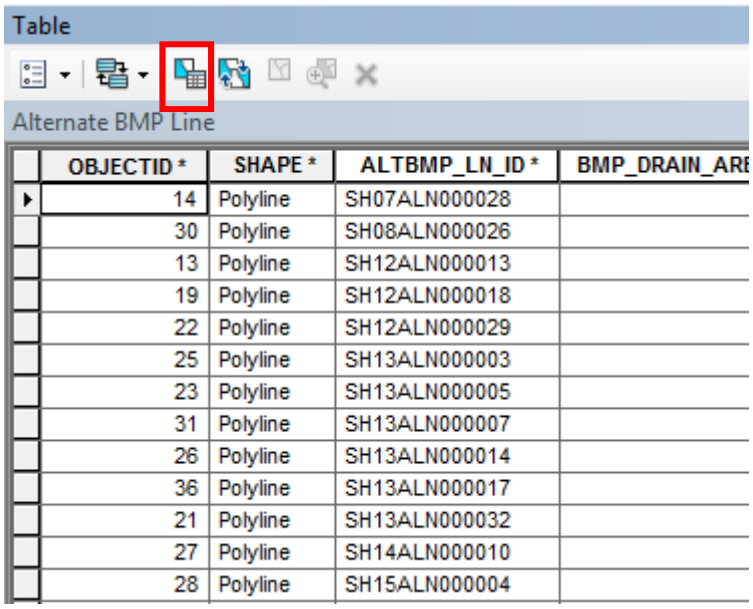


The total stream restoration treatment credit for FY17 is 67 acres.

Strategy	Variable Baseline Year - 2015	2016	2017	Total
	(acres)	(acres)	(acres)	(acres)
Impervious Surface Elimination (to Pervious)	0.49	0.00	1.89	2.38
New Stormwater	87.41	53.53	54.77	195.71
Grass Swales	0.00	9.07	11.60	20.67
Outfall Stabilization	0.00	2.00	16.25	18.25
Retrofit	0.00	94.43	4.78	99.21
Stream Restoration	444.04	137.24	67.00	648.28
Tree Planting	598.27	66.65	22.09	687.01
Redevelopment Credit	0.00	0.00	81.00	81.00
Inlet Cleaning	0.00	0.00	150.00	150.00
Street Sweeping	0.00	0.00	33.00	33.00
Totals	**1,130**	**363**	**442**	**1,936**
20% Restoration Target				**4709**

3.1.3.2 Stream Restoration IAC for FY 2016

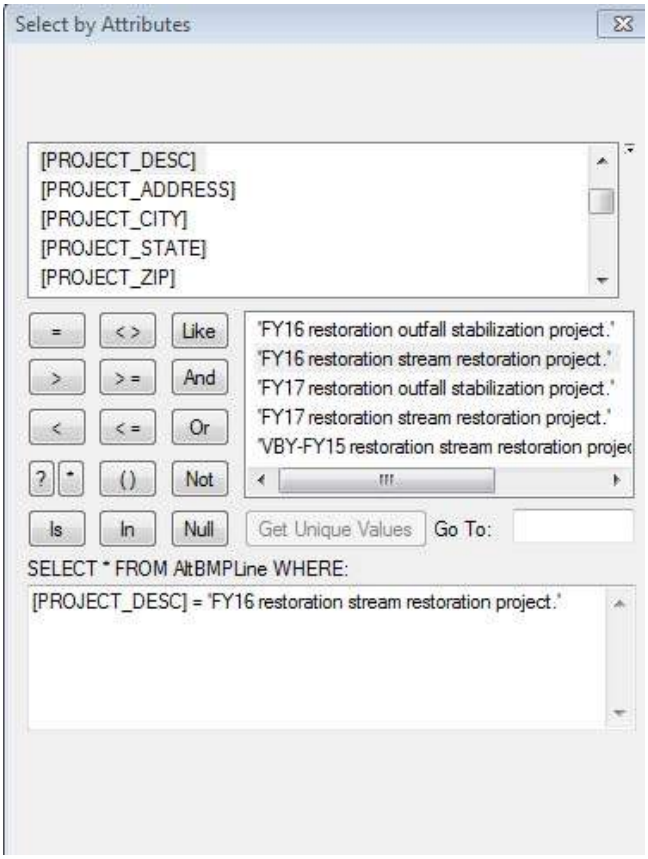
- Within the AltBMPLine attribute table, click the Select by Attributes button.



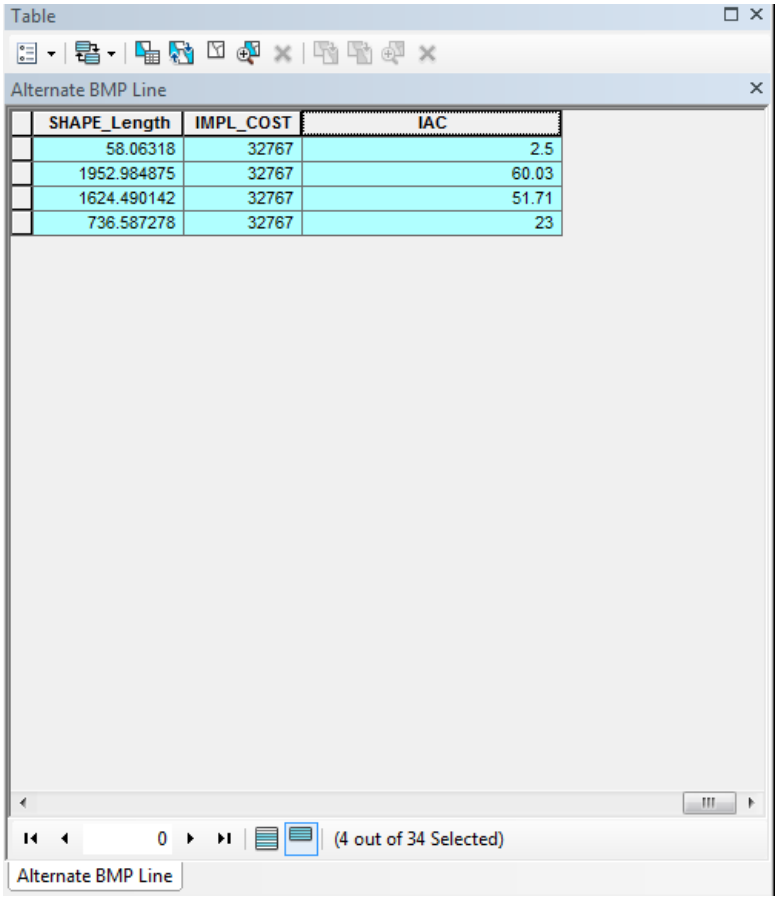
OBJECTID *	SHAPE *	ALTBMP_LN_ID *	BMP_DRAIN_ARE
14	Polyline	SH07ALN000028	
30	Polyline	SH08ALN000026	
13	Polyline	SH12ALN000013	
19	Polyline	SH12ALN000018	
22	Polyline	SH12ALN000029	
25	Polyline	SH13ALN000003	
23	Polyline	SH13ALN000005	
31	Polyline	SH13ALN000007	
26	Polyline	SH13ALN000014	
36	Polyline	SH13ALN000017	
21	Polyline	SH13ALN000032	
27	Polyline	SH14ALN000010	
28	Polyline	SH15ALN000004	

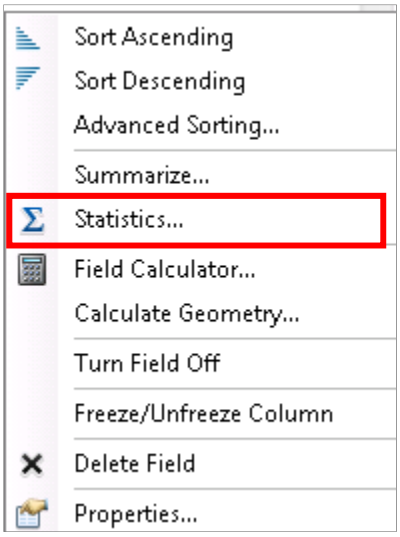
- Within the Select by Attributes dialog window, enter the following selection statement to identify stream restoration for FY 16, and click “Apply”:

  [PROJECT_DESC] = 'FY16 restoration stream restoration project.'

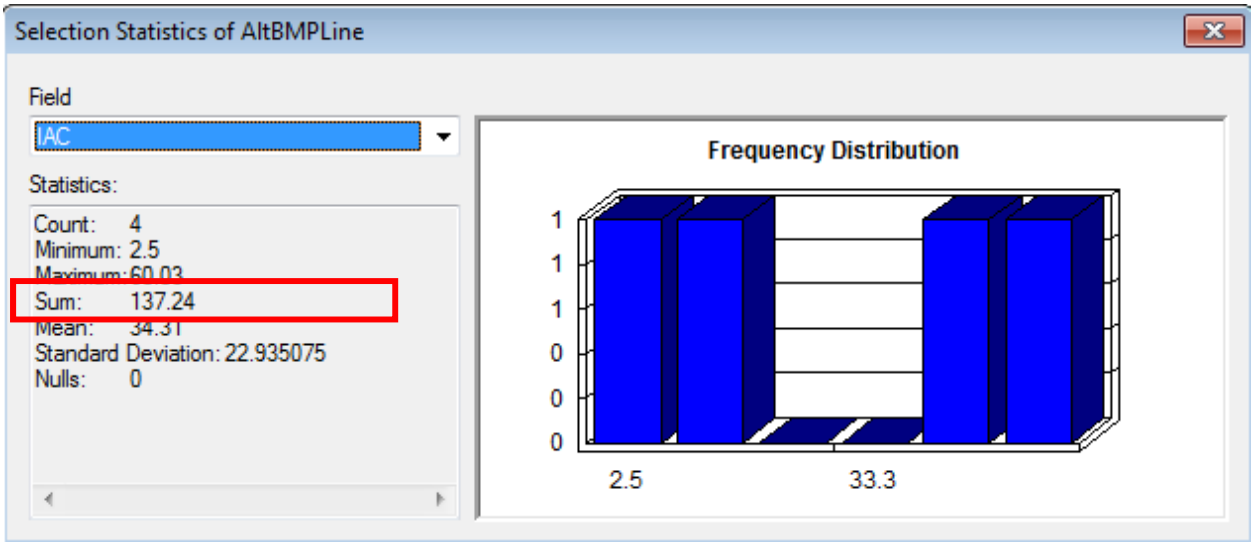


- Ensuring that the selection is retained, right click on the EQU_IMP_ACR field, and select "Statistics…"





- View the "Sum" field to view the total restoration treatment credit claimed for stream restoration FY 16.

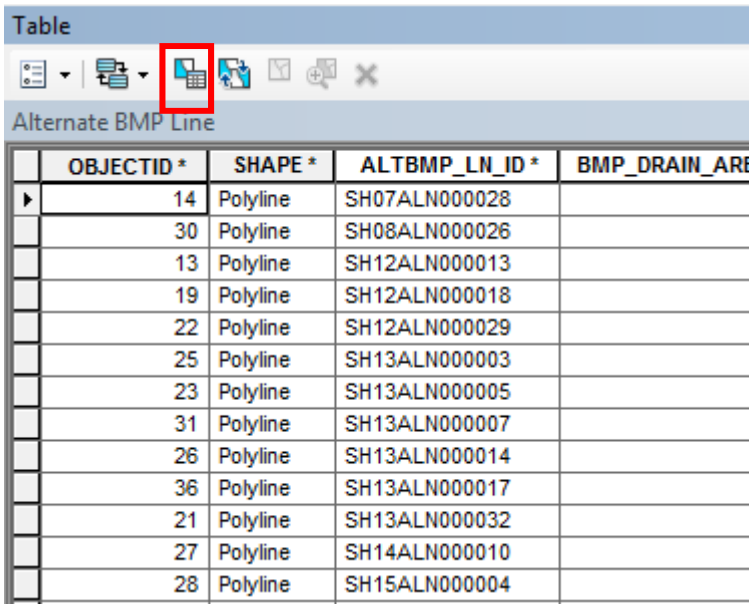


The total stream restoration treatment credit for FY16 is 137.24 acres.

Strategy	Variable Baseline Year - 2015	2016	2017	Total
	(acres)	(acres)	(acres)	(acres)
Impervious Surface Elimination (to Pervious)	0.49	0.00	1.89	2.38
New Stormwater	87.41	53.53	54.77	195.71
Grass Swales	0.00	9.07	11.60	20.67
Outfall Stabilization	0.00	2.00	16.25	18.25
Retrofit	0.00	94.43	4.78	99.21
Stream Restoration	444.04	137.24	67.00	648.28
Tree Planting	598.27	66.65	22.09	687.01
Redevelopment Credit	0.00	0.00	81.00	81.00
Inlet Cleaning	0.00	0.00	150.00	150.00
Street Sweeping	0.00	0.00	33.00	33.00
Totals	**1,130**	**363**	**442**	**1,936**
20% Restoration Target				**4709**

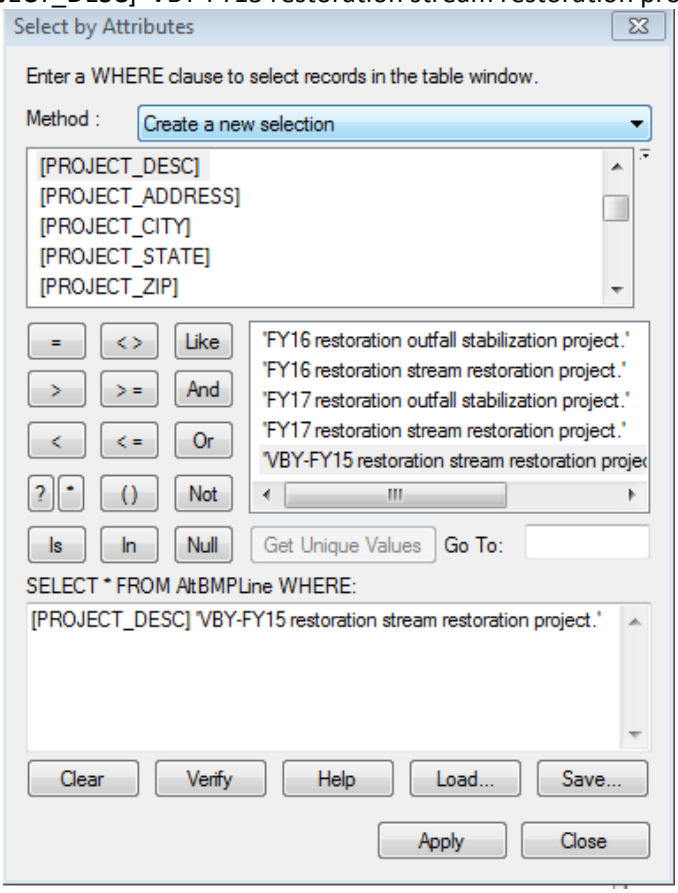
3.1.3.3 Stream Restoration IAC for VBY-2015

- Within the AltBMPLine attribute table, click the Select by Attributes button.

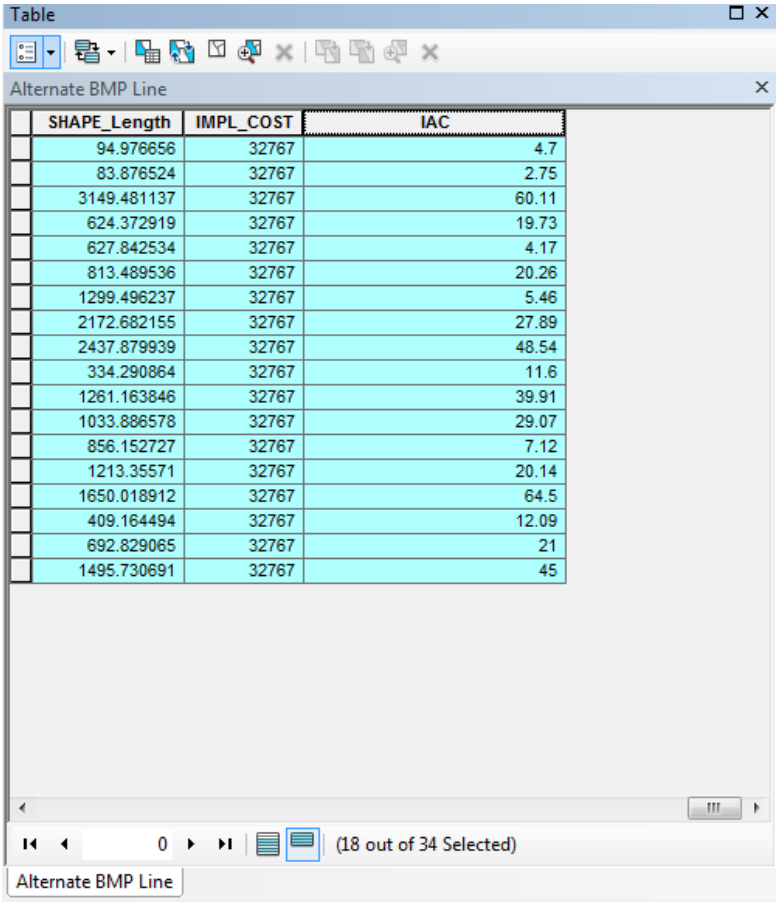


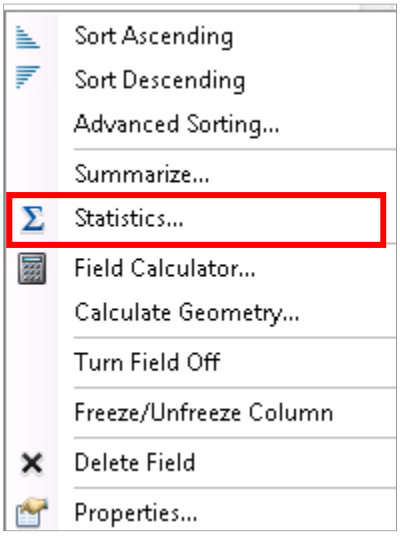
- Within the Select by Attributes dialog window, enter the following selection statement to identify stream restoration for VBY-2015, and click “Apply”:

[PROJECT_DESC] 'VBY-FY15 restoration stream restoration project.'

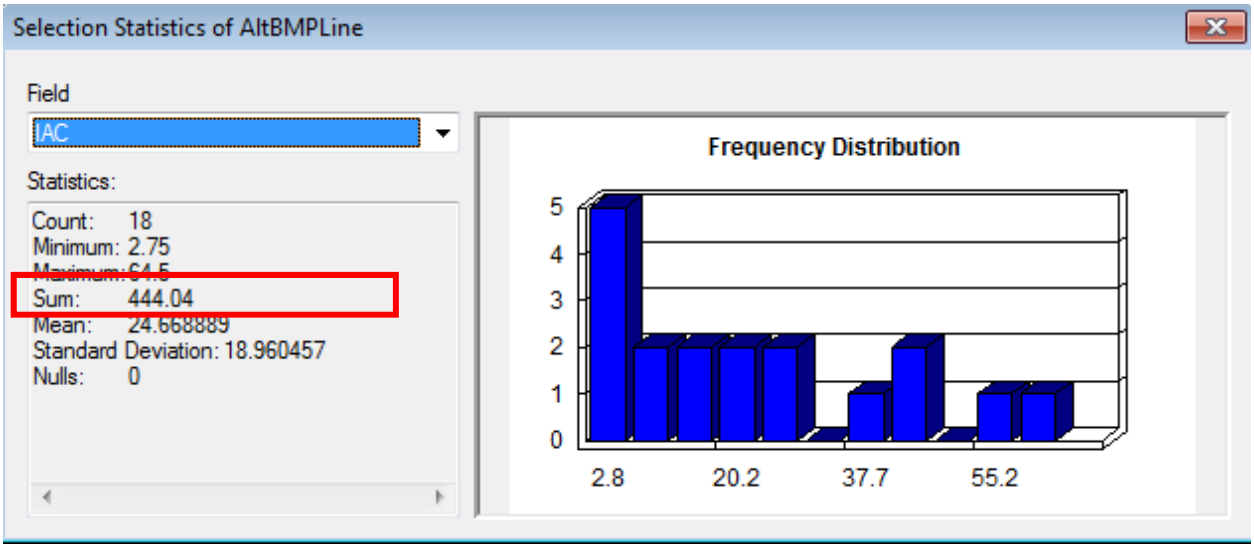


- Ensuring that the selection is retained, right click on the EQU_IMP_ACR field, and select "Statistics…"





- View the "Sum" field to view the total restoration treatment credit claimed for stream restoration VBY-2015.



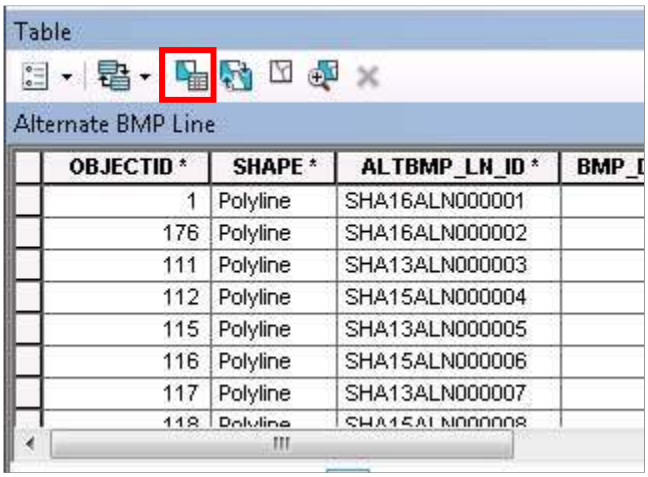
The total stream restoraiton treatment credit for VBY-2015 is 444.04 acres.

Strategy	Variable Baseline Year - 2015	2016	2017	Total
	(acres)	(acres)	(acres)	(acres)
Impervious Surface Elimination (to Pervious)	0.49	0.00	1.89	2.38
New Stormwater	87.41	53.53	54.77	195.71
Grass Swales	0.00	9.07	11.60	20.67
Outfall Stabilization	0.00	2.00	16.25	18.25
Retrofit	0.00	94.43	4.78	99.21
Stream Restoration	444.04	137.24	67.00	648.28
Tree Planting	598.27	66.65	22.09	687.01
Redevelopment Credit	0.00	0.00	81.00	81.00
Inlet Cleaning	0.00	0.00	150.00	150.00
Street Sweeping	0.00	0.00	33.00	33.00
Totals	**1,130**	**363**	**442**	**1,936**
20% Restoration Target				**4709**

3.2 Total Stream Restoration IAC Sum

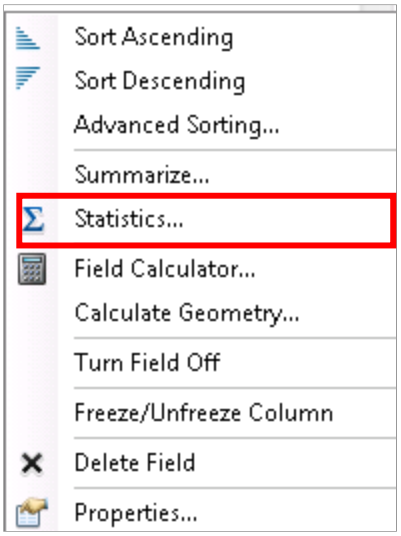
To determine restoration stream restoration IAC, select stream restorations, and sum the EQU_IMP_ACR:

- Within the AltBMPLine feature class, click the Select by Attributes tool.

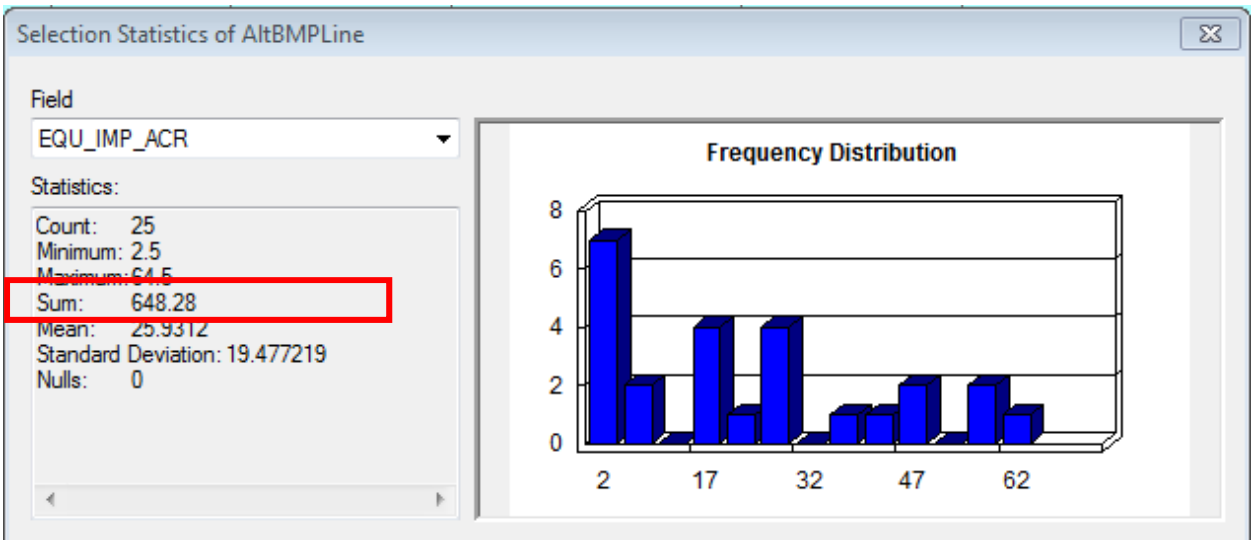


- In the statement box, enter the following selection statement and click “Apply”: [ALTBMP_TYPE] = 'STRE'

- Ensuring that the selection is retained, right click on the EQV_IMP_ACR, and select “Statistics…”



- View the “Sum” field to view the total restoration treatment credit claimed for Stream Restoration.



The total stream restoration treatment credit 648.28 acres.

Strategy	Variable Baseline Year - 2015	2016	2017	Total
	(acres)	(acres)	(acres)	(acres)
Impervious Surface Elimination (to Pervious)	0.49	0.00	1.89	2.38
New Stormwater	87.41	53.53	54.77	195.71
Grass Swales	0.00	9.07	11.60	20.67
Outfall Stabilization	0.00	2.00	16.25	18.25
Retrofit	0.00	94.43	4.78	99.21
Stream Restoration	444.04	137.24	67.00	648.28
Tree Planting	598.27	66.65	22.09	687.01
Redevelopment Credit	0.00	0.00	81.00	81.00
Inlet Cleaning	0.00	0.00	150.00	150.00
Street Sweeping	0.00	0.00	33.00	33.00
Totals	**1,130**	**363**	**442**	**1,936**
20% Restoration Target				**4709**

4.0 Outfall Stabilizations

Calculating the impervious treatment credit for Outfall Stabilizations requires two (2) primary inputs:

- Length of Restoration, from within the MDE MS4 geodatabase (AltBMPLine feature class' LENGTH_REST field)
- Impervious Acre Equivalent factor, from Table 7 of MDE's August 2014 guidance (0.01 for outfall stabilizations)

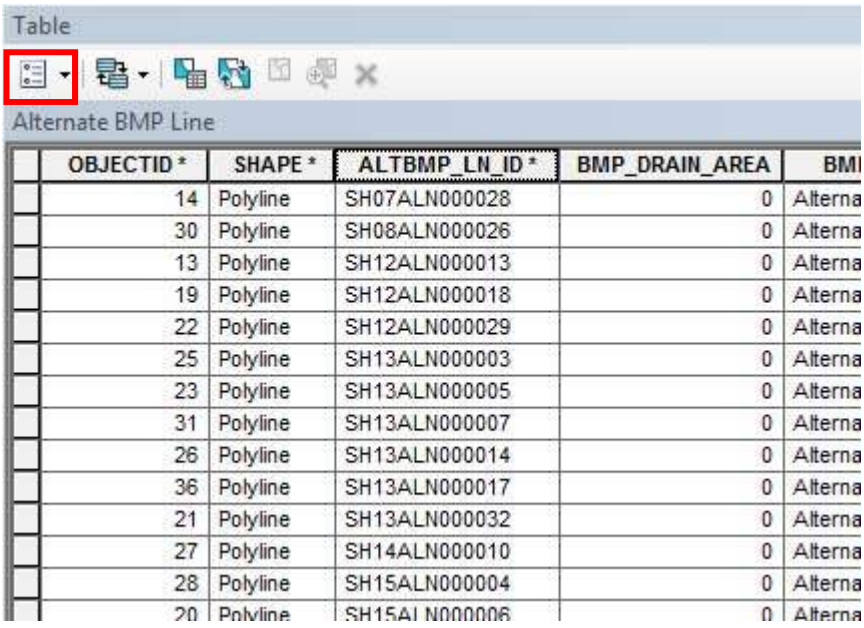
4.1 Outfall Stabilization IAC Calculation

The AltBMPLine feature class contains a field to explicitly capture IAC ("EQU_IMP_ACR"). To verify the IAC, this example will add a new, temporary field to the AltBMPLine feature class. This new field will hold the results of the IAC calculation, so once calculated, will equal the existing MDE field "EQU_IMP_ACR". This field is added as a way to re-calculate the IAC, and ensure values align with the MDE field.

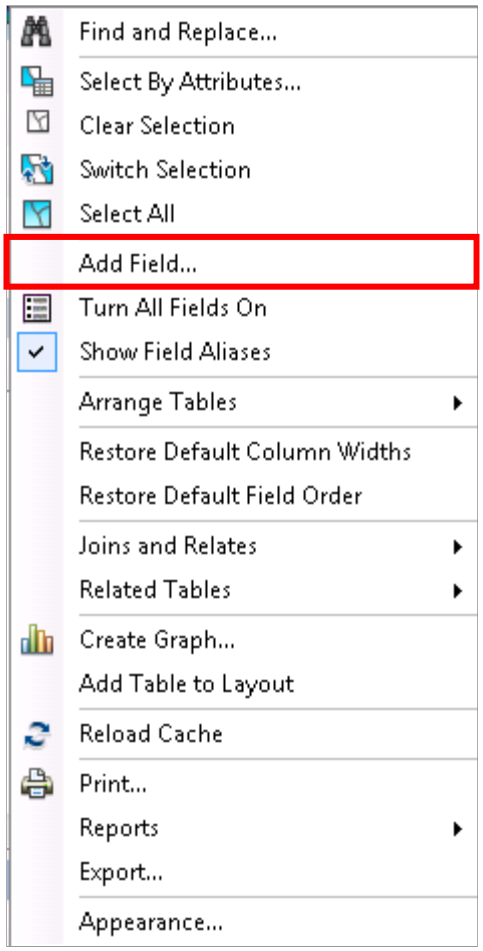
This process could also be done in Excel after exporting the AltBMPLine feature class (the calculation of IAC in Excel is not described within this document).

4.1.1 Add New IAC Field

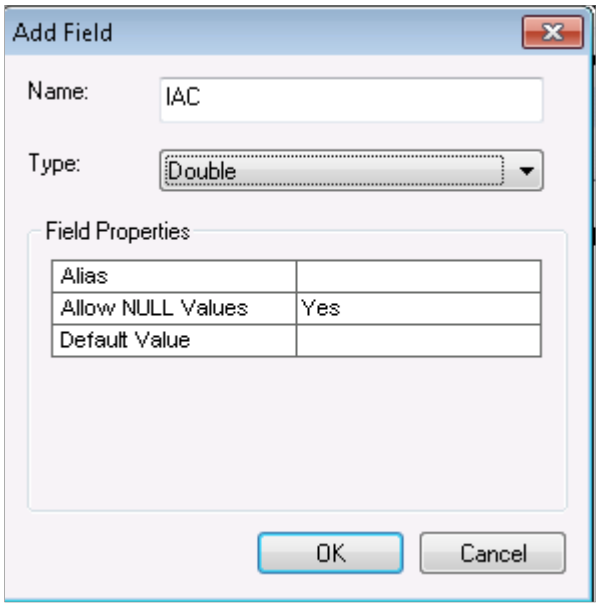
Within the AltBMPLine attribute table, click the Table Options button, and select "Add Field…"



OBJECTID *	SHAPE *	ALTBMP_LN_ID *	BMP_DRAIN_AREA	BMI
14	Polyline	SH07ALN000028	0	Alterna
30	Polyline	SH08ALN000026	0	Alterna
13	Polyline	SH12ALN000013	0	Alterna
19	Polyline	SH12ALN000018	0	Alterna
22	Polyline	SH12ALN000029	0	Alterna
25	Polyline	SH13ALN000003	0	Alterna
23	Polyline	SH13ALN000005	0	Alterna
31	Polyline	SH13ALN000007	0	Alterna
26	Polyline	SH13ALN000014	0	Alterna
36	Polyline	SH13ALN000017	0	Alterna
21	Polyline	SH13ALN000032	0	Alterna
27	Polyline	SH14ALN000010	0	Alterna
28	Polyline	SH15ALN000004	0	Alterna
20	Polyline	SH15ALN000006	0	Alterna

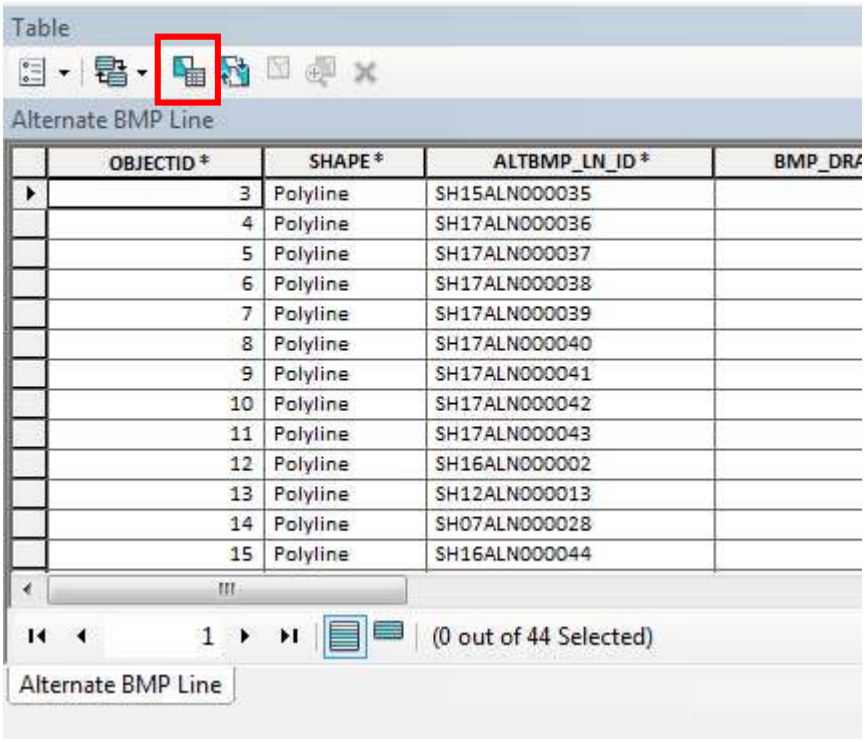


- Within the Add Field dialog window, enter the new field name – "IAC". Set Type = Double. Accept the default Allow Nulls setting. Click "OK".



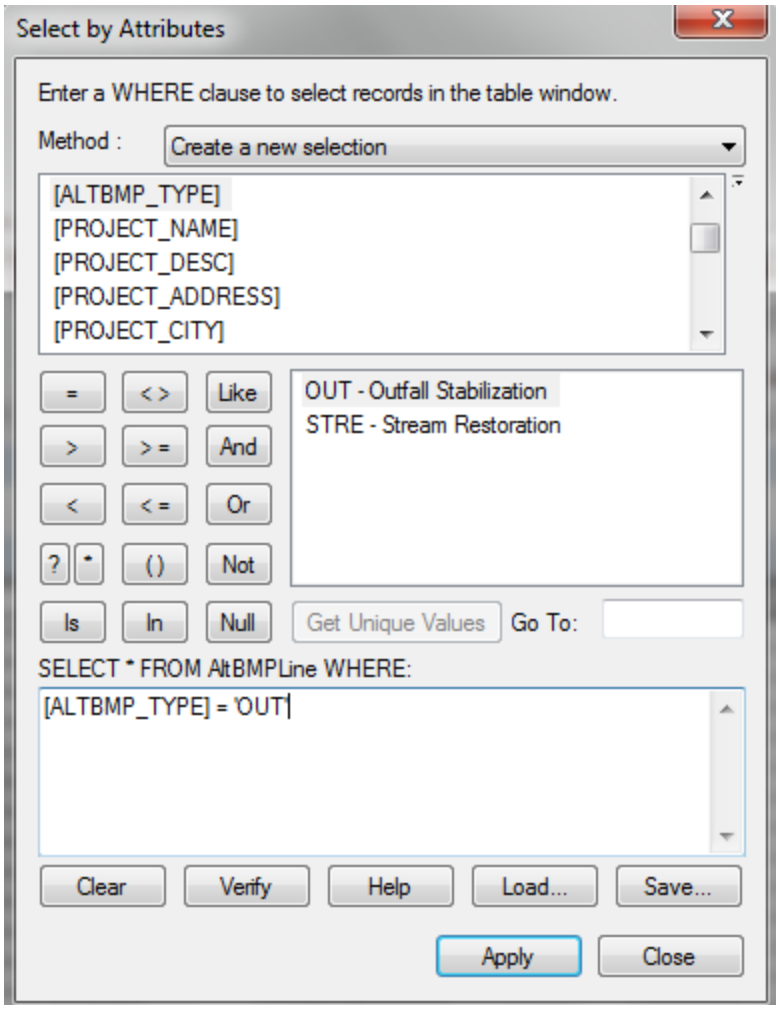
4.1.2 Calculate IAC

- Because several strategies are contained within the AltBMPLine feature class, it is necessary to select Outfall Stabilization strategy features first.
- Within the AltBMPLine attribute table, click the Select by Attributes button.

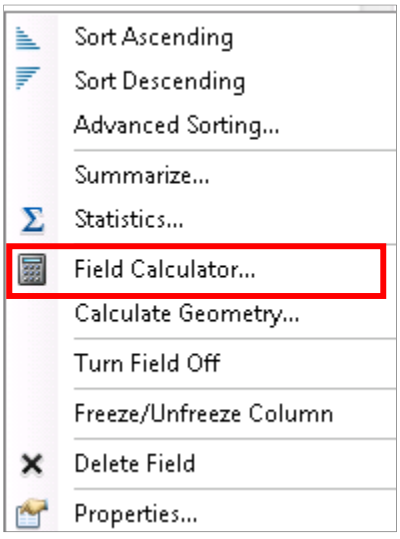


- Within the Select by Attributes dialog window, enter the following selection statement to identify stream restoration projects, and click “Apply”:

  [ALTBMP_TYPE] = ‘OUT’

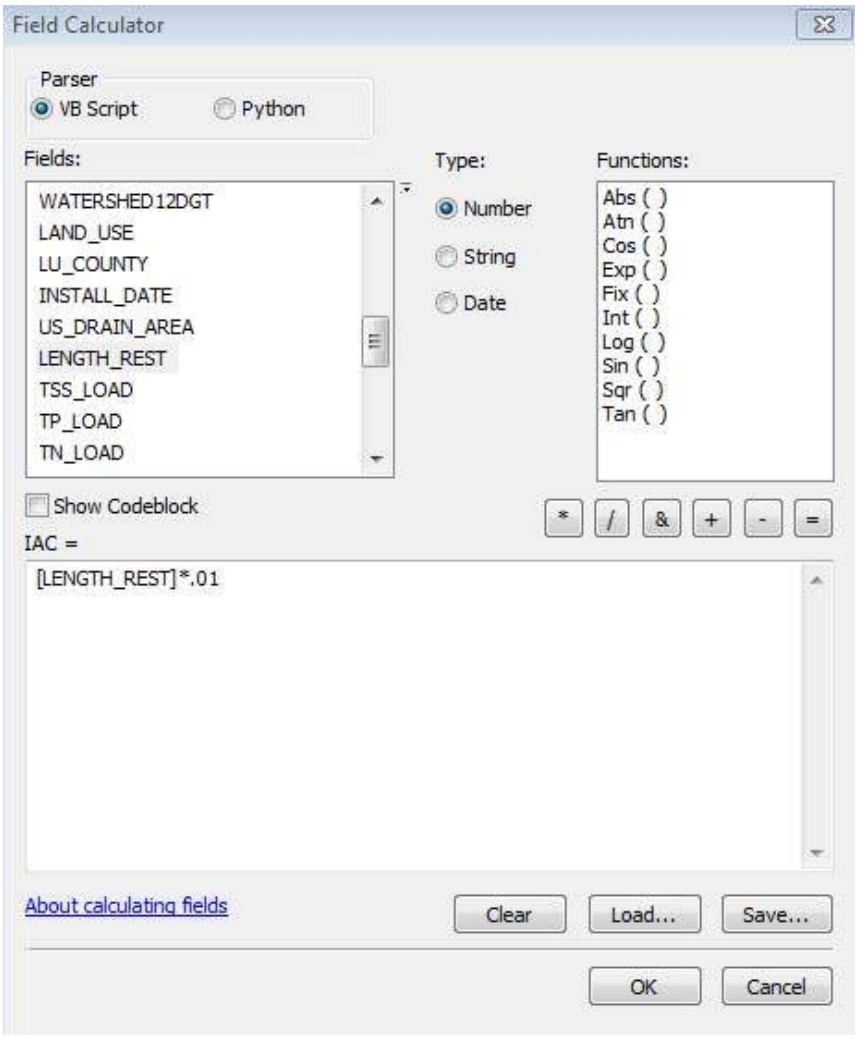


- Ensuring that the selection is retained, right click on the new IAC field, and select "Field Calculator…"



- Within the Field Calculator dialog window, enter the following calculation and click “OK”:

  [LENGTH_REST] * 0.01

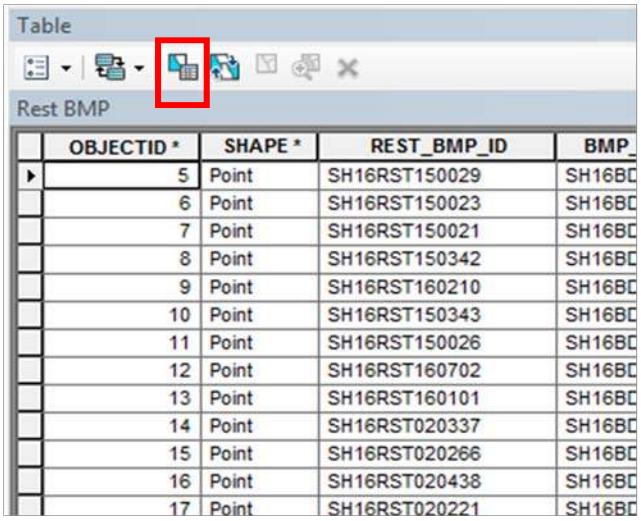


4.1.3 Outfall Stabilization IAC by Fiscal Year

The IAC values for Outfall Stabilization by fiscal year and strategy can be summed using the process below.

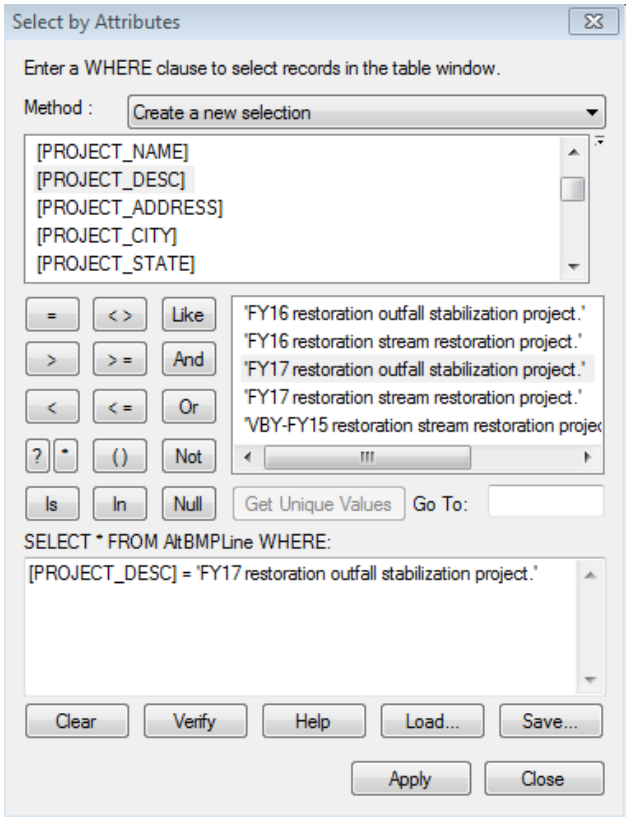
4.1.3.1 Outfall Stabilization IAC for FY 2017

- Within the AltBMPLine attribute table, click the Select by Attributes button.

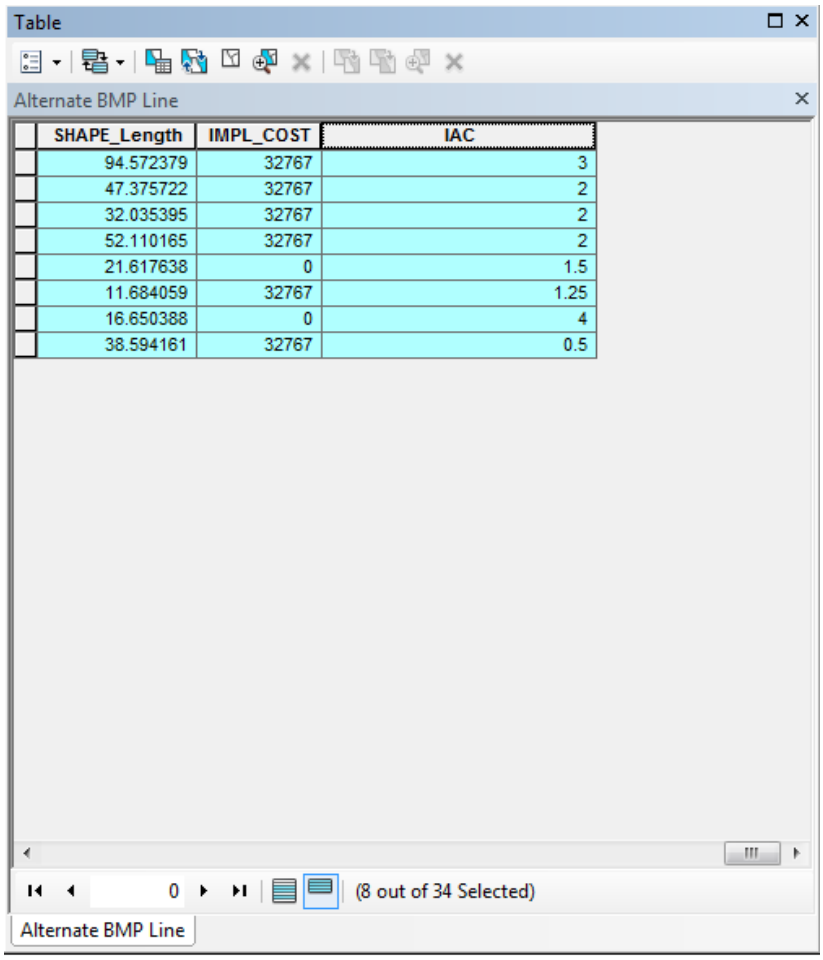


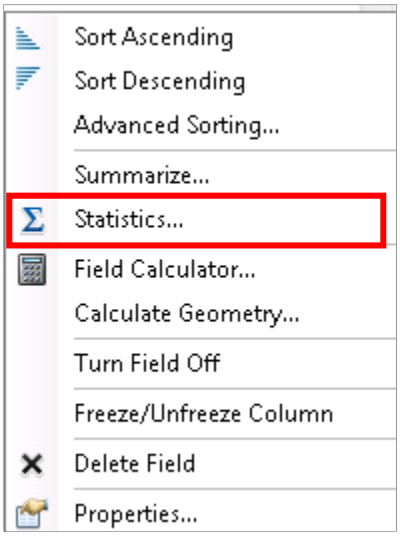
- Within the Select by Attributes dialog window, enter the following selection statement to identify stream restoration for FY 17, and click “Apply”:

[PROJECT_DESC] = 'FY17 restoration outfall stabilization project.'

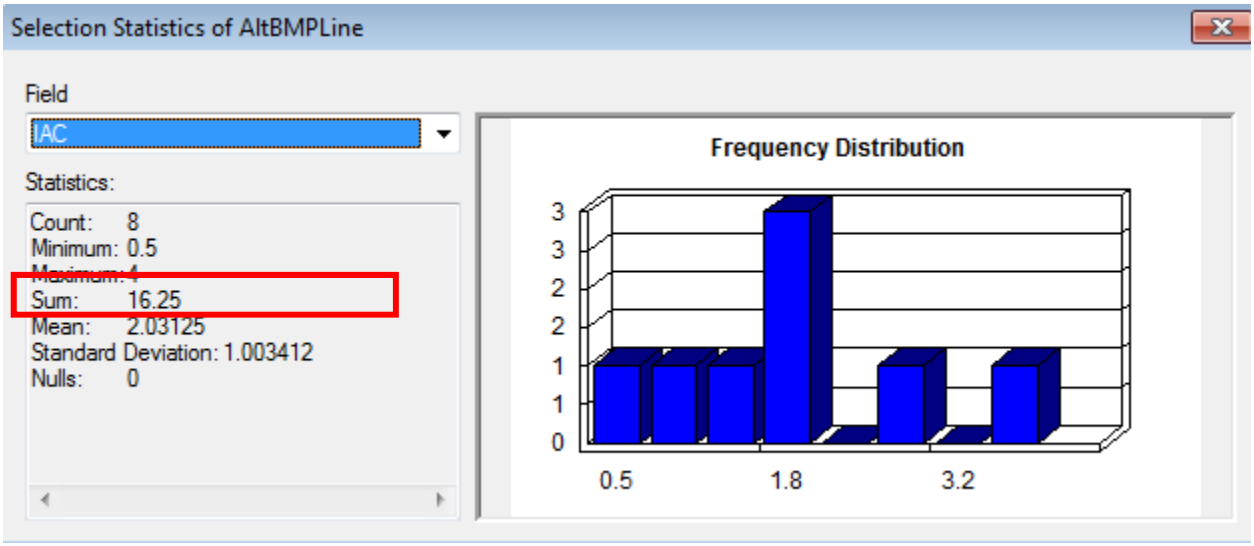


- Ensuring that the selection is retained, right click on the EQU_IMP_ACR field, and select “Statistics…”





- View the “Sum” field to view the total restoration treatment credit claimed for outfall stabilization restoration FY 17.

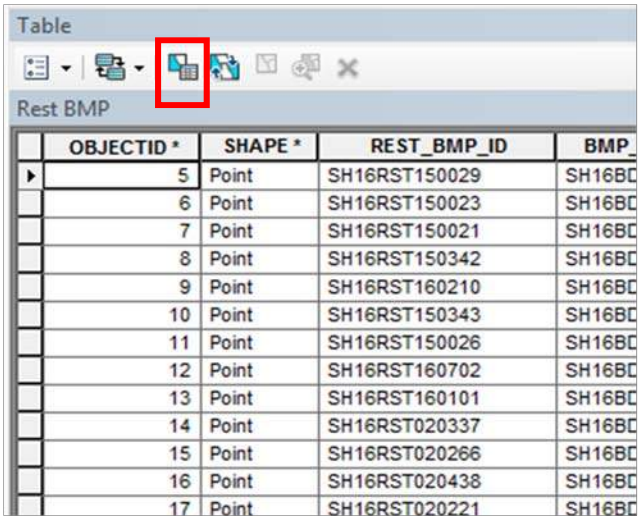


The total outfall stabilization treatment credit for FY17 is 16.25 acres.

Strategy	Variable Baseline Year - 2015	2016	2017	Total
	(acres)	(acres)	(acres)	(acres)
Impervious Surface Elimination (to Pervious)	0.49	0.00	1.89	2.38
New Stormwater	87.41	53.53	54.77	195.71
Grass Swales	0.00	9.07	11.60	20.67
Outfall Stabilization	0.00	2.00	16.25	18.25
Retrofit	0.00	94.43	4.78	99.21
Stream Restoration	444.04	137.24	67.00	648.28
Tree Planting	598.27	66.65	22.09	687.01
Redevelopment Credit	0.00	0.00	81.00	81.00
Inlet Cleaning	0.00	0.00	150.00	150.00
Street Sweeping	0.00	0.00	33.00	33.00
Totals	**1,130**	**363**	**442**	**1,936**
20% Restoration Target				**4709**

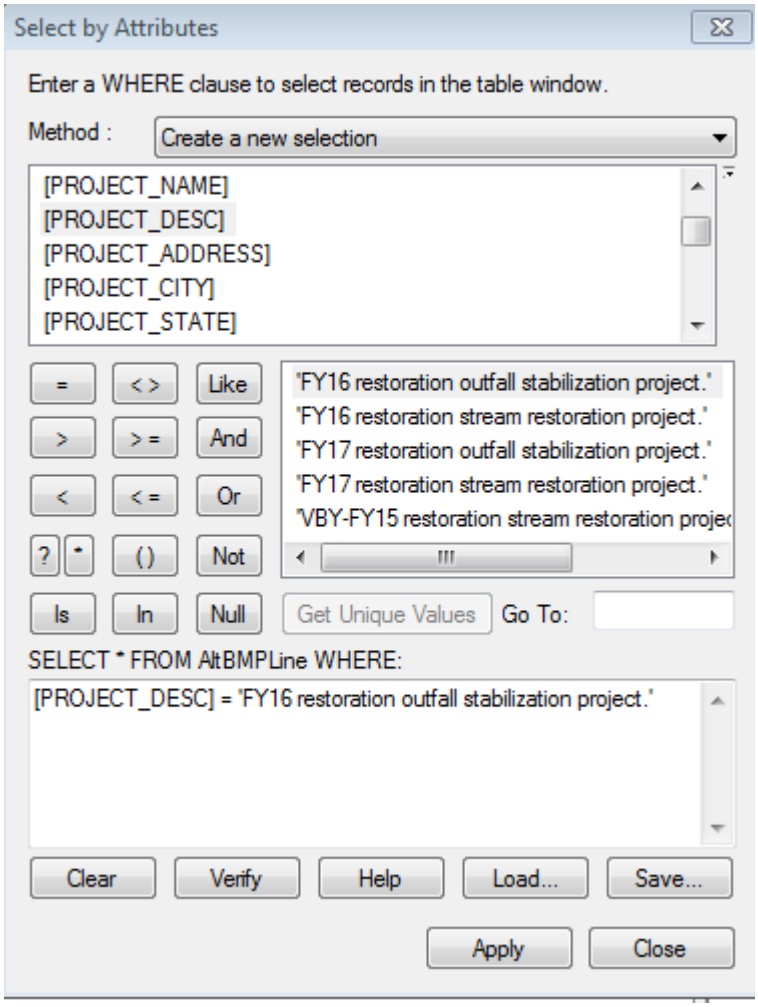
4.1.3.2 Outfall Stabilization IAC for FY 2016

- Within the AltBMPLine attribute table, click the Select by Attributes button.

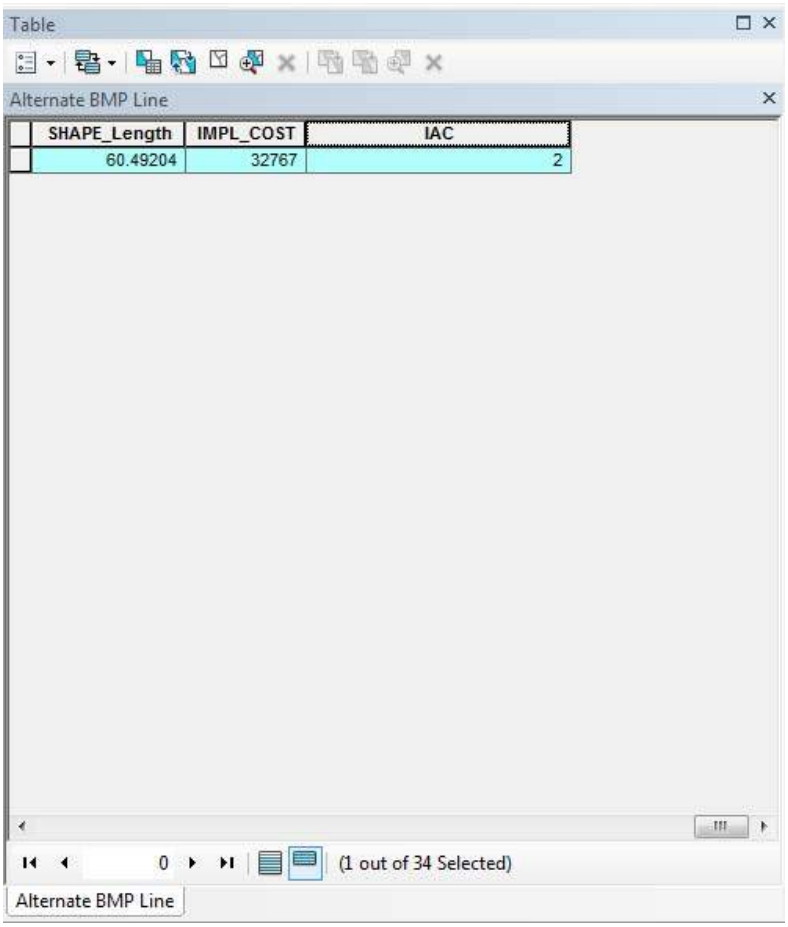


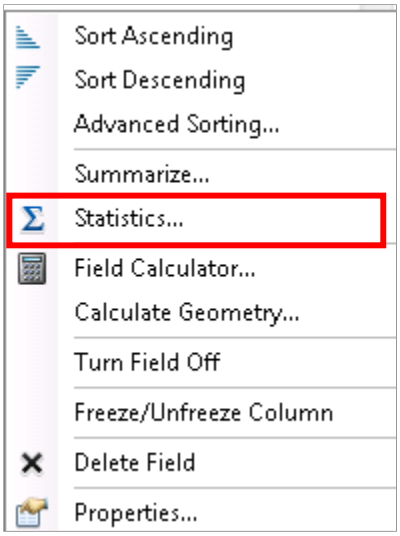
- Within the Select by Attributes dialog window, enter the following selection statement to identify stream restoration for FY 16, and click “Apply”:

  [PROJECT_DESC] = 'FY16 restoration outfall stabilization project.'

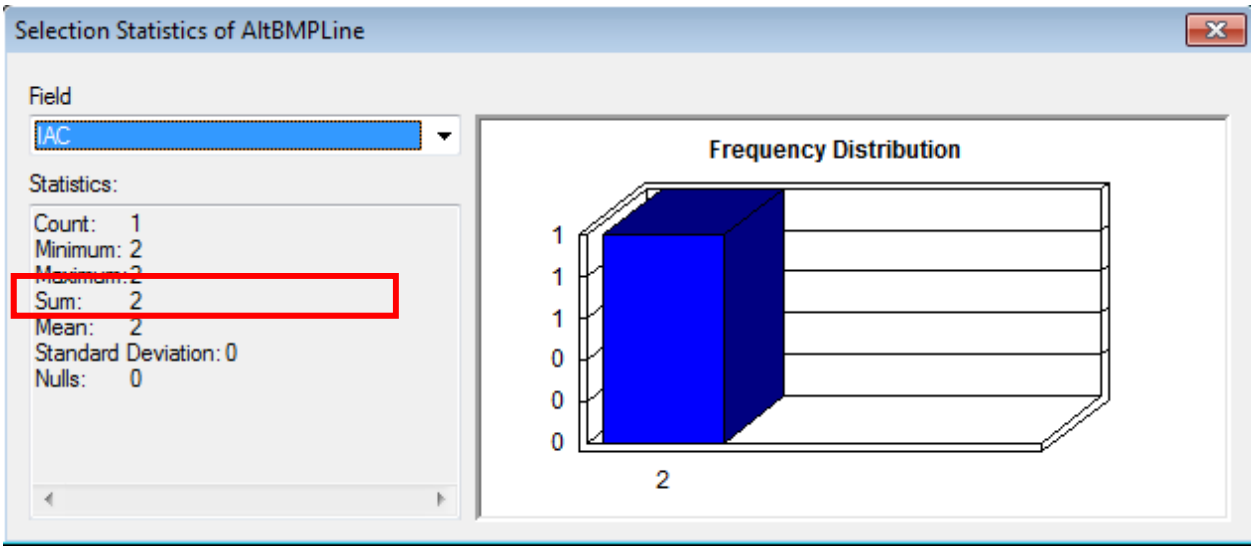


- Ensuring that the selection is retained, right click on the EQU_IMP_ACR field, and select "Statistics…"





- View the “Sum” field to view the total restoration treatment credit claimed for outfall stabilization FY 16.



The total outfall stabilization treatment credit for FY16 is 2 acres.

Strategy	Variable Baseline Year - 2015	2016	2017	Total
	(acres)	(acres)	(acres)	(acres)
Impervious Surface Elimination (to Pervious)	0.49	0.00	1.89	2.38
New Stormwater	87.41	53.53	54.77	195.71
Grass Swales	0.00	9.07	11.60	20.67
Outfall Stabilization	0.00	2.00	16.25	18.25
Retrofit	0.00	94.43	4.78	99.21
Stream Restoration	444.04	137.24	67.00	648.28
Tree Planting	598.27	66.65	22.09	687.01
Redevelopment Credit	0.00	0.00	81.00	81.00
Inlet Cleaning	0.00	0.00	150.00	150.00
Street Sweeping	0.00	0.00	33.00	33.00
Totals	**1,130**	**363**	**442**	**1,936**
20% Restoration Target				**4709**

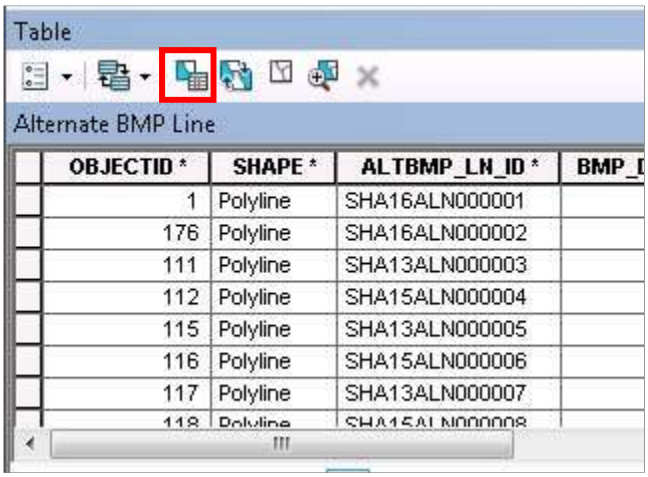
4.1.3.3 Outfall Stabilization IAC for VBY-2015

There are no restoration outfall stabilizations for VBY-2015

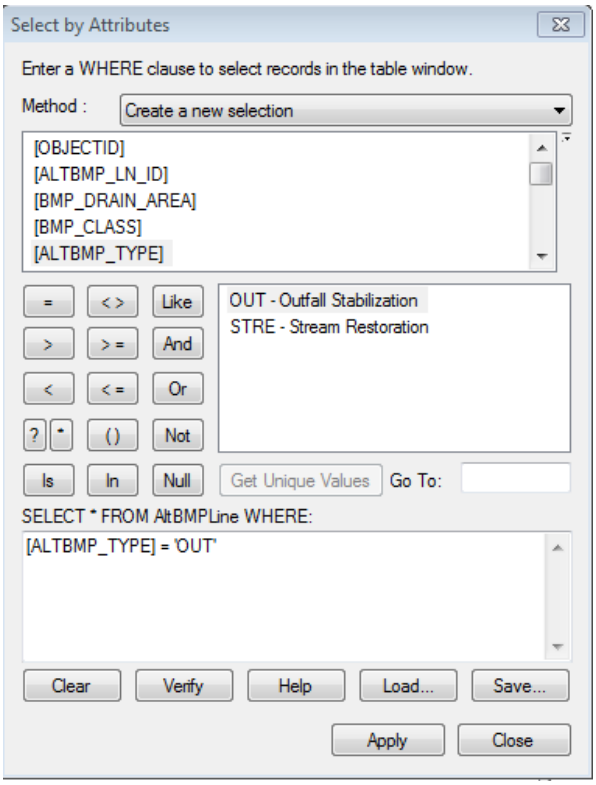
4.2 Total Outfall Stabilization IAC Sum

To determine restoration outfall stabilization IAC, select outfall stabilization, and sum the EQU_IMP_ACR:

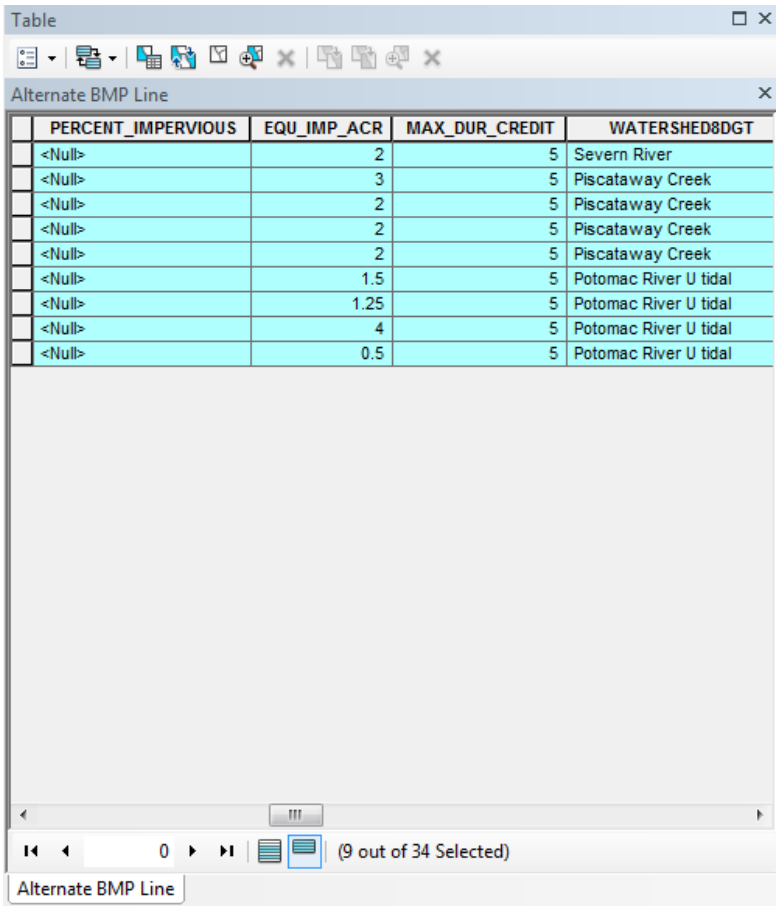
- Within the AltBMPLine feature class, click the Select by Attributes tool.

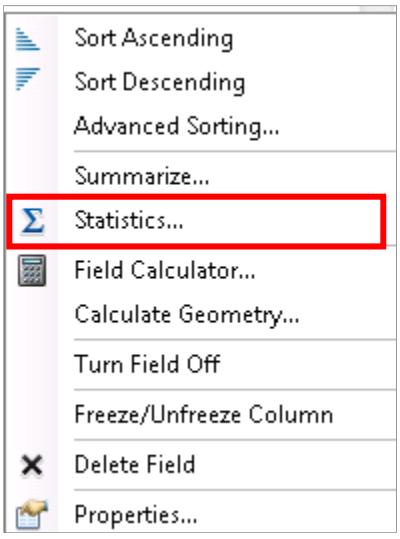


- In the statement box, enter the following selection statement and click “Apply”: [ALTBMP_TYPE] = 'OUT'

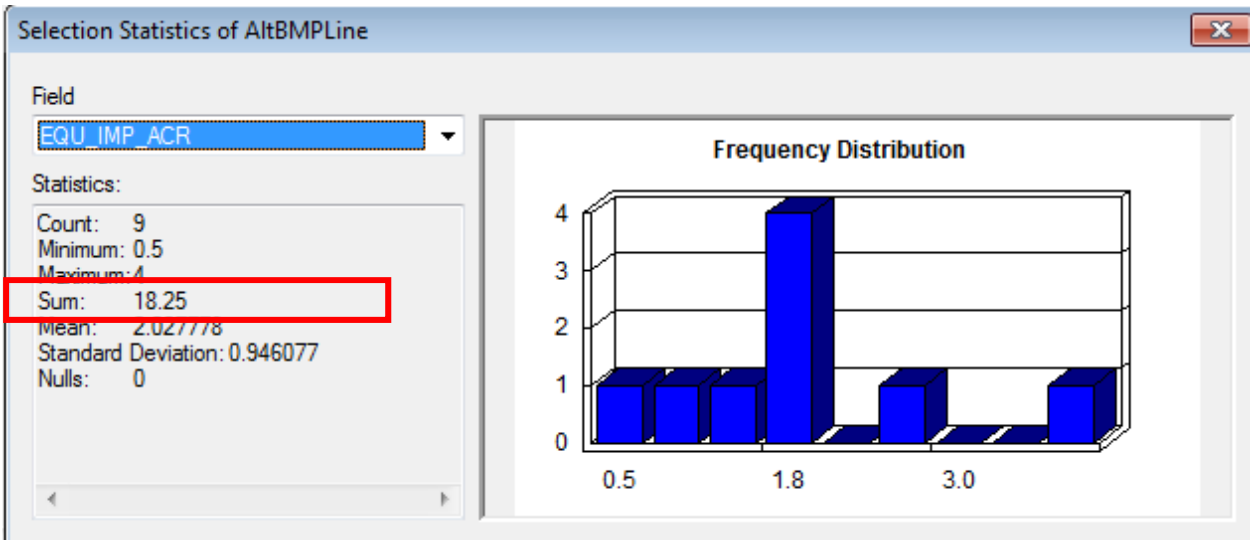


- Ensuring that the selection is retained, right click on the new IAC field, and select “Statistics…”





- View the “Sum” field to view the total restoration treatment credit claimed for outfall stabilization.



The total outfall stabilization treatment credit 18.25 acres.

Strategy	Variable Baseline Year - 2015	2016	2017	Total
	(acres)	(acres)	(acres)	(acres)
Impervious Surface Elimination (to Pervious)	0.49	0.00	1.89	2.38
New Stormwater	87.41	53.53	54.77	195.71
Grass Swales	0.00	9.07	11.60	20.67
Outfall Stabilization	0.00	2.00	16.25	18.25
Retrofit	0.00	94.43	4.78	99.21
Stream Restoration	444.04	137.24	67.00	648.28
Tree Planting	598.27	66.65	22.09	687.01
Redevelopment Credit	0.00	0.00	81.00	81.00
Inlet Cleaning	0.00	0.00	150.00	150.00
Street Sweeping	0.00	0.00	33.00	33.00
Totals	**1,130**	**363**	**442**	**1,936**
20% Restoration Target				**4709**

5.0 Tree Plantings

Calculating the impervious treatment credit for Tree Plantings requires two (2) primary inputs:

- Acres Planted, from within the MDE MS4 geodatabase (AltBMPPoly feature class' ACRES_PLANTED field).

  Note: Because the field type of this field is Short Integer, it cannot accurately capture the actual acres planted. Therefore, this input value must be calculated elsewhere.
- Impervious Acre Equivalent factor, from Table 7 of MDE's August 2014 guidance (0.38 for Reforestation on Pervious Urban)

5.1 Tree Planting IAC Calculation

The AltBMPPolygon feature does contain a field to capture acres planted, but because the field type of this field is Short Integer, it cannot accurately capture the actual acres planted. Therefore, this input value must be calculated elsewhere. This example will add a new, temporary field to the AltBMPPolygon feature class. This new field will hold the results of the IAC calculation, so once calculated, will equal the existing MDE field "EQU_IMP_ACR". This field is added as a way to re-calculate the IAC, and ensure values align with the MDE field.

This process could also be done in Excel after exporting the AltBMPPolygon feature class (the calculation of IAC in Excel is not described within this document).

5.1.1 Add New Fields

Two new fields will need to be added, one to extract the acres planted and one to run the impervious area equivalent formula.

- Within the AltBMPPolygon attribute table, click the Table Options button, and select "Add Field…"

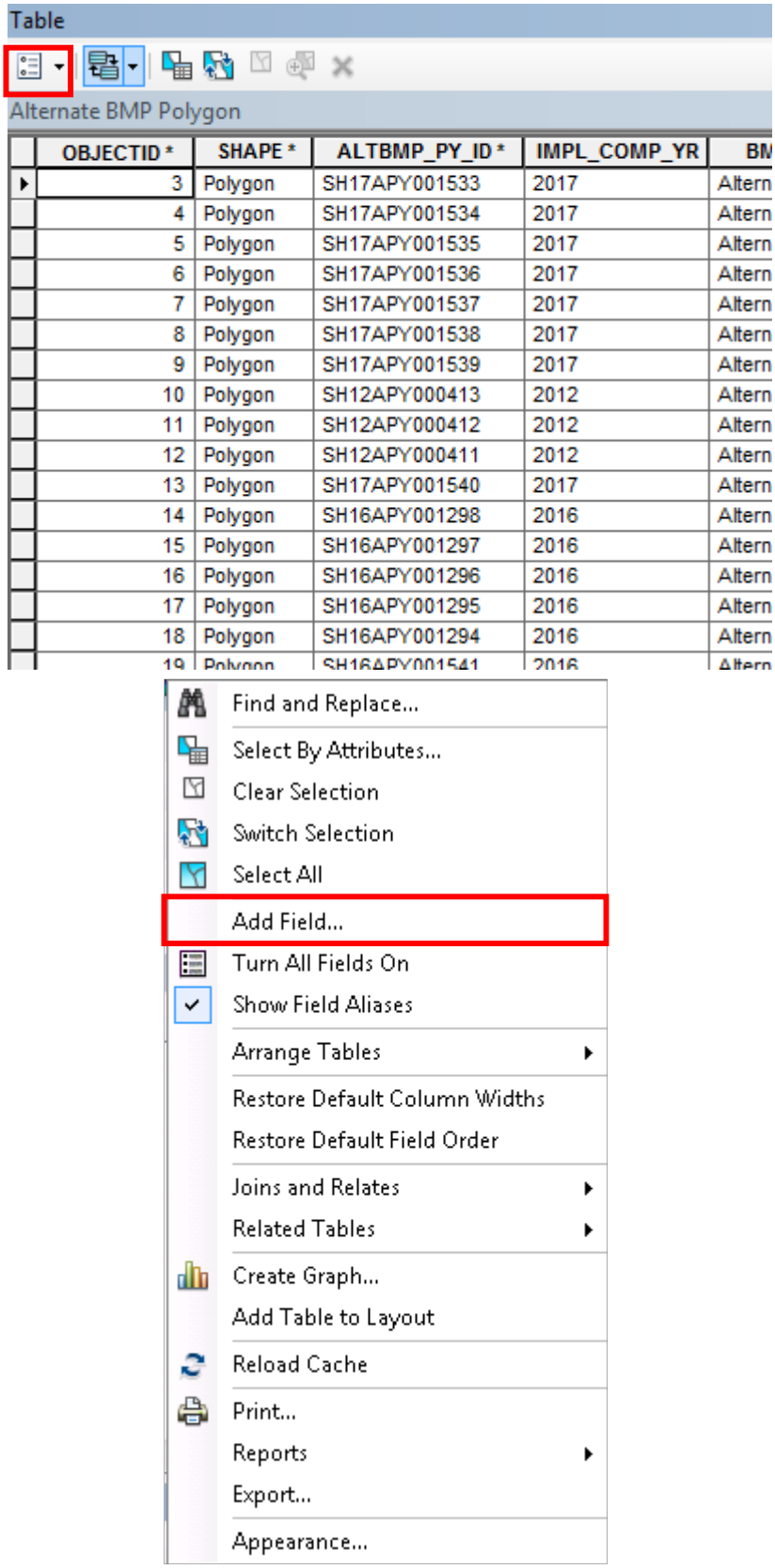
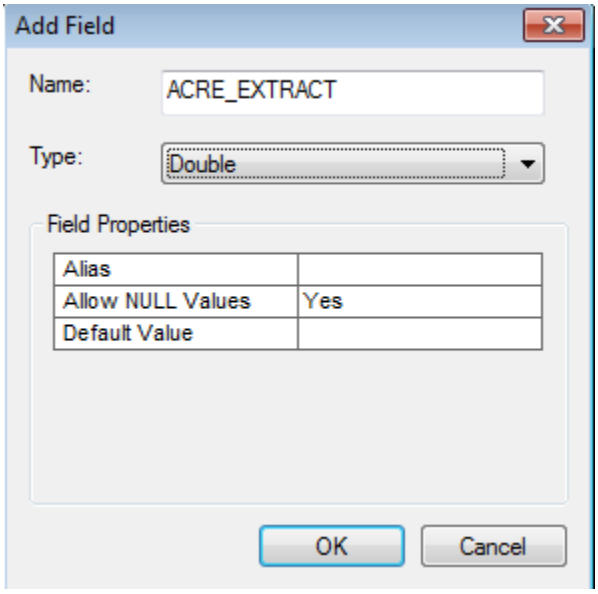
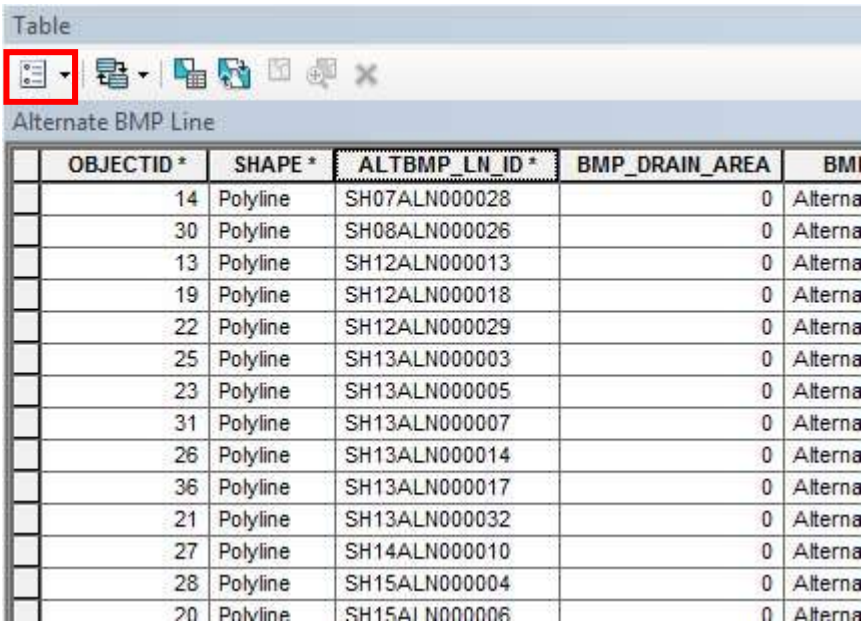


Table
Alternate BMP Polygon
OBJECTID *
SHAPE *
ALTBMP_PY_ID *
IMPL_COMP_YR
BM
3 Polygon SH17APY001533 2017 Altern
4 Polygon SH17APY001534 2017 Altern
5 Polygon SH17APY001535 2017 Altern
6 Polygon SH17APY001536 2017 Altern
7 Polygon SH17APY001537 2017 Altern
8 Polygon SH17APY001538 2017 Altern
9 Polygon SH17APY001539 2017 Altern
10 Polygon SH12APY000413 2012 Altern
11 Polygon SH12APY000412 2012 Altern
12 Polygon SH12APY000411 2012 Altern
13 Polygon SH17APY001540 2017 Altern
14 Polygon SH16APY001298 2016 Altern
15 Polygon SH16APY001297 2016 Altern
16 Polygon SH16APY001296 2016 Altern
17 Polygon SH16APY001295 2016 Altern
18 Polygon SH16APY001294 2016 Altern
Find and Replace...
Select By Attributes...
Clear Selection
Switch Selection
Select All
Add Field...
Turn All Fields On
Show Field Aliases
Arrange Tables
Restore Default Column Widths
Restore Default Field Order
Joins and Relates
Related Tables
Create Graph...
Add Table to Layout
Reload Cache
Print...
Reports
Export...
Appearance...

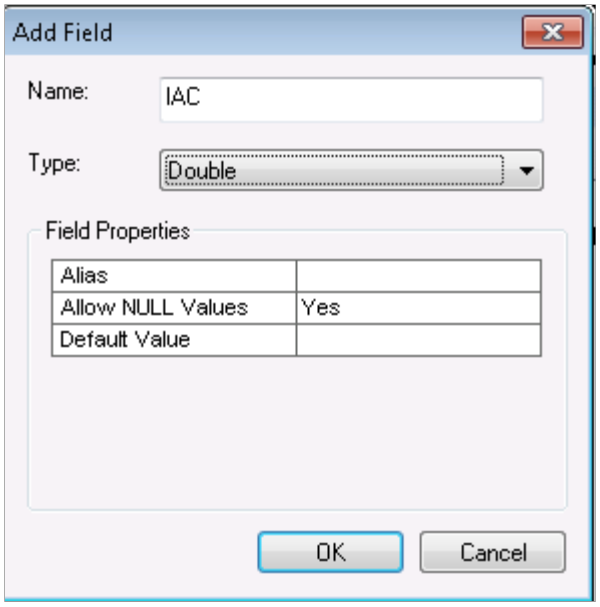
- Within the Add Field dialog window, enter the new field name – “ACRE_EXTRACT”. Set Type = Double. Accept the default Allow Nulls setting. Click “OK”.



- Within the AltBMPPolygonattribute table, click the Table Options button, and select “Add Field…”



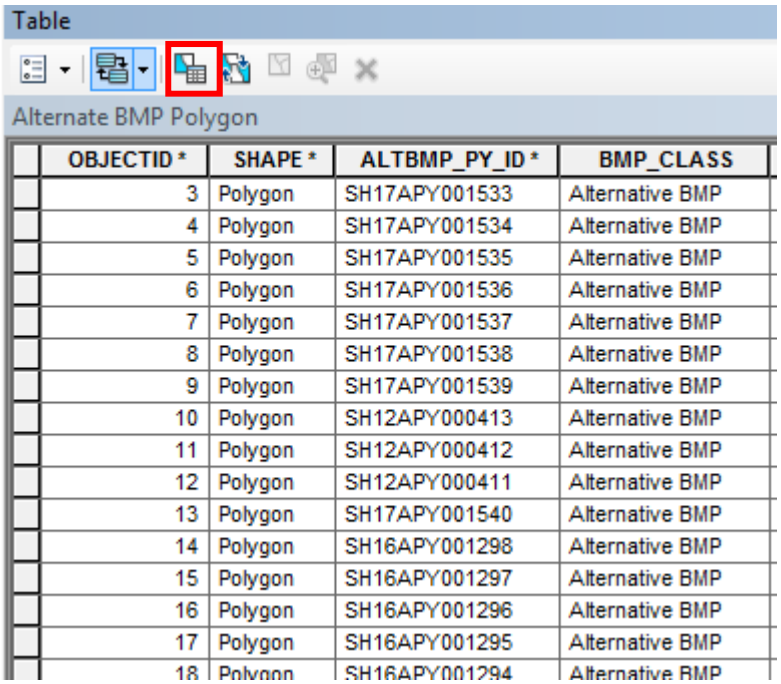
- Within the Add Field dialog window, enter the new field name – “IAC”. Set Type = Double. Accept the default Allow Nulls setting. Click “OK”.



5.1.2 Calculate Acres Planted and IAC

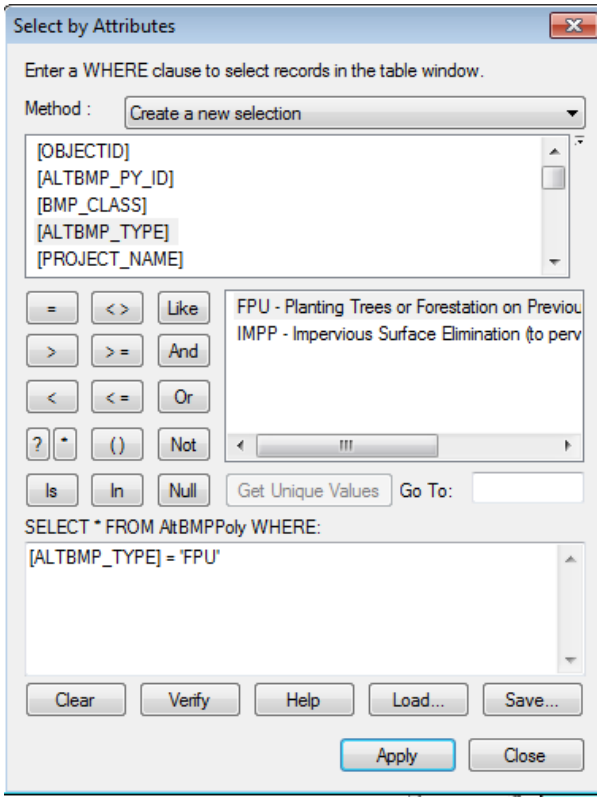
Because multiple strategies exist within the AltBMPPolygon feature class, select the targeted strategy prior to obtain the acres planted and the sum of IAC.

- Within the AltBMPPolygon attribute table, click the Select by Attributes button.



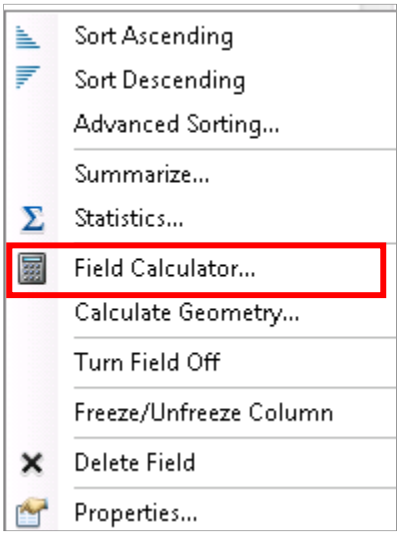
OBJECTID *	SHAPE *	ALTBMP_PY_ID *	BMP_CLASS
3	Polygon	SH17APY001533	Alternative BMP
4	Polygon	SH17APY001534	Alternative BMP
5	Polygon	SH17APY001535	Alternative BMP
6	Polygon	SH17APY001536	Alternative BMP
7	Polygon	SH17APY001537	Alternative BMP
8	Polygon	SH17APY001538	Alternative BMP
9	Polygon	SH17APY001539	Alternative BMP
10	Polygon	SH12APY000413	Alternative BMP
11	Polygon	SH12APY000412	Alternative BMP
12	Polygon	SH12APY000411	Alternative BMP
13	Polygon	SH17APY001540	Alternative BMP
14	Polygon	SH16APY001298	Alternative BMP
15	Polygon	SH16APY001297	Alternative BMP
16	Polygon	SH16APY001296	Alternative BMP
17	Polygon	SH16APY001295	Alternative BMP
18	Polygon	SH16APY001294	Alternative BMP

- Within the Select by Attributes dialog window, enter the following selection statement and click "Apply": [ALTBMP_TYPE] = 'FPU'



The values for acres planted are contained within the GEN_COMMENTS field. To extract those values the function below will need to be performed.

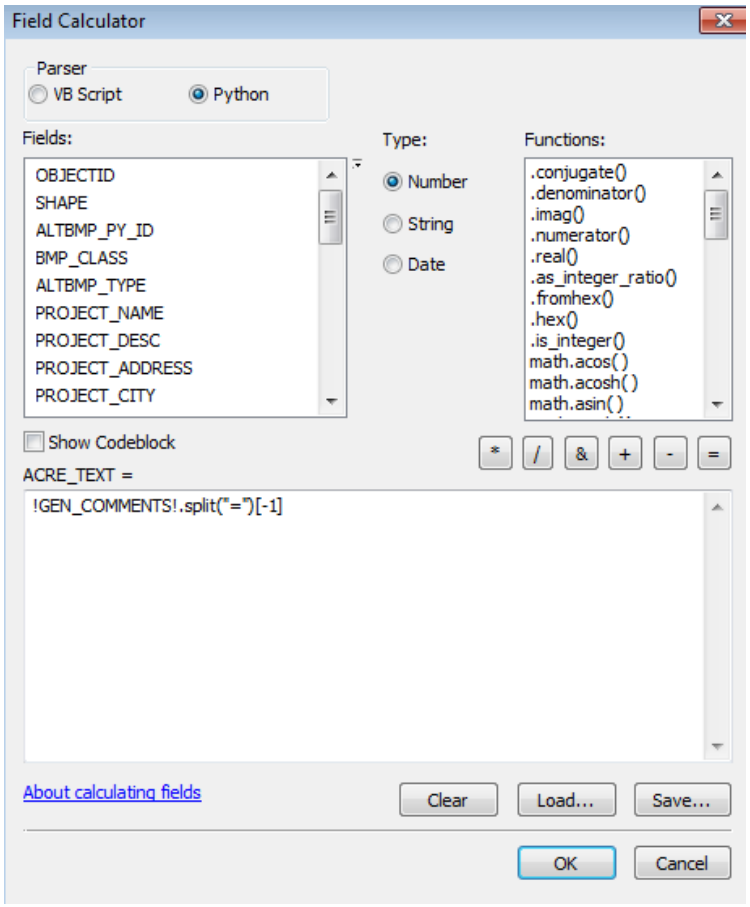
- Right click on the new ACRE_EXTRACT field, and select “Field Calculator…”



- Within the Field Calculator dialog window, enter the following calculation and click “OK”:

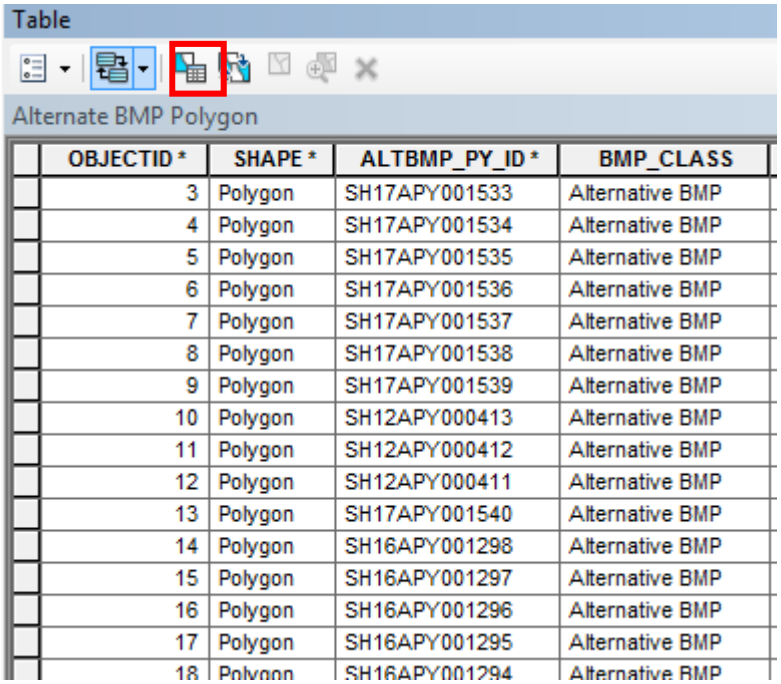
  float(!GEN_COMMENTS!.split("=")[-1])

This formula will extract the text acres from the GEN_COMMENTS field and convert it to a number in one step.



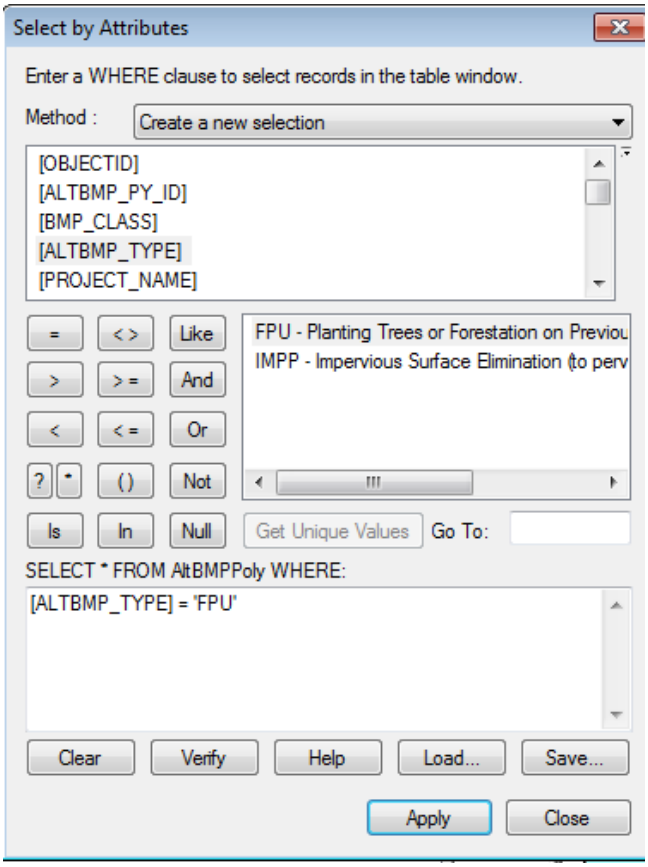
Because multiple strategies exist within the AltBMPPolygon feature class, select the targeted strategy prior to obtain the sum of IAC.

- Within the AltBMPPolygon attribute table, click the Select by Attributes button.

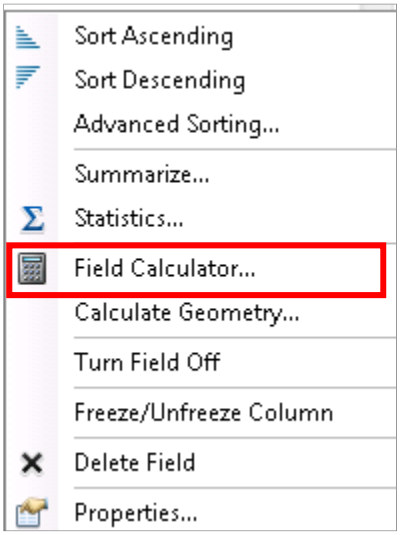


OBJECTID *	SHAPE *	ALTBMP_PY_ID *	BMP_CLASS
3	Polygon	SH17APY001533	Alternative BMP
4	Polygon	SH17APY001534	Alternative BMP
5	Polygon	SH17APY001535	Alternative BMP
6	Polygon	SH17APY001536	Alternative BMP
7	Polygon	SH17APY001537	Alternative BMP
8	Polygon	SH17APY001538	Alternative BMP
9	Polygon	SH17APY001539	Alternative BMP
10	Polygon	SH12APY000413	Alternative BMP
11	Polygon	SH12APY000412	Alternative BMP
12	Polygon	SH12APY000411	Alternative BMP
13	Polygon	SH17APY001540	Alternative BMP
14	Polygon	SH16APY001298	Alternative BMP
15	Polygon	SH16APY001297	Alternative BMP
16	Polygon	SH16APY001296	Alternative BMP
17	Polygon	SH16APY001295	Alternative BMP
18	Polygon	SH16APY001294	Alternative BMP

- Within the Select by Attributes dialog window, enter the following selection statement and click "Apply": [ALTBMP_TYPE] = 'FPU'

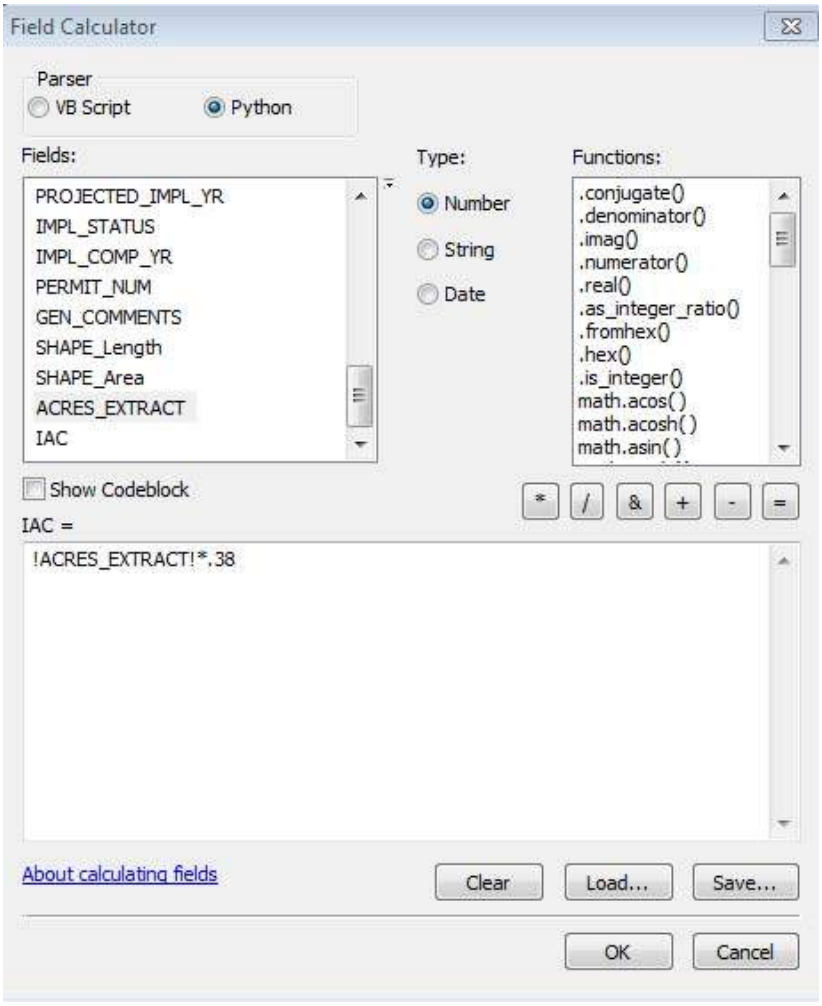


- Right click on the new IAC field, and select “Field Calculator…”



- Within the Field Calculator dialog window, enter the following calculation and click “OK”:

[ACRES_EXTRACT]*.38

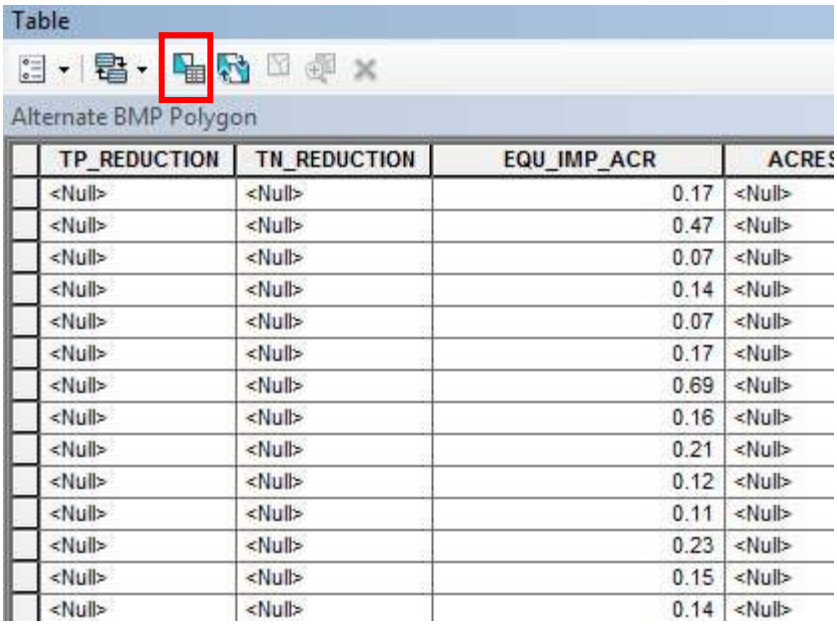


5.1.3 Tree Planting IAC by Fiscal Year

The IAC values for Tree Planting by fiscal year and strategy can be summed using the process below.

5.1.3.1 Tree Planting IAC for FY 2017

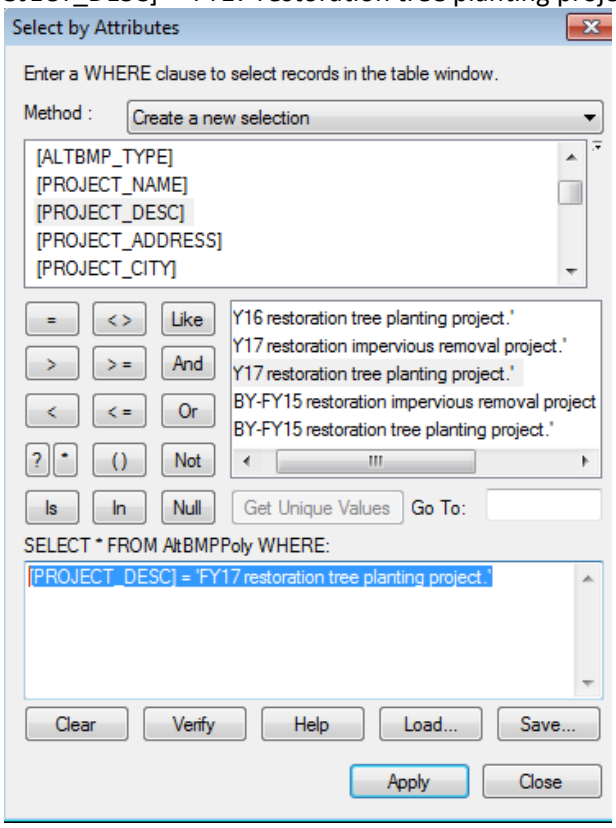
- Within the AltBMPPolygon attribute table, click the Select by Attributes button.



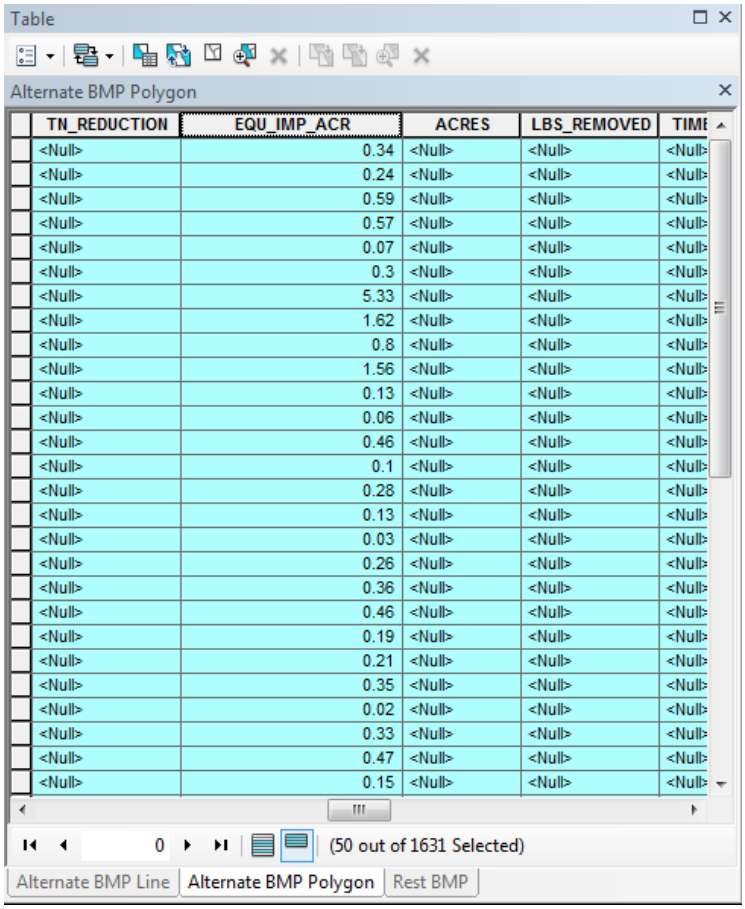
TP_REDUCTION	TN_REDUCTION	EQU_IMP_ACR	ACRES
<Null>	<Null>	0.17	<Null>
<Null>	<Null>	0.47	<Null>
<Null>	<Null>	0.07	<Null>
<Null>	<Null>	0.14	<Null>
<Null>	<Null>	0.07	<Null>
<Null>	<Null>	0.17	<Null>
<Null>	<Null>	0.69	<Null>
<Null>	<Null>	0.16	<Null>
<Null>	<Null>	0.21	<Null>
<Null>	<Null>	0.12	<Null>
<Null>	<Null>	0.11	<Null>
<Null>	<Null>	0.23	<Null>
<Null>	<Null>	0.15	<Null>
<Null>	<Null>	0.14	<Null>

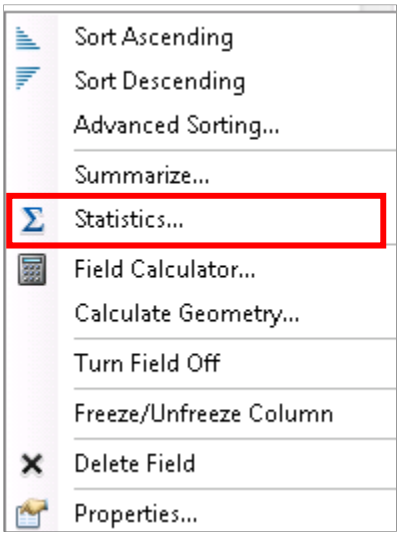
- Within the Select by Attributes dialog window, enter the following selection statement to identify tree planting for FY 17, and click “Apply”:

[PROJECT_DESC] = 'FY17 restoration tree planting project.'

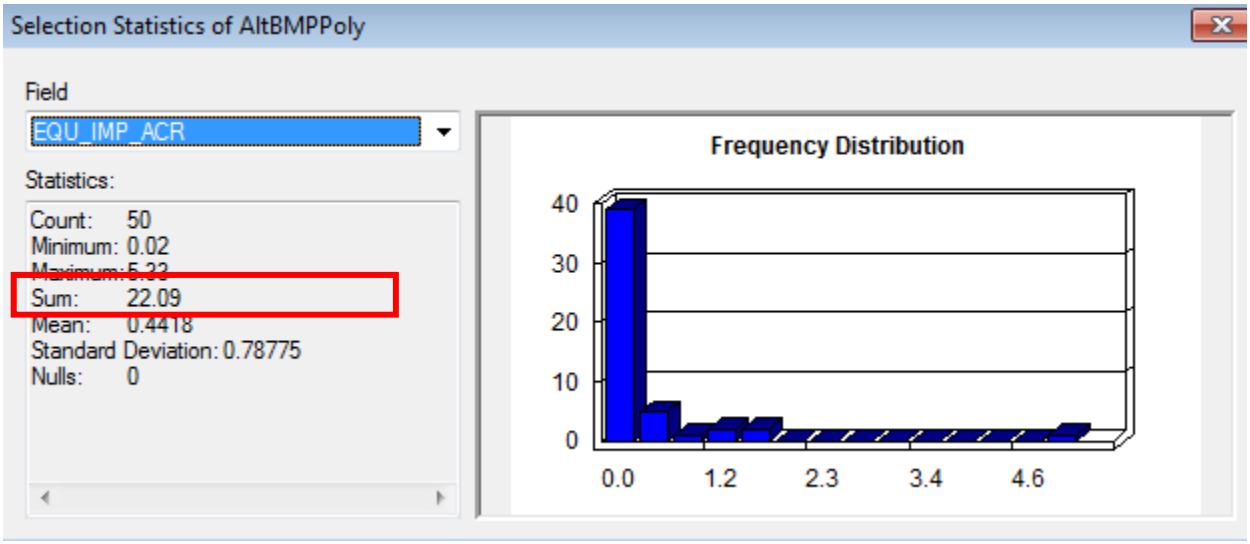


- Ensuring that the selection is retained, right click on the EQU_IMP_ACR field, and select “Statistics…”





- View the “Sum” field to view the total restoration treatment credit claimed for Tree Planting restoration FY 17.

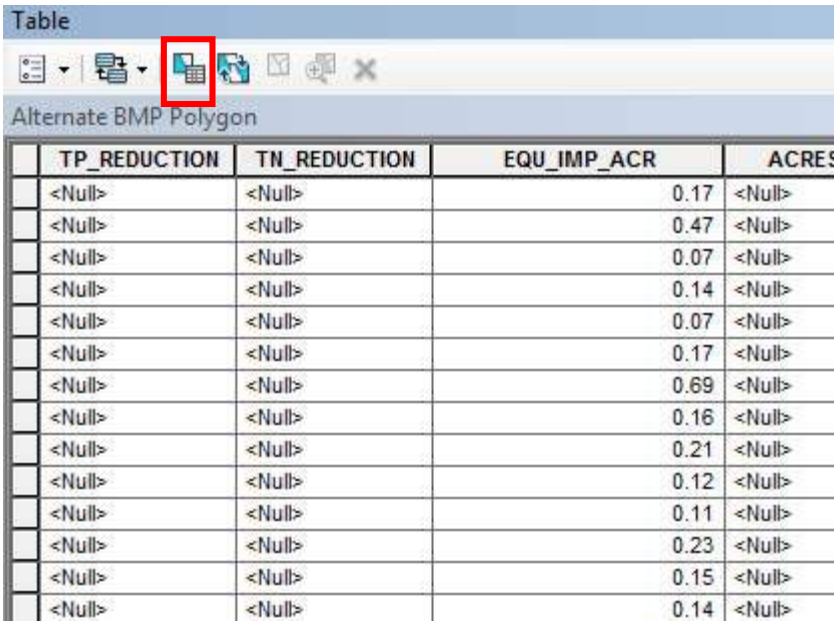


The total tree planting treatment credit for FY17 is 22.09 acres.

Strategy	Variable Baseline Year - 2015	2016	2017	Total
	(acres)	(acres)	(acres)	(acres)
Impervious Surface Elimination (to Pervious)	0.49	0.00	1.89	2.38
New Stormwater	87.41	53.53	54.77	195.71
Grass Swales	0.00	9.07	11.60	20.67
Outfall Stabilization	0.00	2.00	16.25	18.25
Retrofit	0.00	94.43	4.78	99.21
Stream Restoration	444.04	137.24	67.00	648.28
Tree Planting	598.27	66.65	22.09	687.01
Redevelopment Credit	0.00	0.00	81.00	81.00
Inlet Cleaning	0.00	0.00	150.00	150.00
Street Sweeping	0.00	0.00	33.00	33.00
Totals	**1,130**	**363**	**442**	**1,936**
20% Restoration Target				**4709**

5.1.3.2 Tree Planting IAC for FY 2016

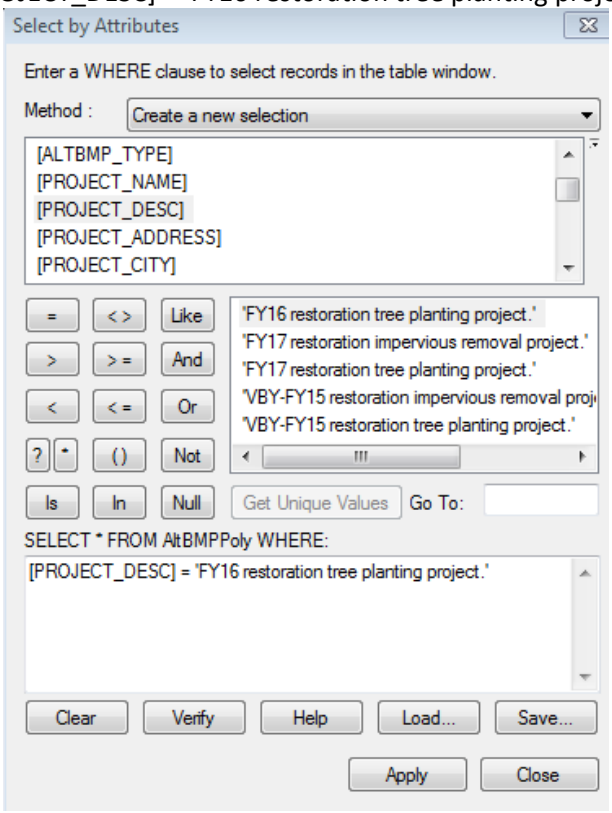
- Within the AltBMPPolygon attribute table, click the Select by Attributes button.



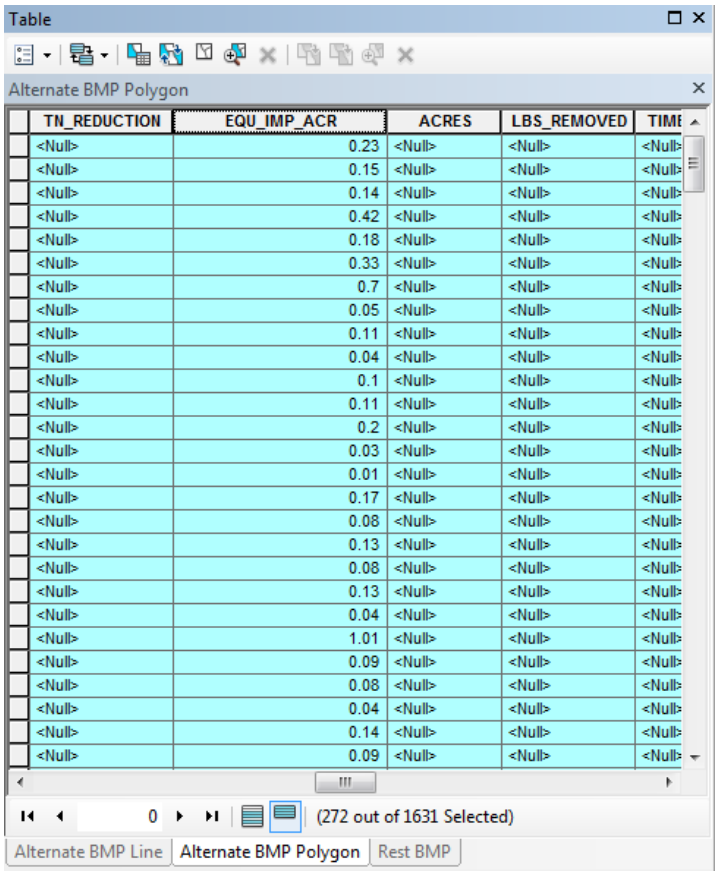
TP_REDUCTION	TN_REDUCTION	EQU_IMP_ACR	ACRES
<Null>	<Null>	0.17	<Null>
<Null>	<Null>	0.47	<Null>
<Null>	<Null>	0.07	<Null>
<Null>	<Null>	0.14	<Null>
<Null>	<Null>	0.07	<Null>
<Null>	<Null>	0.17	<Null>
<Null>	<Null>	0.69	<Null>
<Null>	<Null>	0.16	<Null>
<Null>	<Null>	0.21	<Null>
<Null>	<Null>	0.12	<Null>
<Null>	<Null>	0.11	<Null>
<Null>	<Null>	0.23	<Null>
<Null>	<Null>	0.15	<Null>
<Null>	<Null>	0.14	<Null>

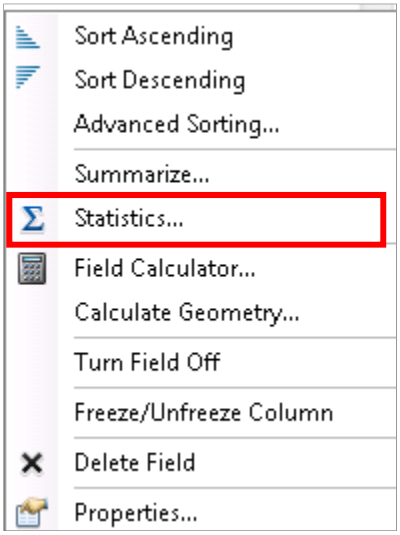
- Within the Select by Attributes dialog window, enter the following selection statement to identify tree planting for FY 16, and click “Apply”:

  [PROJECT_DESC] = 'FY16 restoration tree planting project.'

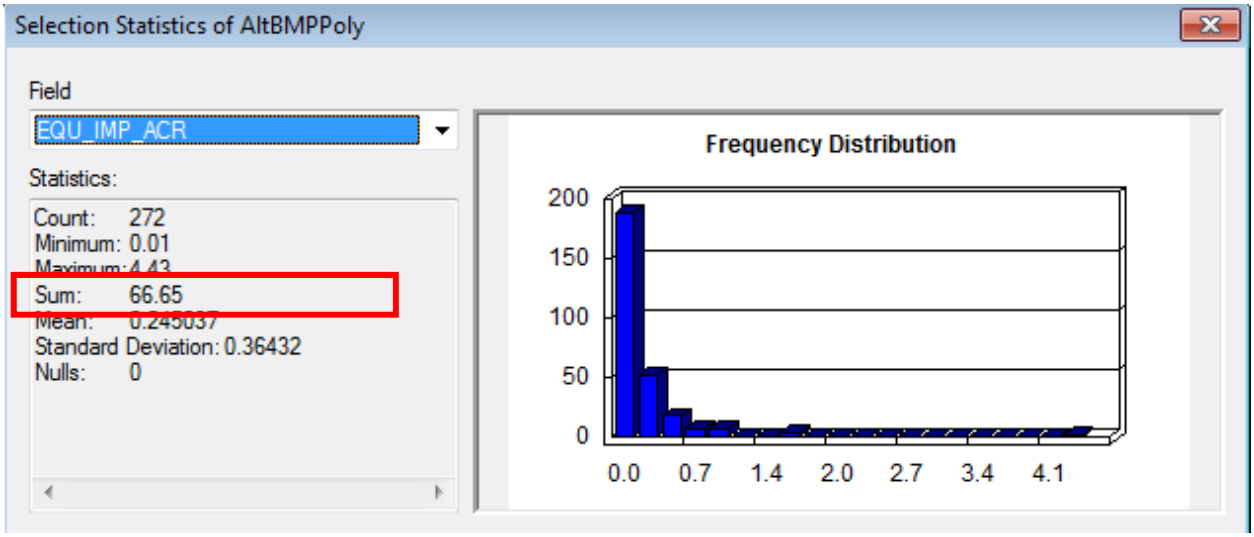


- Ensuring that the selection is retained, right click on the EQU_IMP_ACR field, and select “Statistics…”





- View the “Sum” field to view the total restoration treatment credit claimed for Tree Planting FY 16.

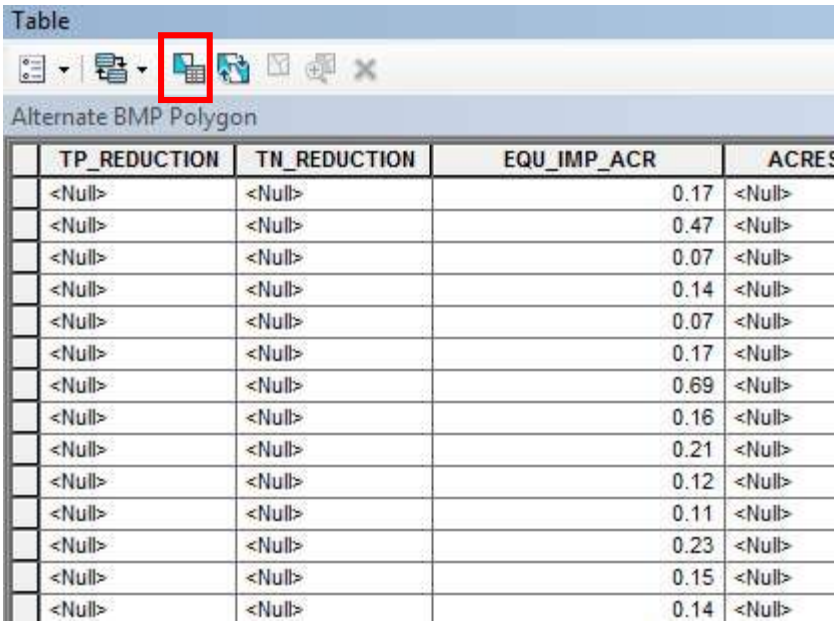


The total tree planting treatment credit for FY16 is 66.65 acres.

Strategy	Variable Baseline Year - 2015	2016	2017	Total
	(acres)	(acres)	(acres)	(acres)
Impervious Surface Elimination (to Pervious)	0.49	0.00	1.89	2.38
New Stormwater	87.41	53.53	54.77	195.71
Grass Swales	0.00	9.07	11.60	20.67
Outfall Stabilization	0.00	2.00	16.25	18.25
Retrofit	0.00	94.43	4.78	99.21
Stream Restoration	444.04	137.24	67.00	648.28
Tree Planting	598.27	66.65	22.09	687.01
Redevelopment Credit	0.00	0.00	81.00	81.00
Inlet Cleaning	0.00	0.00	150.00	150.00
Street Sweeping	0.00	0.00	33.00	33.00
Totals	**1,130**	**363**	**442**	**1,936**
20% Restoration Target				**4709**

5.1.3.3 Tree Planting IAC for VBY-2015

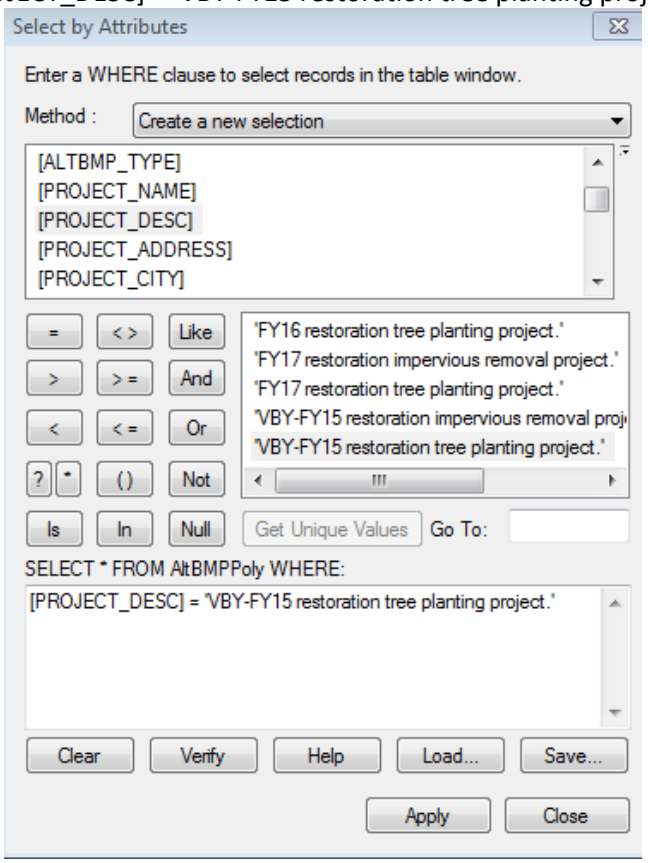
- Within the AltBMPPolygon attribute table, click the Select by Attributes button.



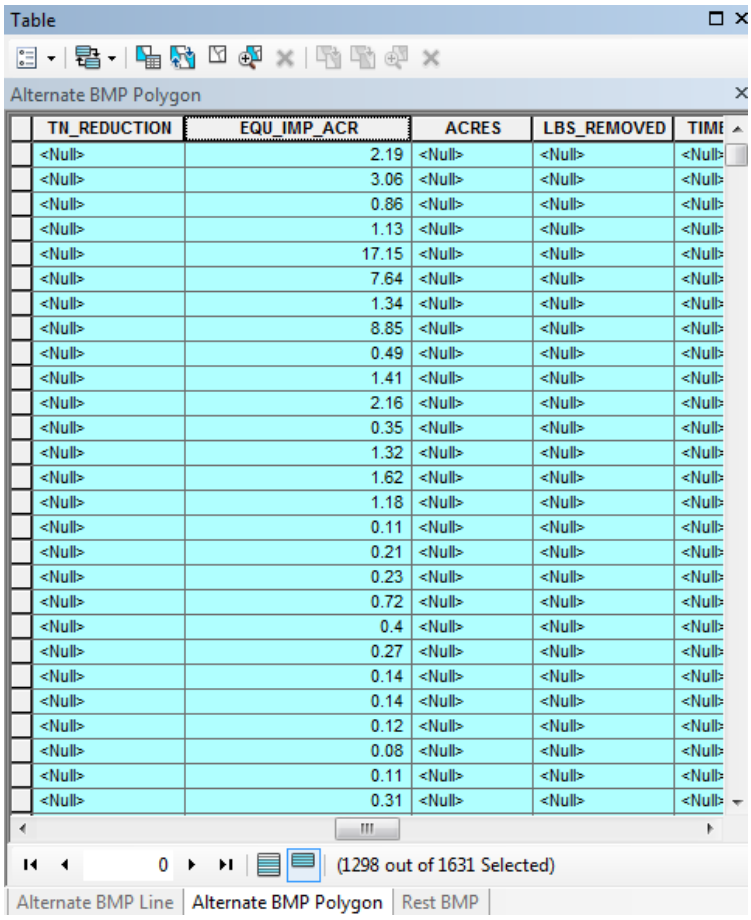
TP_REDUCTION	TN_REDUCTION	EQU_IMP_ACR	ACRES
<Null>	<Null>	0.17	<Null>
<Null>	<Null>	0.47	<Null>
<Null>	<Null>	0.07	<Null>
<Null>	<Null>	0.14	<Null>
<Null>	<Null>	0.07	<Null>
<Null>	<Null>	0.17	<Null>
<Null>	<Null>	0.69	<Null>
<Null>	<Null>	0.16	<Null>
<Null>	<Null>	0.21	<Null>
<Null>	<Null>	0.12	<Null>
<Null>	<Null>	0.11	<Null>
<Null>	<Null>	0.23	<Null>
<Null>	<Null>	0.15	<Null>
<Null>	<Null>	0.14	<Null>

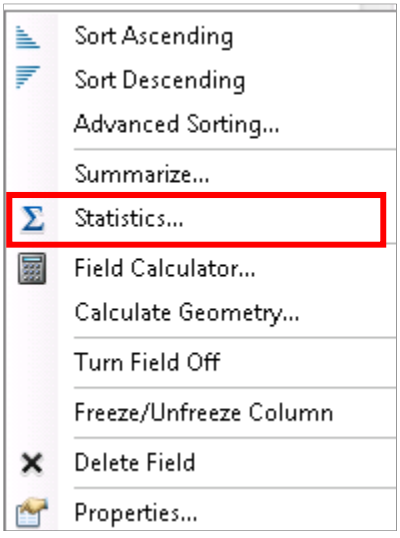
- Within the Select by Attributes dialog window, enter the following selection statement to identify tree planting for VBY-2015, and click “Apply”:

  [PROJECT_DESC] = 'VBY-FY15 restoration tree planting project.'

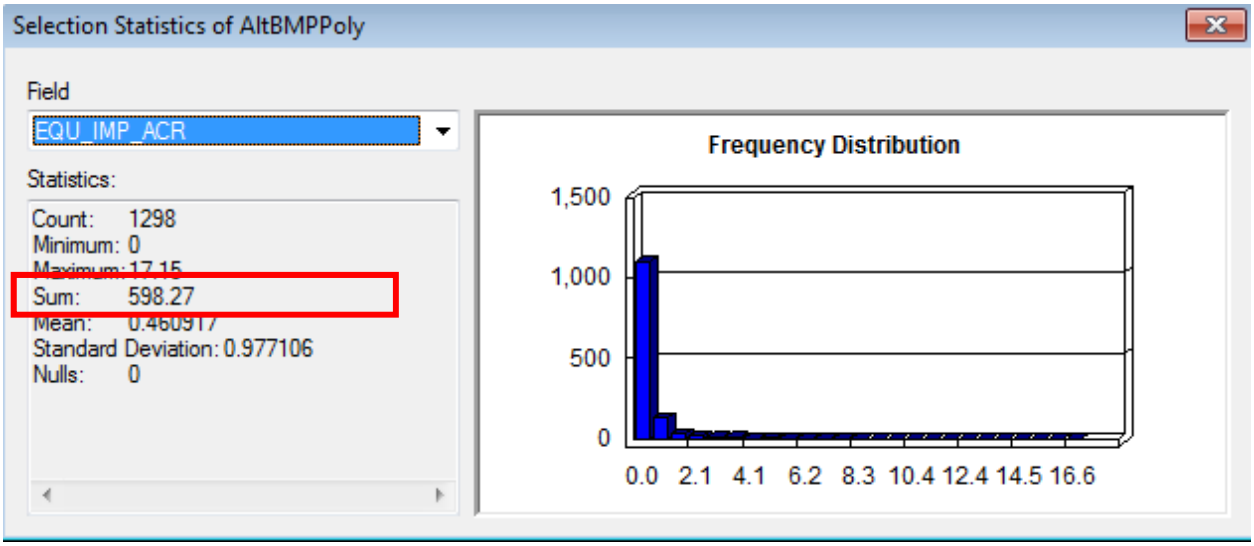


- Ensuring that the selection is retained, right click on the EQU_IMP_ACR field, and select “Statistics…”





- View the “Sum” field to view the total restoration treatment credit claimed for tree planting VBY-2015.



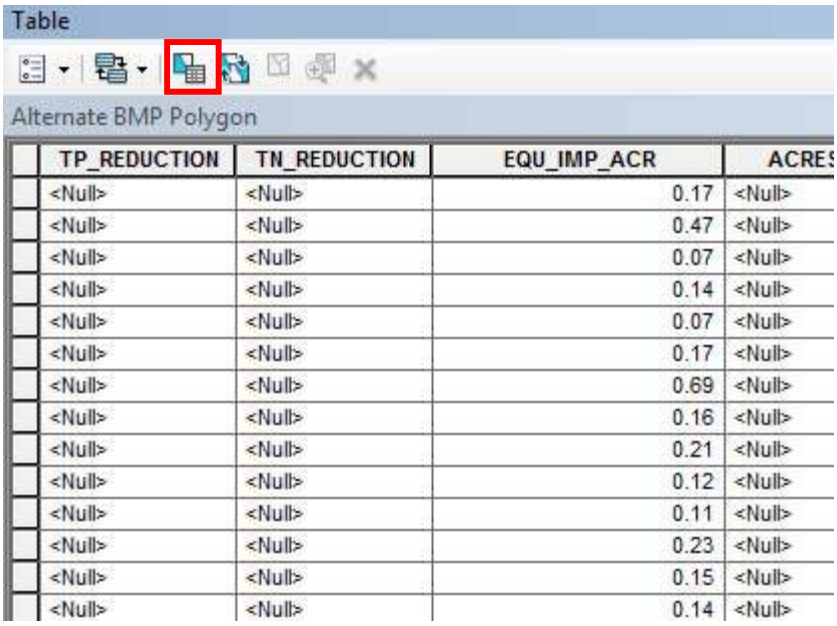
The total stream restoration treatment credit for VBY-2015 is 598.27 acres.

Strategy	Variable Baseline Year - 2015	2016	2017	Total
	(acres)	(acres)	(acres)	(acres)
Impervious Surface Elimination (to Pervious)	0.49	0.00	1.89	2.38
New Stormwater	87.41	53.53	54.77	195.71
Grass Swales	0.00	9.07	11.60	20.67
Outfall Stabilization	0.00	2.00	16.25	18.25
Retrofit	0.00	94.43	4.78	99.21
Stream Restoration	444.04	137.24	67.00	648.28
Tree Planting	598.27	66.65	22.09	687.01
Redevelopment Credit	0.00	0.00	81.00	81.00
Inlet Cleaning	0.00	0.00	150.00	150.00
Street Sweeping	0.00	0.00	33.00	33.00
Totals	**1,130**	**363**	**442**	**1,936**
20% Restoration Target				**4709**

5.2 Total Tree Planting IAC Sum

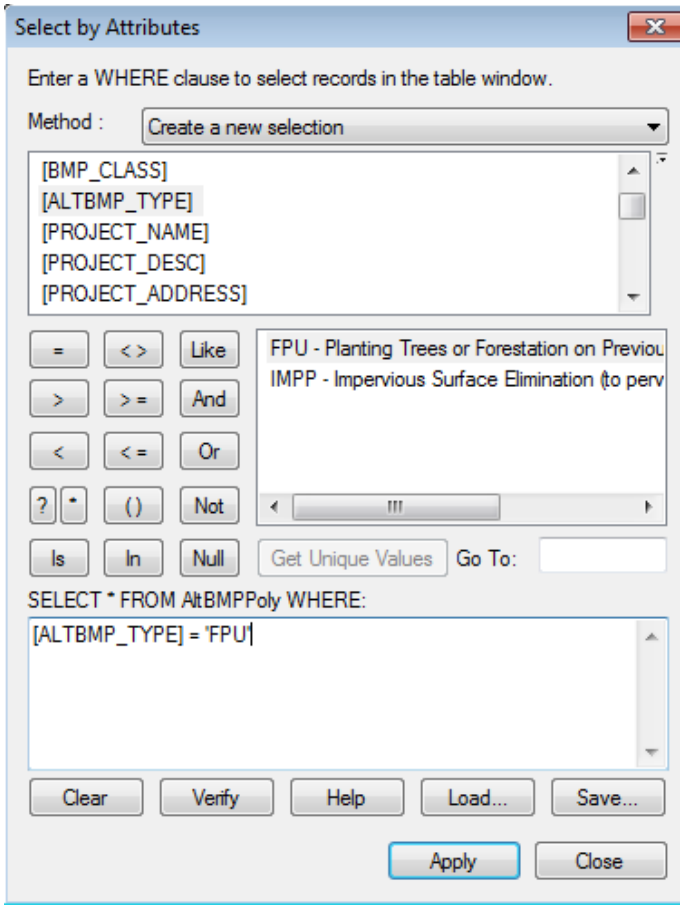
To determine total restoration Tree Planting IAC, select Tree Planting, and sum the EQU_IMP_ACR:

- Within the AltBMPPolygon feature class, click the Select by Attributes tool.

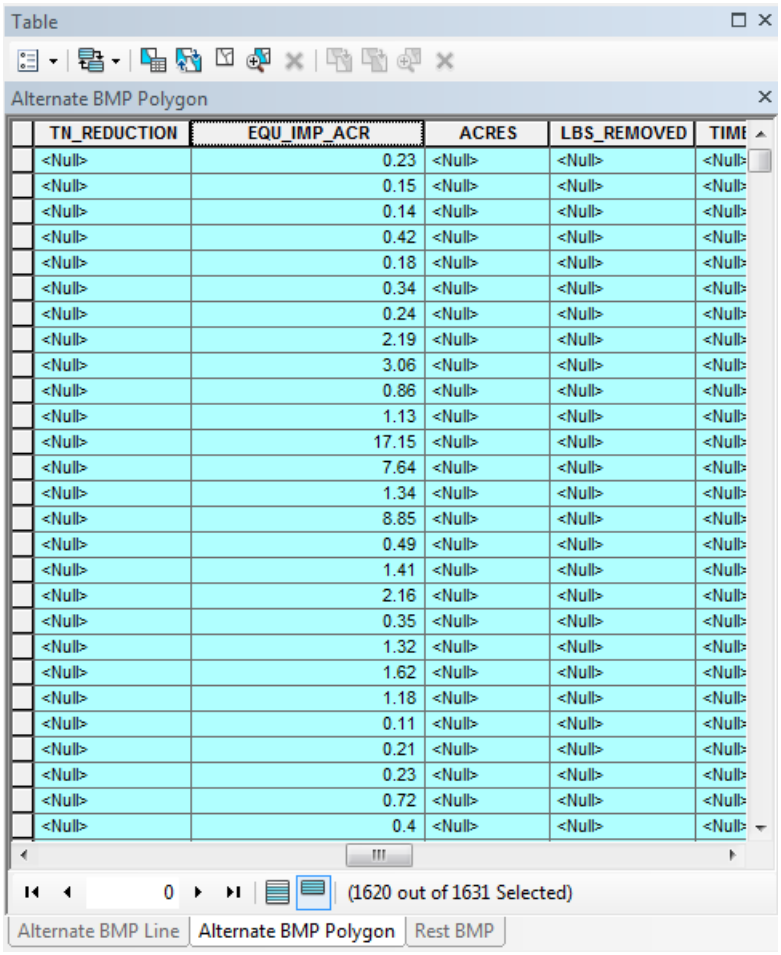


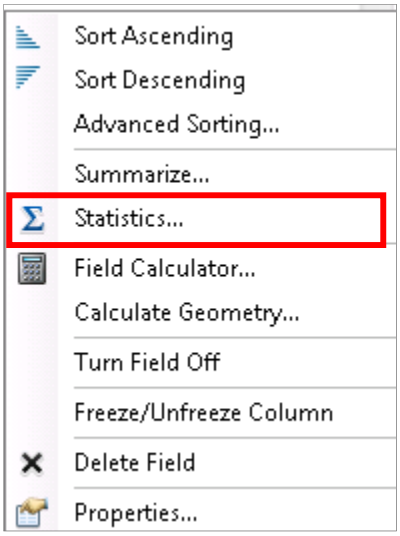
TP_REDUCTION	TN_REDUCTION	EQU_IMP_ACR	ACRES
<Null>	<Null>	0.17	<Null>
<Null>	<Null>	0.47	<Null>
<Null>	<Null>	0.07	<Null>
<Null>	<Null>	0.14	<Null>
<Null>	<Null>	0.07	<Null>
<Null>	<Null>	0.17	<Null>
<Null>	<Null>	0.69	<Null>
<Null>	<Null>	0.16	<Null>
<Null>	<Null>	0.21	<Null>
<Null>	<Null>	0.12	<Null>
<Null>	<Null>	0.11	<Null>
<Null>	<Null>	0.23	<Null>
<Null>	<Null>	0.15	<Null>
<Null>	<Null>	0.14	<Null>

- In the statement box, enter the following selection statement and click “Apply”: [ALTBMP_TYPE] = 'FPU'

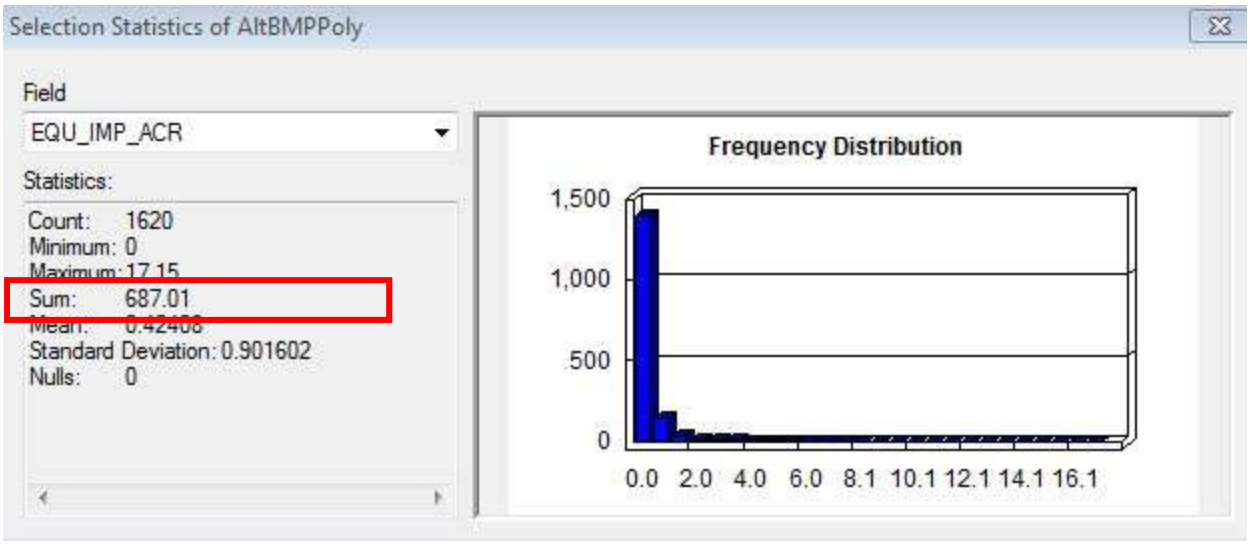


- Ensuring that the selection is retained, right click on the new IAC field, and select “Statistics…”





- View the “Sum” field to view the total restoration treatment credit claimed for Tree Planting



The total tree planting treatment credit 687.01 acres.

Strategy	Variable Baseline Year - 2015	2016	2017	Total
	(acres)	(acres)	(acres)	(acres)
Impervious Surface Elimination (to Pervious)	0.49	0.00	1.89	2.38
New Stormwater	87.41	53.53	54.77	195.71
Grass Swales	0.00	9.07	11.60	20.67
Outfall Stabilization	0.00	2.00	16.25	18.25
Retrofit	0.00	94.43	4.78	99.21
Stream Restoration	444.04	137.24	67.00	648.28
Tree Planting	598.27	66.65	22.09	687.01
Redevelopment Credit	0.00	0.00	81.00	81.00
Inlet Cleaning	0.00	0.00	150.00	150.00
Street Sweeping	0.00	0.00	33.00	33.00
Totals	**1,130**	**363**	**442**	**1,936**
20% Restoration Target				**4709**

6.0 Impervious Area Removal

Calculating the impervious treatment credit for Impervious Area Removal requires two (2) primary inputs:

• Impervious Acres Eliminated, from within the MDE MS4 geodatabase (AltBMPPoly feature class' IMP_ACR_ELIM field).

• Impervious Acre Equivalent factor, from Table 7 of MDE's August 2014 guidance (0.75 for Impervious Urban to Pervious)

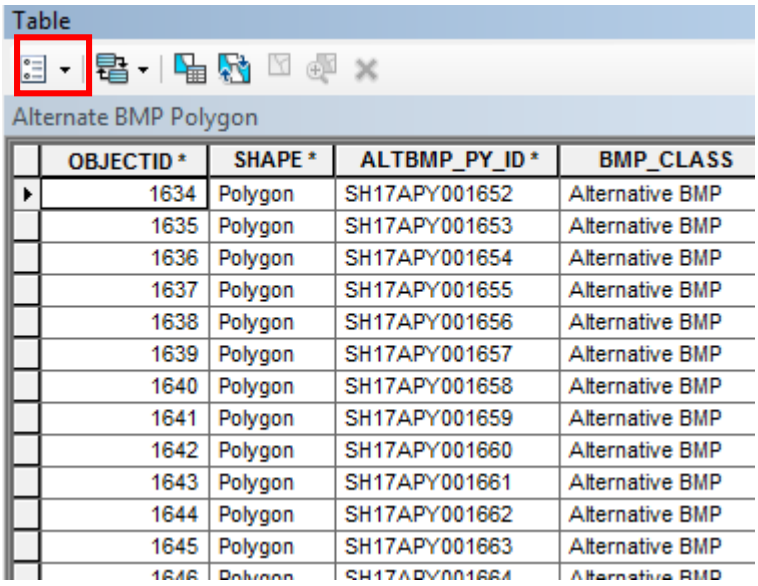
6.1 Impervious Area Removal IAC Calculation

The AltBMPLinePolygon feature class contains a field to explicitly capture IAC ("EQU_IMP_ACR"). To verify the IAC, this example will add a new, temporary field to the AltBMPPolygon feature class. This new field will hold the results of the IAC calculation, so once calculated, will equal the existing MDE field "EQU_IMP_ACR". This field is added as a way to re-calculate the IAC, and ensure values align with the MDE field.

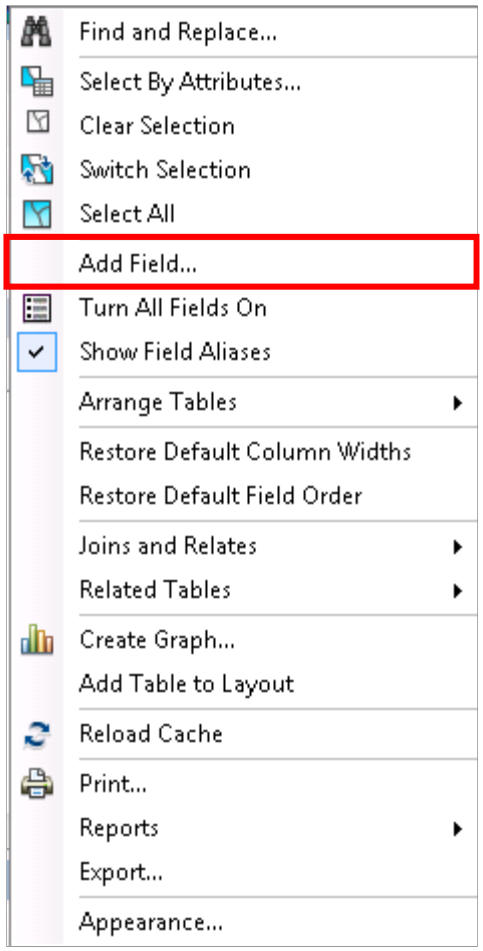
This process could also be done in Excel after exporting the AltBMPPolygon feature class (the calculation of IAC in Excel is not described within this document).

6.1.1 Add New IAC Field

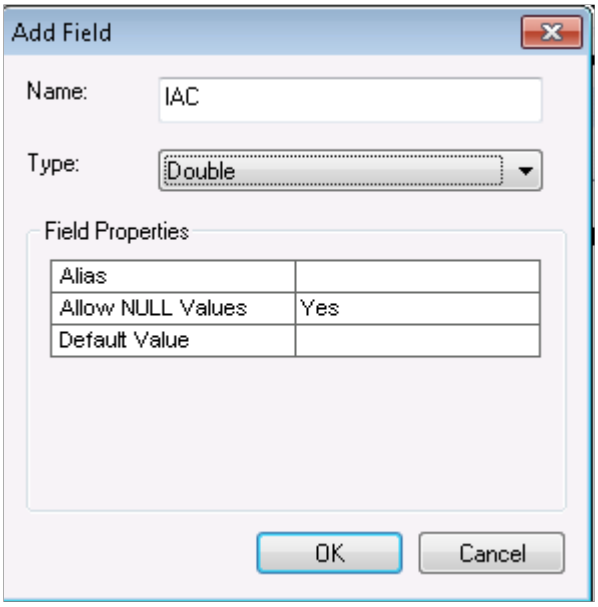
Within the AltBMPPolygon attribute table, click the Table Options button, and select "Add Field…"



OBJECTID *	SHAPE *	ALTBMP_PY_ID *	BMP_CLASS
1634	Polygon	SH17APY001652	Alternative BMP
1635	Polygon	SH17APY001653	Alternative BMP
1636	Polygon	SH17APY001654	Alternative BMP
1637	Polygon	SH17APY001655	Alternative BMP
1638	Polygon	SH17APY001656	Alternative BMP
1639	Polygon	SH17APY001657	Alternative BMP
1640	Polygon	SH17APY001658	Alternative BMP
1641	Polygon	SH17APY001659	Alternative BMP
1642	Polygon	SH17APY001660	Alternative BMP
1643	Polygon	SH17APY001661	Alternative BMP
1644	Polygon	SH17APY001662	Alternative BMP
1645	Polygon	SH17APY001663	Alternative BMP



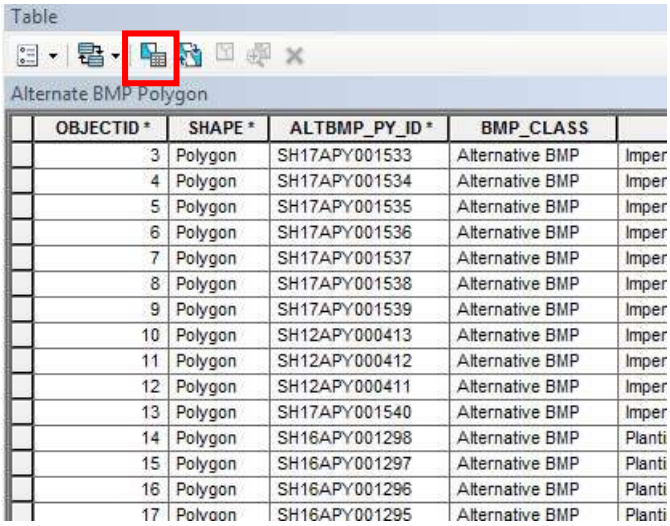
- Within the Add Field dialog window, enter the new field name – "IAC". Set Type = Double. Accept the default Allow Nulls setting. Click "OK".



6.1.2 Calculate IAC

Since tree planting and impervious area removal require different calculations to determine EQU_IMP_ACR, an attribute query is required. To determine restoration impervious area removal IAC, select impervious area removal, and sum the EQU_IMP_ACR:

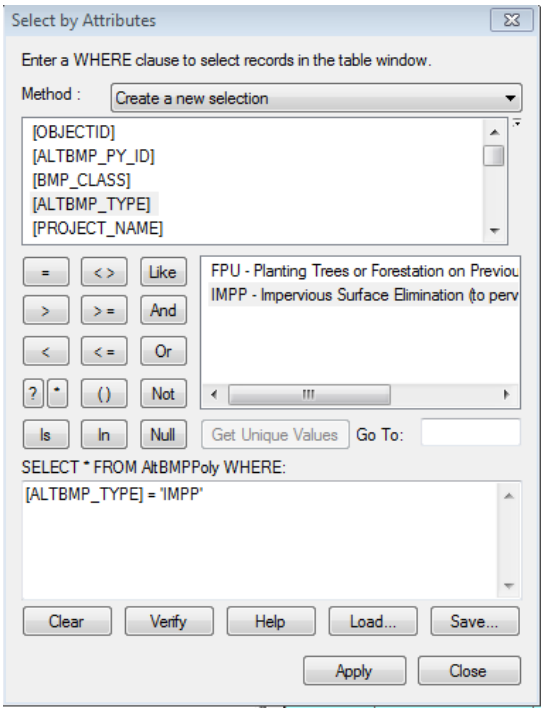
- Within the AltBMPPolygon feature class, click the Select by Attributes tool.



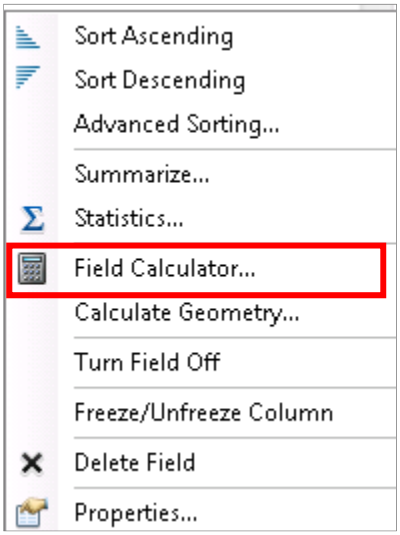
OBJECTID *	SHAPE *	ALTBMP_PY_ID *	BMP_CLASS	
3	Polygon	SH17APY001533	Alternative BMP	Imper
4	Polygon	SH17APY001534	Alternative BMP	Imper
5	Polygon	SH17APY001535	Alternative BMP	Imper
6	Polygon	SH17APY001536	Alternative BMP	Imper
7	Polygon	SH17APY001537	Alternative BMP	Imper
8	Polygon	SH17APY001538	Alternative BMP	Imper
9	Polygon	SH17APY001539	Alternative BMP	Imper
10	Polygon	SH12APY000413	Alternative BMP	Imper
11	Polygon	SH12APY000412	Alternative BMP	Imper
12	Polygon	SH12APY000411	Alternative BMP	Imper
13	Polygon	SH17APY001540	Alternative BMP	Imper
14	Polygon	SH16APY001298	Alternative BMP	Planti
15	Polygon	SH16APY001297	Alternative BMP	Planti
16	Polygon	SH16APY001296	Alternative BMP	Planti
17	Polygon	SH16APY001295	Alternative BMP	Planti

- In the statement box, enter the following selection statement and click “Apply”:

  [ALTBMP_TYPE] = 'IMPP'

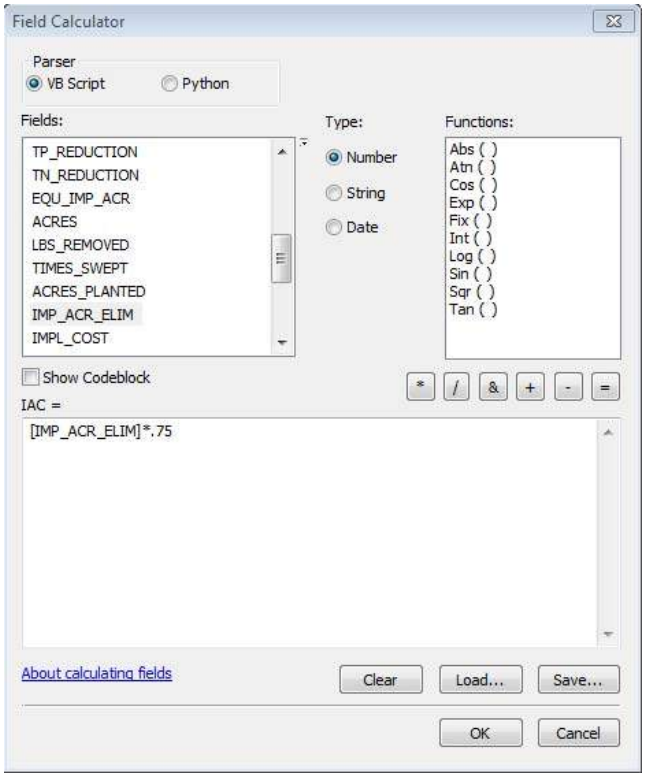


- Right click on the new IAC field, and select "Field Calculator…"



- Within the Field Calculator dialog window, enter the following calculation and click "OK":

[IMP_ACR_ELIM]*.75

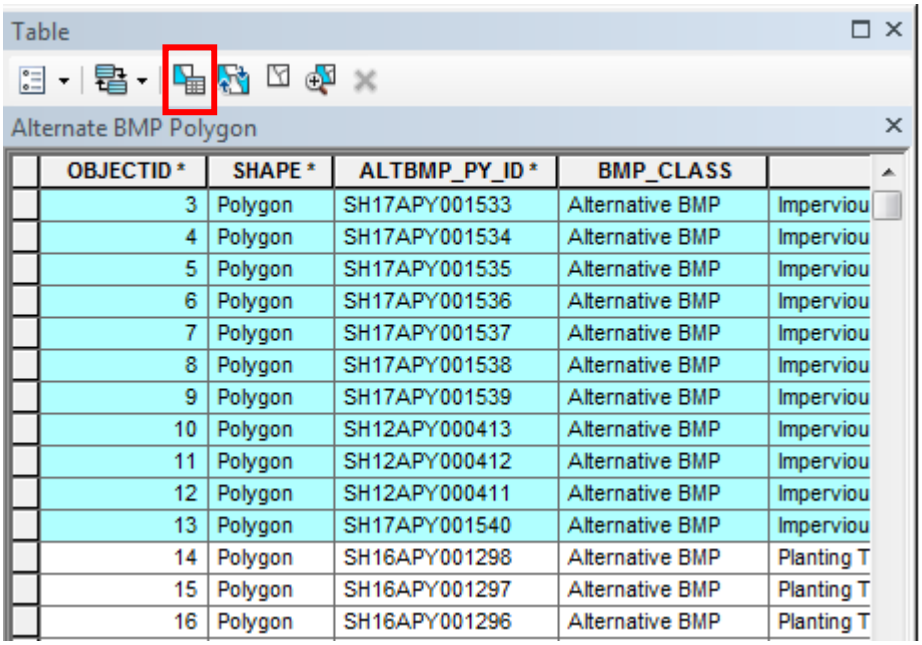


6.1.3 Impervious Area Removal IAC by Fiscal Year

The IAC values for Impervious Area Removal by fiscal year and strategy can be summed using the process below.

6.1.3.1 Impervious Area Removal IAC for FY 2017

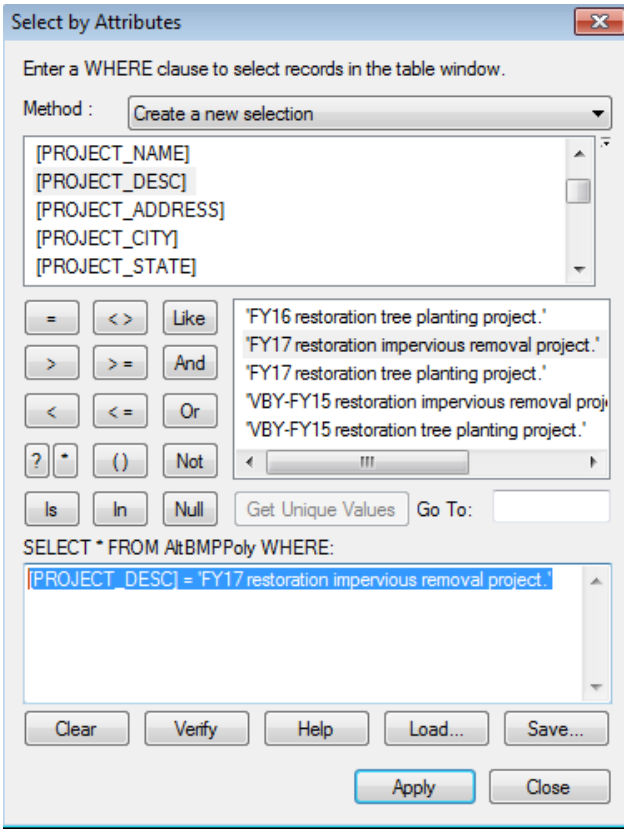
- Within the AltBMPPoly attribute table, click the Select by Attributes button.



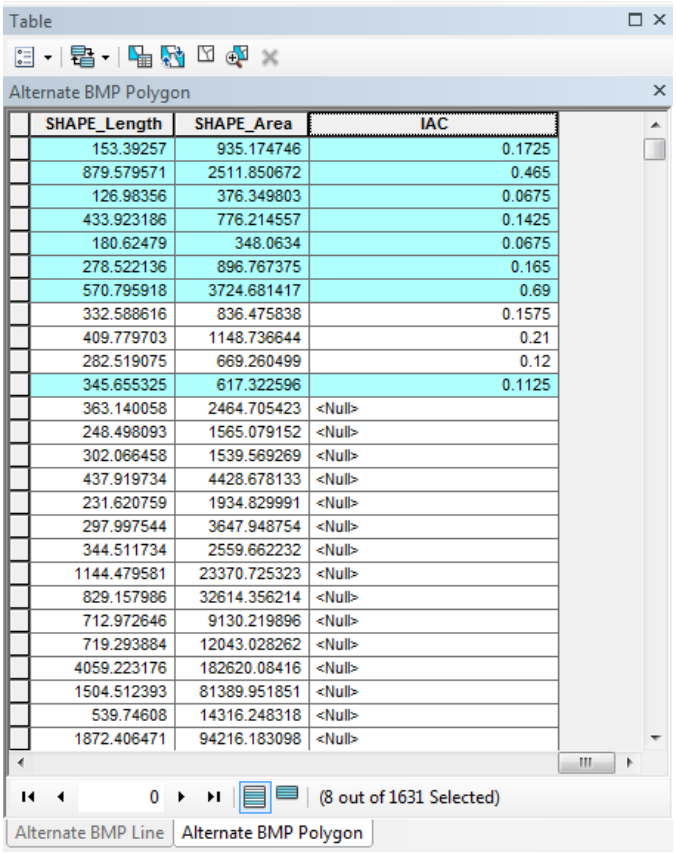
OBJECTID *	SHAPE *	ALTBMP_PY_ID *	BMP_CLASS	
3	Polygon	SH17APY001533	Alternative BMP	Imperviou
4	Polygon	SH17APY001534	Alternative BMP	Imperviou
5	Polygon	SH17APY001535	Alternative BMP	Imperviou
6	Polygon	SH17APY001536	Alternative BMP	Imperviou
7	Polygon	SH17APY001537	Alternative BMP	Imperviou
8	Polygon	SH17APY001538	Alternative BMP	Imperviou
9	Polygon	SH17APY001539	Alternative BMP	Imperviou
10	Polygon	SH12APY000413	Alternative BMP	Imperviou
11	Polygon	SH12APY000412	Alternative BMP	Imperviou
12	Polygon	SH12APY000411	Alternative BMP	Imperviou
13	Polygon	SH17APY001540	Alternative BMP	Imperviou
14	Polygon	SH16APY001298	Alternative BMP	Planting T
15	Polygon	SH16APY001297	Alternative BMP	Planting T
16	Polygon	SH16APY001296	Alternative BMP	Planting T

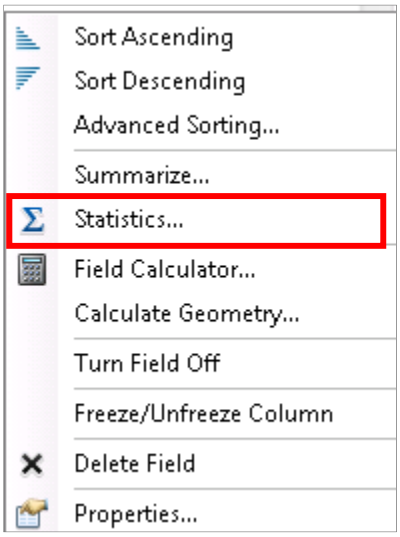
- Within the Select by Attributes dialog window, enter the following selection statement to identify Impervio*us* Area Removal for FY 17, and click “Apply”:

  [PROJECT_DESC] = 'FY17 restoration impervious removal project.'

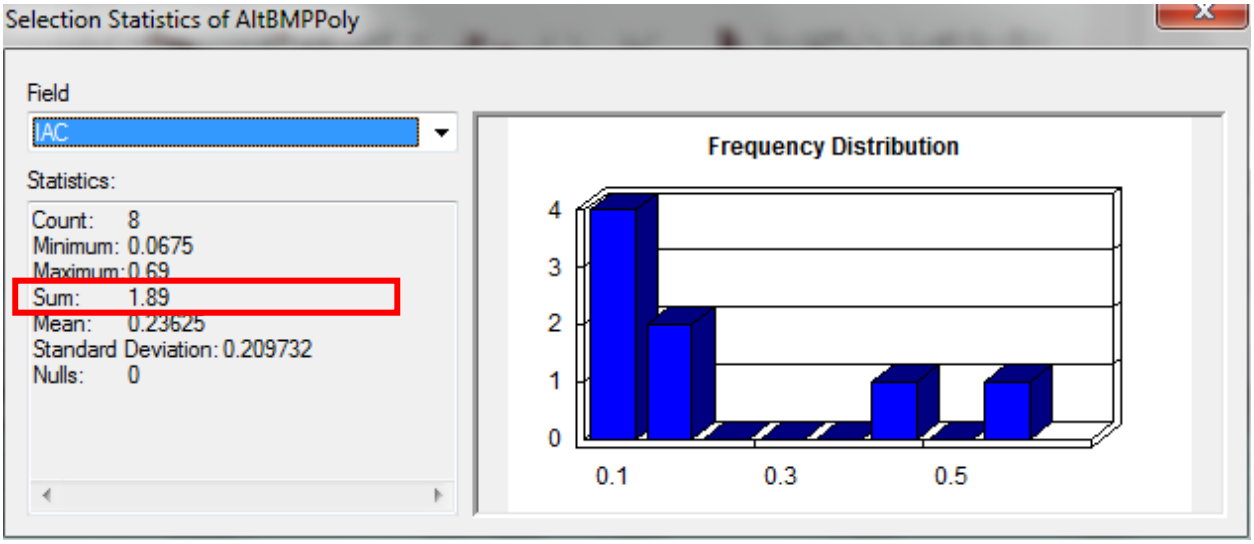


- Ensuring that the selection is retained, right click on the EQU_IMP_ACR field, and select “Statistics…”





- View the “Sum” field to view the total restoration treatment credit claimed for Impervious Area Removal FY 17.



The total impervious area removal treatment credit for FY17 is 1.89 acres.

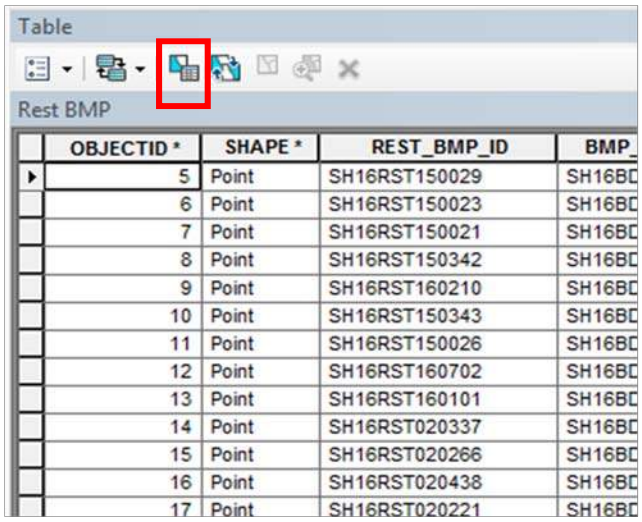
Strategy	Variable Baseline Year - 2015	2016	2017	Total
	(acres)	(acres)	(acres)	(acres)
Impervious Surface Elimination (to Pervious)	0.49	0.00	1.89	2.38
New Stormwater	87.41	53.53	54.77	195.71
Grass Swales	0.00	9.07	11.60	20.67
Outfall Stabilization	0.00	2.00	16.25	18.25
Retrofit	0.00	94.43	4.78	99.21
Stream Restoration	444.04	137.24	67.00	648.28
Tree Planting	598.27	66.65	22.09	687.01
Redevelopment Credit	0.00	0.00	81.00	81.00
Inlet Cleaning	0.00	0.00	150.00	150.00
Street Sweeping	0.00	0.00	33.00	33.00
Totals	**1,130**	**363**	**442**	**1,936**
20% Restoration Target				**4709**

6.1.3.2 Impervious Area Removal IAC for FY 2016

There are no impervious area removals for FY 16.

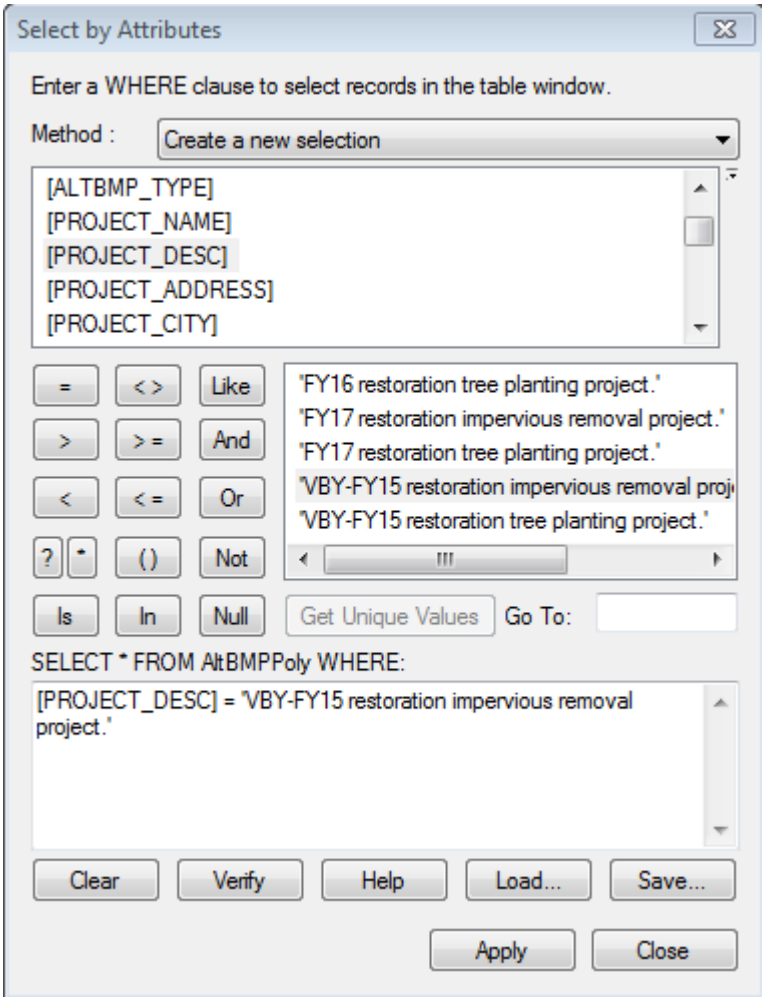
6.1.3.3 Impervious Area Removal IAC for VBY-2015

- Within the AltBMPPoly attribute table, click the Select by Attributes button.

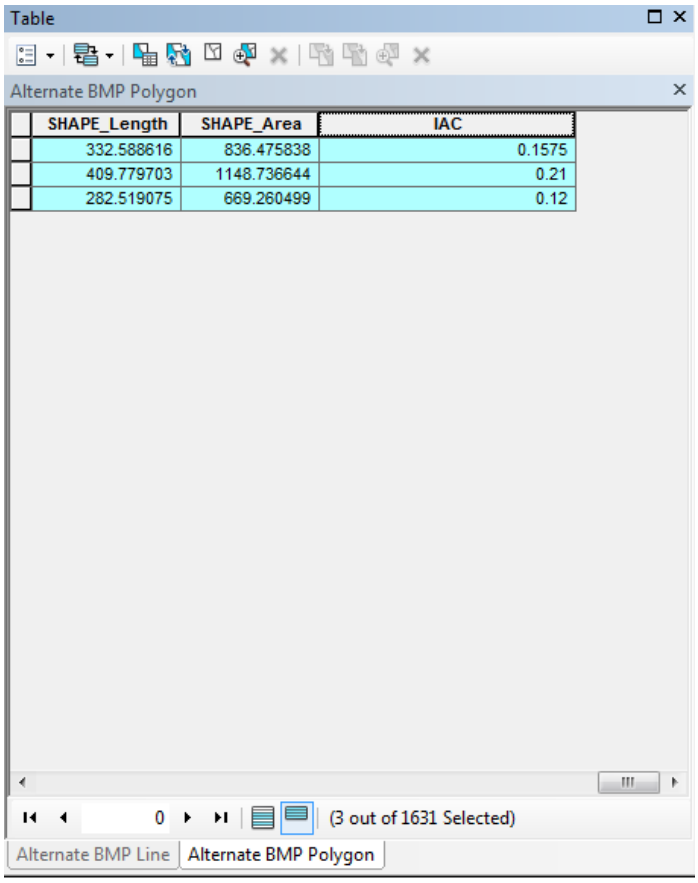


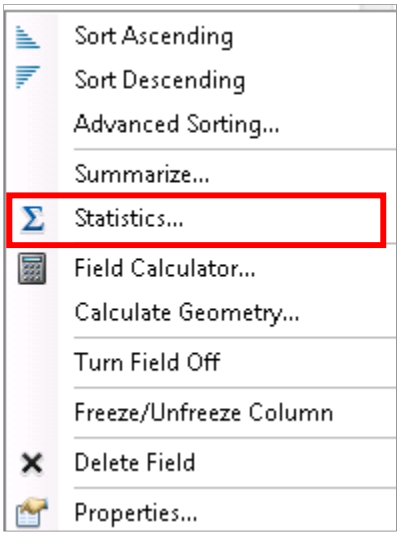
- Within the Select by Attributes dialog window, enter the following selection statement to identify Impervious Area Removal for VBY-2015, and click “Apply”:

  [PROJECT_DESC] = 'VBY-FY15 restoration impervious removal project.'

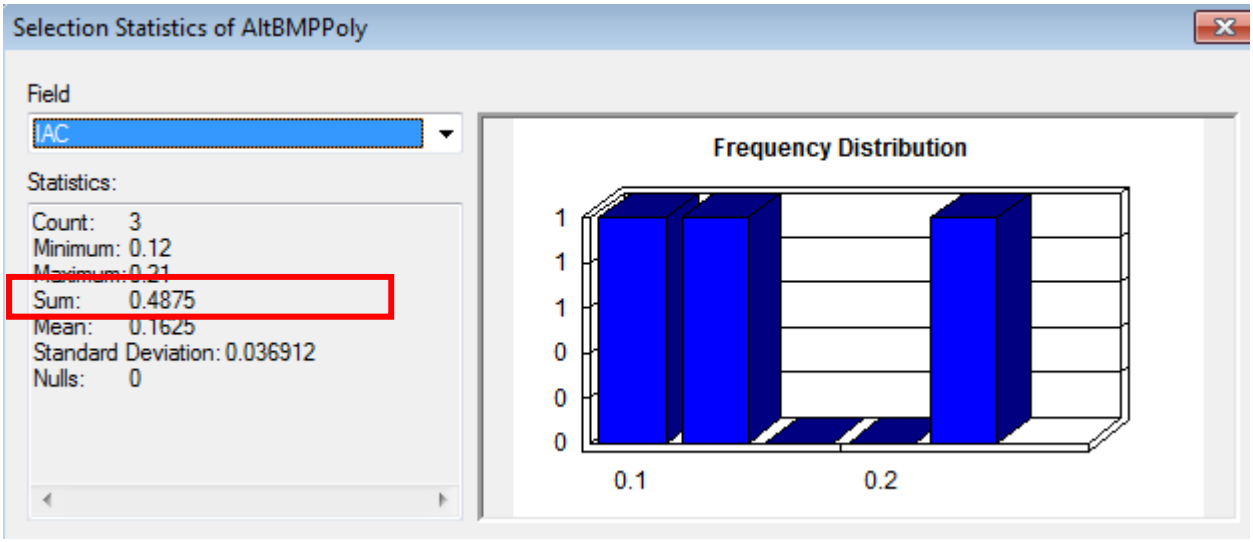


- Ensuring that the selection is retained, right click on the EQU_IMP_ACR field, and select "Statistics…"





- View the "Sum" field to view the total restoration treatment credit claimed for Impervious Area Removal VBY-2015.



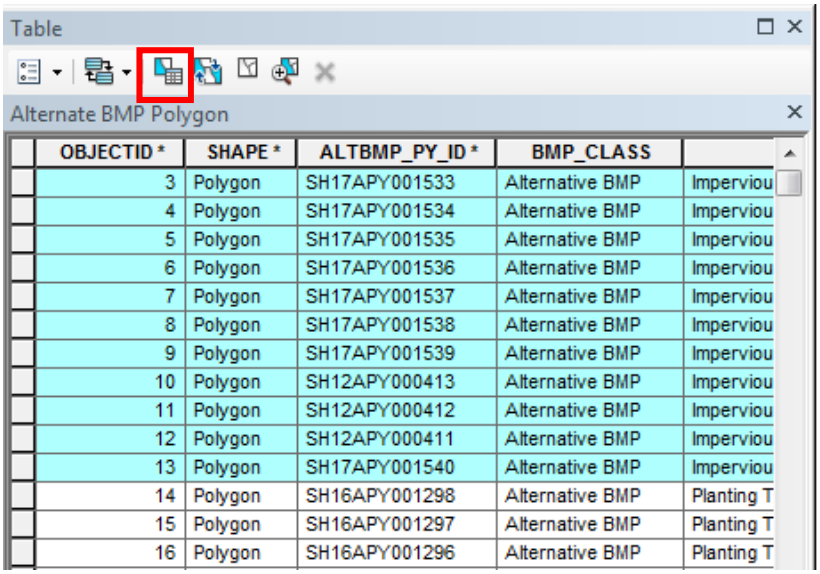
The total impervious area removal treatment credit for VBY-2015 is 0.49 acres.

Strategy	Variable Baseline Year - 2015	2016	2017	Total
	(acres)	(acres)	(acres)	(acres)
Impervious Surface Elimination (to Pervious)	0.49	0.00	1.89	2.38
New Stormwater	87.41	53.53	54.77	195.71
Grass Swales	0.00	9.07	11.60	20.67
Outfall Stabilization	0.00	2.00	16.25	18.25
Retrofit	0.00	94.43	4.78	99.21
Stream Restoration	444.04	137.24	67.00	648.28
Tree Planting	598.27	66.65	22.09	687.01
Redevelopment Credit	0.00	0.00	81.00	81.00
Inlet Cleaning	0.00	0.00	150.00	150.00
Street Sweeping	0.00	0.00	33.00	33.00
Totals	**1,130**	**363**	**442**	**1,936**
20% Restoration Target				**4709**

6.2 Total Impervious Area Removal IAC Sum

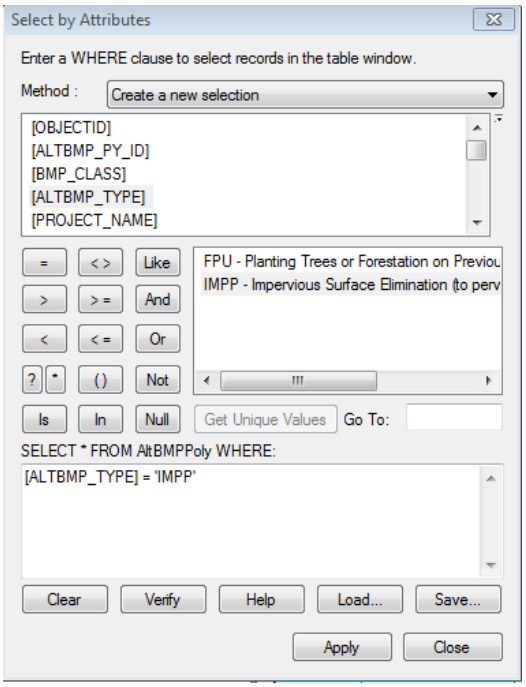
To determine restoration Impervious Area Removal IAC, select Impervious Area Removals, and sum the EQU_IMP_ACR:

- Within the AltBMPoly feature class, click the Select by Attributes tool.

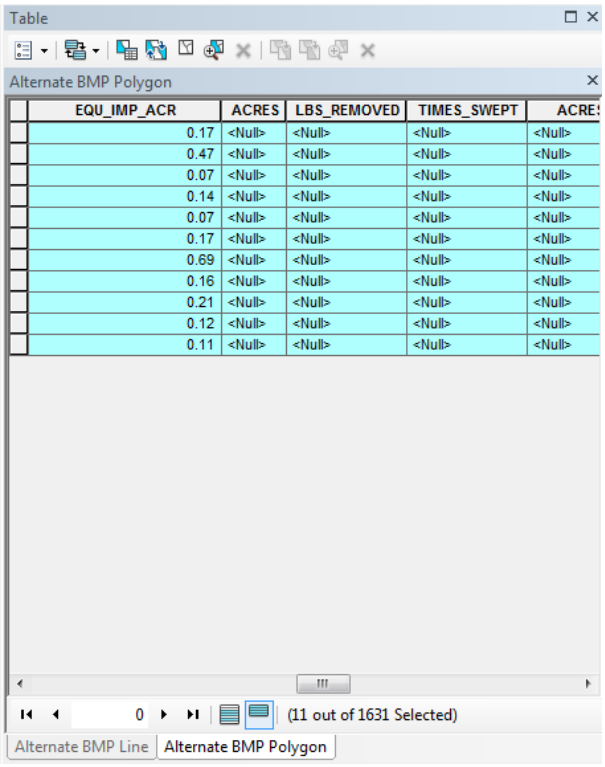


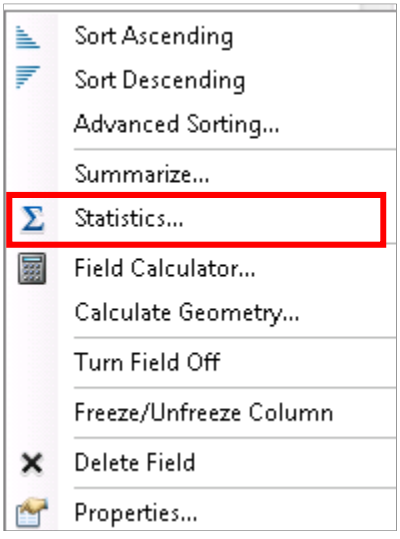
OBJECTID *	SHAPE *	ALTBMP_PY_ID *	BMP_CLASS	
3	Polygon	SH17APY001533	Alternative BMP	Imperviou
4	Polygon	SH17APY001534	Alternative BMP	Imperviou
5	Polygon	SH17APY001535	Alternative BMP	Imperviou
6	Polygon	SH17APY001536	Alternative BMP	Imperviou
7	Polygon	SH17APY001537	Alternative BMP	Imperviou
8	Polygon	SH17APY001538	Alternative BMP	Imperviou
9	Polygon	SH17APY001539	Alternative BMP	Imperviou
10	Polygon	SH12APY000413	Alternative BMP	Imperviou
11	Polygon	SH12APY000412	Alternative BMP	Imperviou
12	Polygon	SH12APY000411	Alternative BMP	Imperviou
13	Polygon	SH17APY001540	Alternative BMP	Imperviou
14	Polygon	SH16APY001298	Alternative BMP	Planting T
15	Polygon	SH16APY001297	Alternative BMP	Planting T
16	Polygon	SH16APY001296	Alternative BMP	Planting T

- In the statement box, enter the following selection statement and click “Apply”: [ALTBMP_TYPE] = 'IMPP'

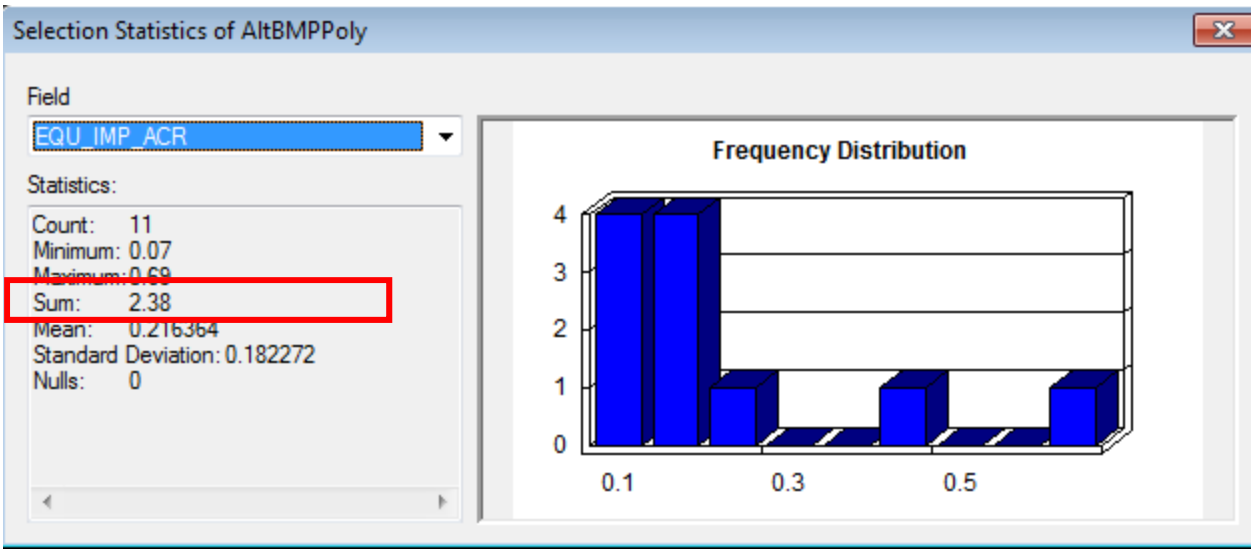


- Ensuring that the selection is retained, right click on the EQU_IMP_ACR, and select “Statistics…”





- View the “Sum” field to view the total restoration treatment credit claimed for Impervious Area Removal



The total impervious area removal treatment credit 2.38 acres.

Strategy	Variable Baseline Year - 2015	2016	2017	Total
	(acres)	(acres)	(acres)	(acres)
Impervious Surface Elimination (to Pervious)	0.49	0.00	1.89	2.38
New Stormwater	87.41	53.53	54.77	195.71
Grass Swales	0.00	9.07	11.60	20.67
Outfall Stabilization	0.00	2.00	16.25	18.25
Retrofit	0.00	94.43	4.78	99.21
Stream Restoration	444.04	137.24	67.00	648.28
Tree Planting	598.27	66.65	22.09	687.01
Redevelopment Credit	0.00	0.00	81.00	81.00
Inlet Cleaning	0.00	0.00	150.00	150.00
Street Sweeping	0.00	0.00	33.00	33.00
Totals	**1,130**	**363**	**442**	**1,936**
20% Restoration Target				**4709**

7.0 Inlet Cleaning

Calculating the impervious treatment credit for Inlet Cleaning requires two (2) primary inputs:

- Pounds removed from within the MDE MS4 geodatabase (AltBMPPoly feature class' LBS_REMOVED field)
- Impervious Acre Equivalent factor, from Table 7 of MDE's August 2014 guidance (.4 for catch basin cleaning.

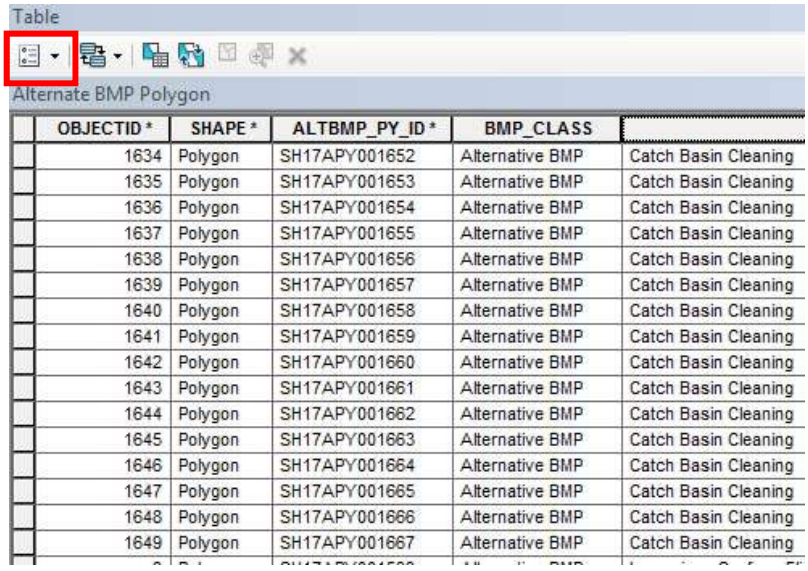
7.1 Inlet Cleaning IAC Calculation

The AltBMPPoly feature class contains a field to explicitly capture IAC ("EQU_IMP_ACR"). To verify the IAC, this example will add a new, temporary field to the AltBMPPoly feature class. This new field will hold the results of the IAC calculation, so once calculated, will equal the existing MDE field "EQU_IMP_ACR". This field is added as a way to re-calculate the IAC, and ensure values align with the MDE field.

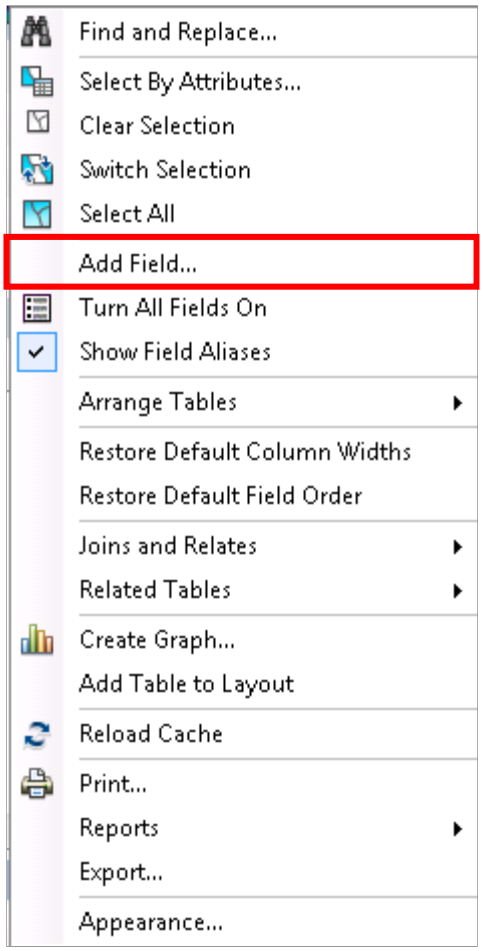
This process could also be done in Excel after exporting the AltBMPLine feature class (the calculation of IAC in Excel is not described within this document).

7.1.1 Add New IAC Field

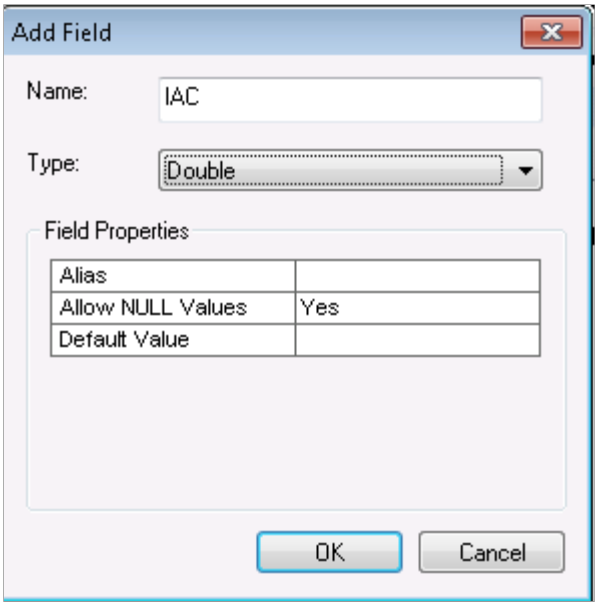
Within the AltBMPPoly attribute table, click the Table Options button, and select "Add Field…"



OBJECTID *	SHAPE *	ALTBMP_PY_ID *	BMP_CLASS	
1634	Polygon	SH17APY001652	Alternative BMP	Catch Basin Cleaning
1635	Polygon	SH17APY001653	Alternative BMP	Catch Basin Cleaning
1636	Polygon	SH17APY001654	Alternative BMP	Catch Basin Cleaning
1637	Polygon	SH17APY001655	Alternative BMP	Catch Basin Cleaning
1638	Polygon	SH17APY001656	Alternative BMP	Catch Basin Cleaning
1639	Polygon	SH17APY001657	Alternative BMP	Catch Basin Cleaning
1640	Polygon	SH17APY001658	Alternative BMP	Catch Basin Cleaning
1641	Polygon	SH17APY001659	Alternative BMP	Catch Basin Cleaning
1642	Polygon	SH17APY001660	Alternative BMP	Catch Basin Cleaning
1643	Polygon	SH17APY001661	Alternative BMP	Catch Basin Cleaning
1644	Polygon	SH17APY001662	Alternative BMP	Catch Basin Cleaning
1645	Polygon	SH17APY001663	Alternative BMP	Catch Basin Cleaning
1646	Polygon	SH17APY001664	Alternative BMP	Catch Basin Cleaning
1647	Polygon	SH17APY001665	Alternative BMP	Catch Basin Cleaning
1648	Polygon	SH17APY001666	Alternative BMP	Catch Basin Cleaning
1649	Polygon	SH17APY001667	Alternative BMP	Catch Basin Cleaning



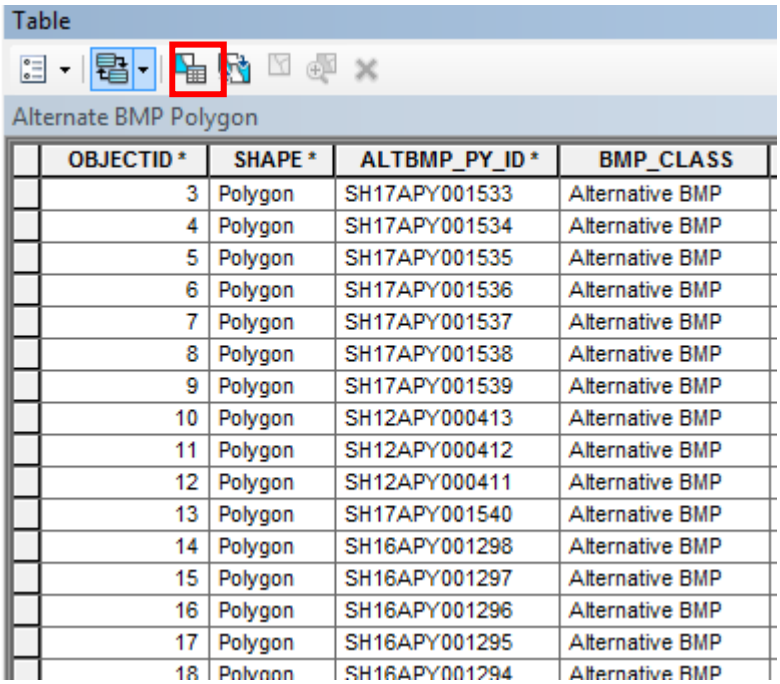
- Within the Add Field dialog window, enter the new field name – "IAC". Set Type = Double. Accept the default Allow Nulls setting. Click "OK". This field may already have been created in a previous step. It can be re-used to calculate the IAC for catch basin cleaning only.



7.1.2 Calculate IAC

Because multiple strategies exist within the AltBMPPoly feature class, select the targeted strategy prior to obtain the sum of IAC.

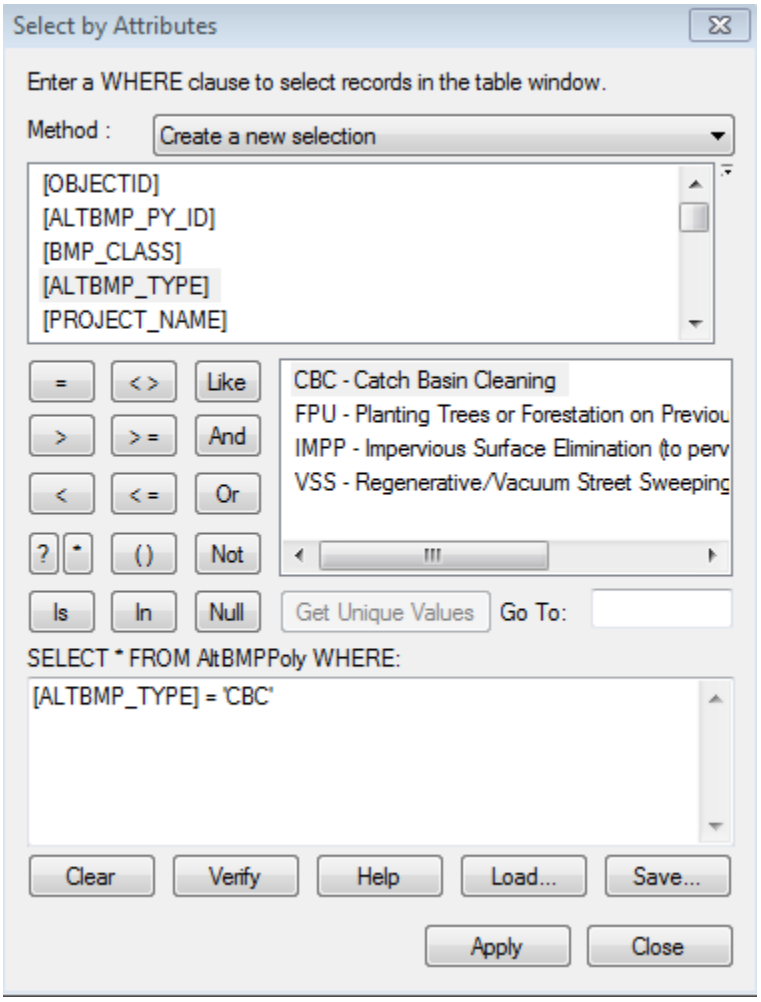
- Within the AltBMPPoly attribute table, click the Select by Attributes button.



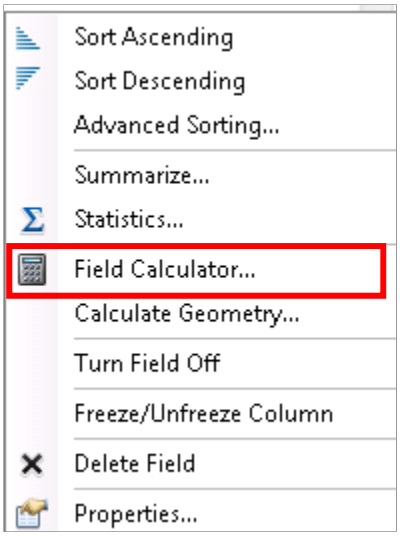
OBJECTID *	SHAPE *	ALTBMP_PY_ID *	BMP_CLASS
3	Polygon	SH17APY001533	Alternative BMP
4	Polygon	SH17APY001534	Alternative BMP
5	Polygon	SH17APY001535	Alternative BMP
6	Polygon	SH17APY001536	Alternative BMP
7	Polygon	SH17APY001537	Alternative BMP
8	Polygon	SH17APY001538	Alternative BMP
9	Polygon	SH17APY001539	Alternative BMP
10	Polygon	SH12APY000413	Alternative BMP
11	Polygon	SH12APY000412	Alternative BMP
12	Polygon	SH12APY000411	Alternative BMP
13	Polygon	SH17APY001540	Alternative BMP
14	Polygon	SH16APY001298	Alternative BMP
15	Polygon	SH16APY001297	Alternative BMP
16	Polygon	SH16APY001296	Alternative BMP
17	Polygon	SH16APY001295	Alternative BMP
18	Polygon	SH16APY001294	Alternative BMP

- Within the Select by Attributes dialog window, enter the following selection statement and click "Apply":

[ALTBMP_TYPE] = 'CBC'



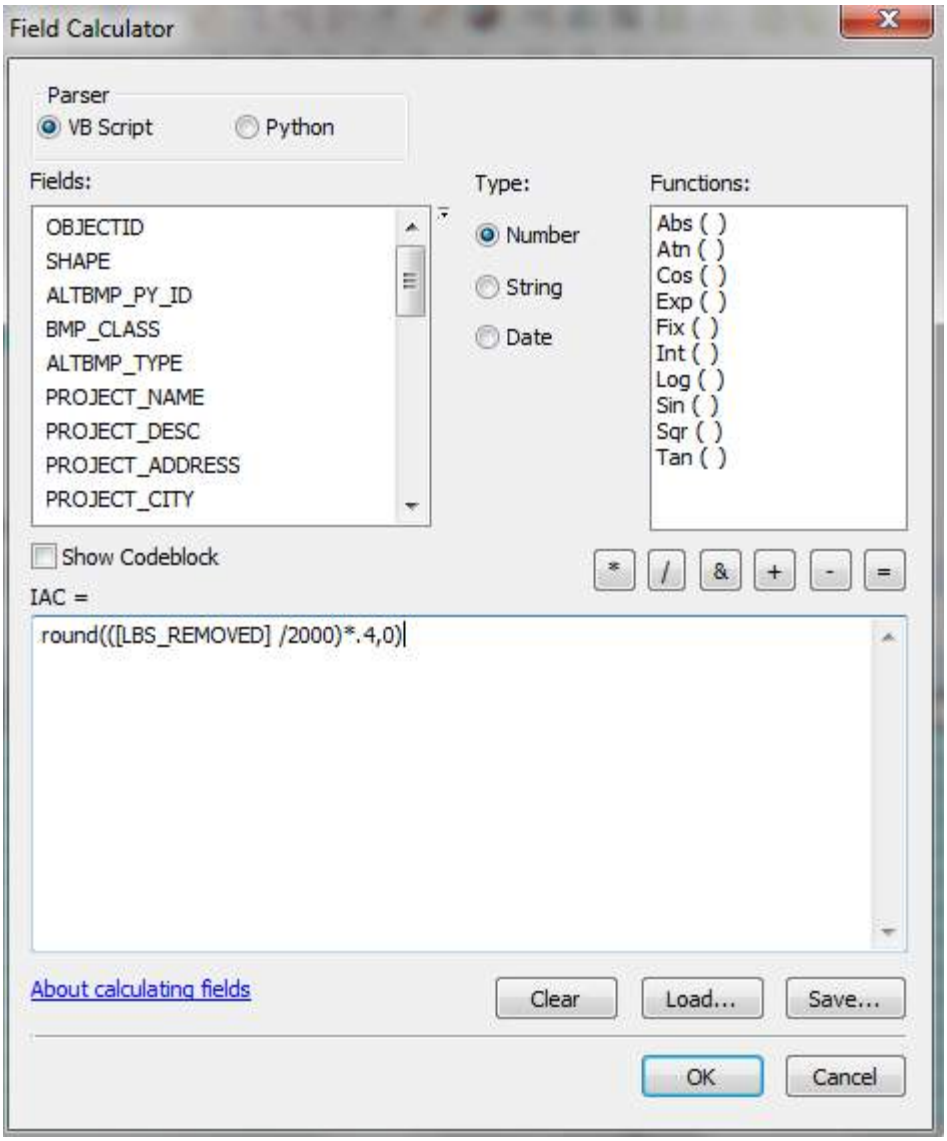
- Right click on the new IAC field, and select "Field Calculator…"



- Within the Field Calculator dialog window, enter the following calculation and click "OK":

  round([LBS_REMOVED]/2000)*.4,0)

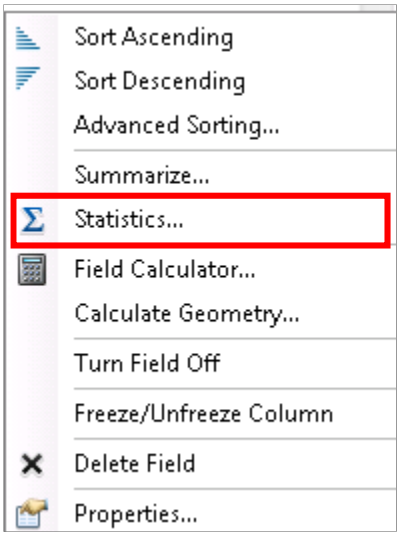
  This formula represents the conversion from dry weight pounds to tons, then multiplied by the Impervious Acre Equivalent factor of 0.40. This strategy is also rounded slightly to achieve a value of 150 impervious equivalent acres. Refer to Section E in the Annual Report text for an expanded description of the inlet cleaning program and the capped credit achievement approach for FY17.



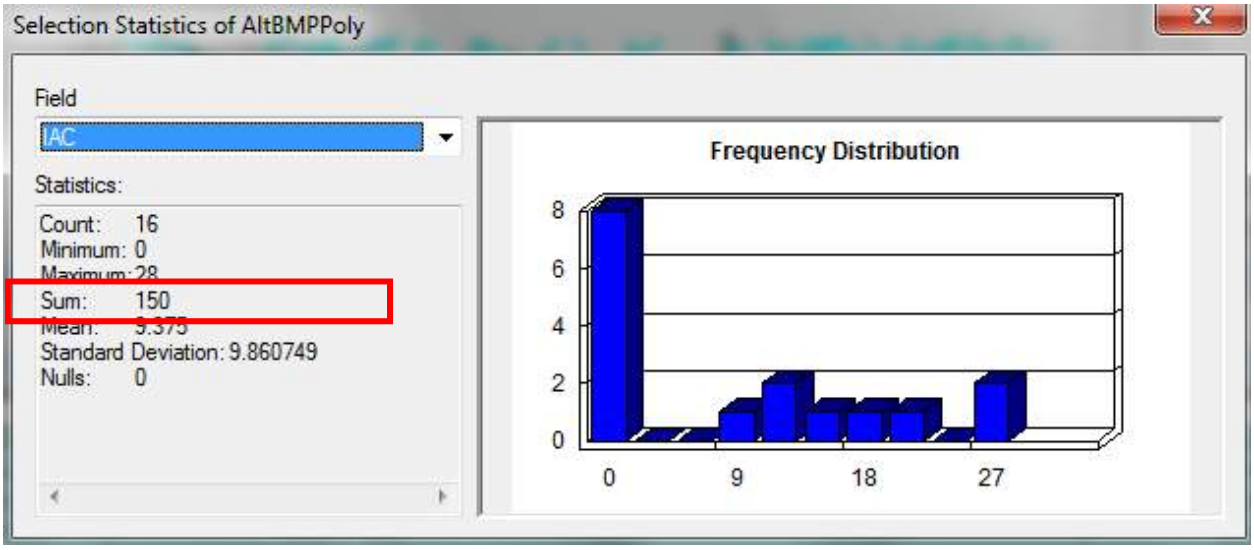
7.2 Total Inlet Cleaning IAC Sum

To determine restoration inlet cleaning IAC, select inlet cleaning, and sum the EQU_IMP_ACR:

- Ensuring that the selection is retained, right click on the EQV_IMP_ACR, and select “Statistics…”



- View the "Sum" field to view the total restoration treatment credit claimed for Inlet Cleaning.



The total inlet cleaning treatment credit 150 acres.

Strategy	Variable Baseline Year - 2015	2016	2017	Total
	(acres)	(acres)	(acres)	(acres)
Impervious Surface Elimination (to Pervious)	0.49	0.00	1.89	2.38
New Stormwater	87.41	53.53	54.77	195.71
Grass Swales	0.00	9.07	11.60	20.67
Outfall Stabilization	0.00	2.00	16.25	18.25
Retrofit	0.00	94.43	4.78	99.21
Stream Restoration	444.04	137.24	67.00	648.28
Tree Planting	598.27	66.65	22.09	687.01
Redevelopment Credit	0.00	0.00	81.00	81.00
Inlet Cleaning	0.00	0.00	150.00	150.00
Street Sweeping	0.00	0.00	33.00	33.00
Totals	**1,130**	**363**	**442**	**1,936**
20% Restoration Target				**4709**

8.0 Street Sweeping

Calculating the impervious treatment credit for street sweeping requires two (2) primary inputs:

- Times swept from within the MDE MS4 geodatabase (AltBMPPoly feature class' TIMES_SWEPT field); this is representative of the timeframe in which the route was swept with the required biweekly frequency.
- Impervious Acre Equivalent factor, from Table 7 of MDE's August 2014 guidance: 0.13.

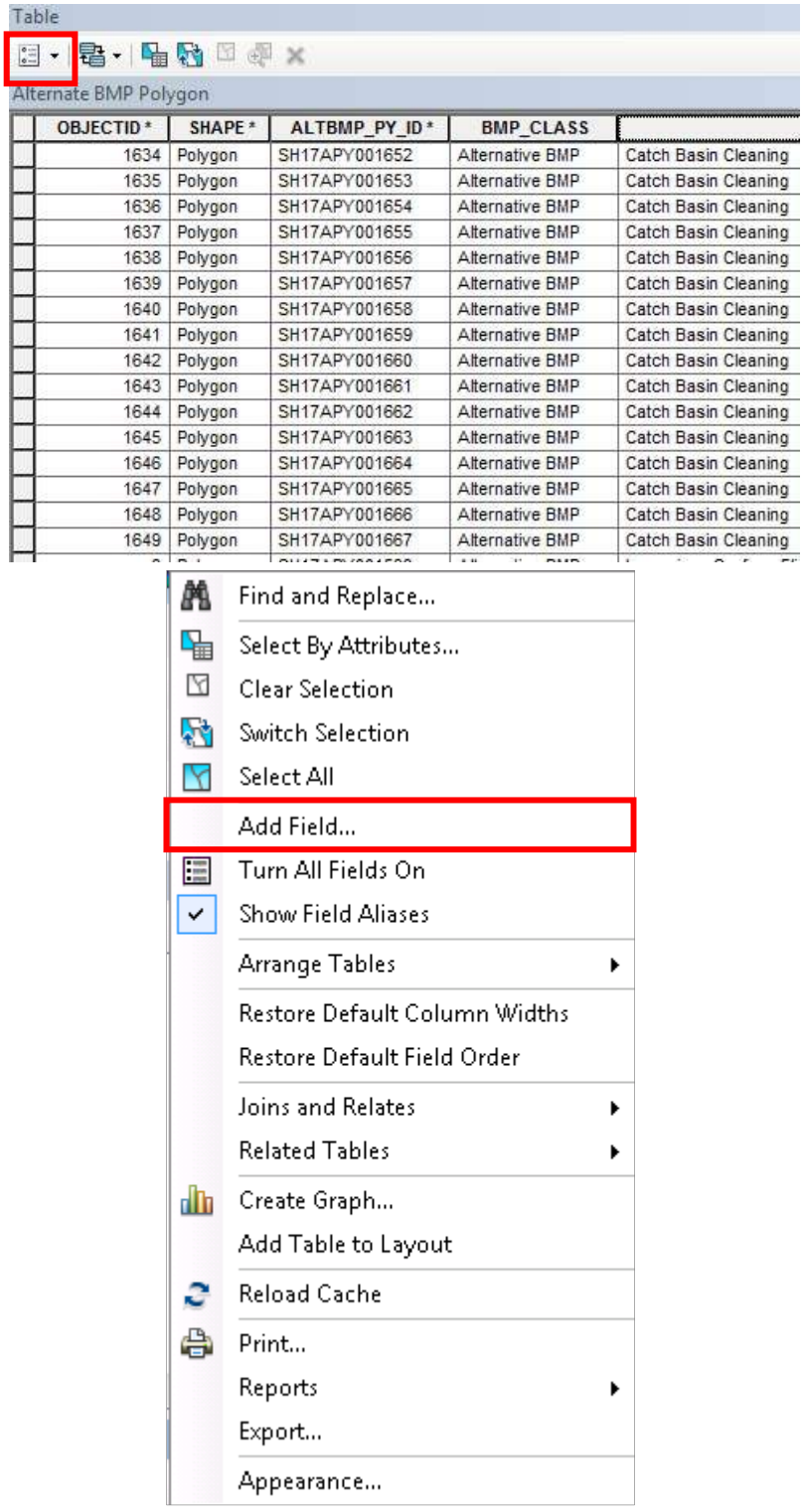
8.1 Street Sweeping IAC Calculation

The AltBMPPoly feature class contains a field to explicitly capture IAC ("EQU_IMP_ACR"). To verify the IAC, this example will add a new, temporary field to the AltBMPPoly feature class. This new field will hold the results of the IAC calculation, so once calculated, will equal the existing MDE field "EQU_IMP_ACR". This field is added as a way to re-calculate the IAC, and ensure values align with the MDE field.

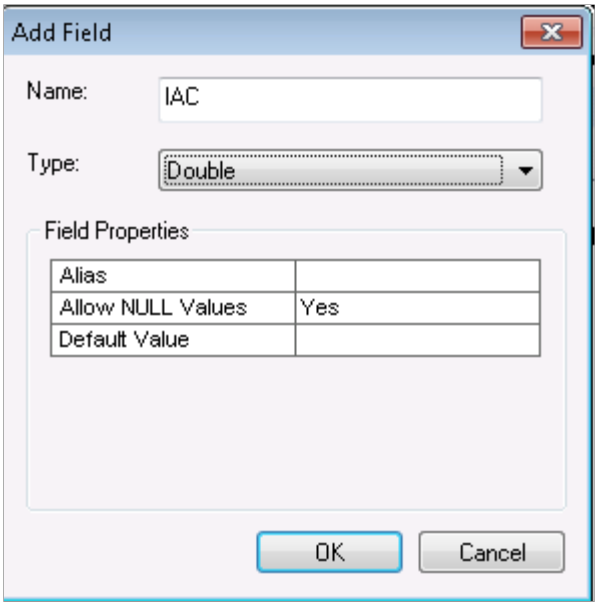
This process could also be done in Excel after exporting the AltBMPLine feature class (the calculation of IAC in Excel is not described within this document).

8.1.1 Add New IAC Field

Within the AltBMPLine attribute table, click the Table Options button, and select "Add Field…"



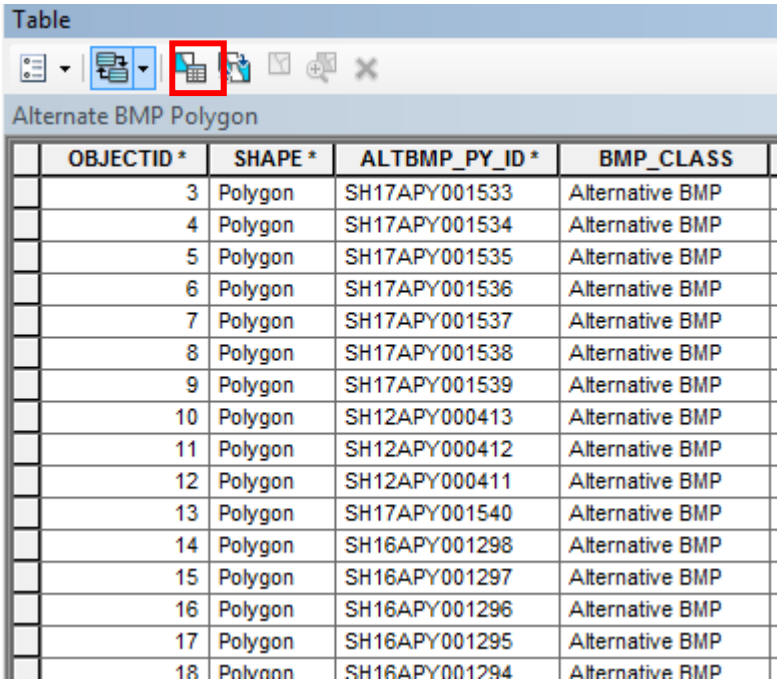
- Within the Add Field dialog window, enter the new field name – "IAC". Set Type = Double. Accept the default Allow Nulls setting. Click "OK". This field may already have been created in a previous step. It can be re-used to calculate the IAC street sweeping only.



8.1.2 Calculate IAC

Because multiple strategies exist within the AltBMPPoly feature class, select the targeted strategy prior to obtain the sum of IAC.

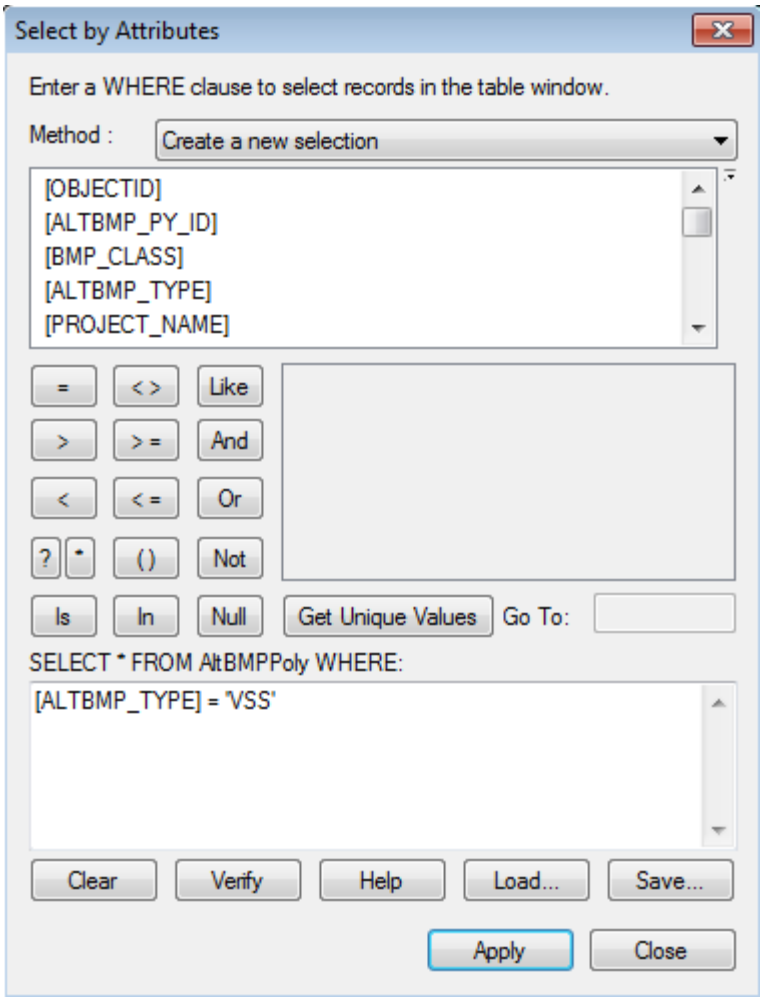
- Within the AltBMPPoly attribute table, click the Select by Attributes button.



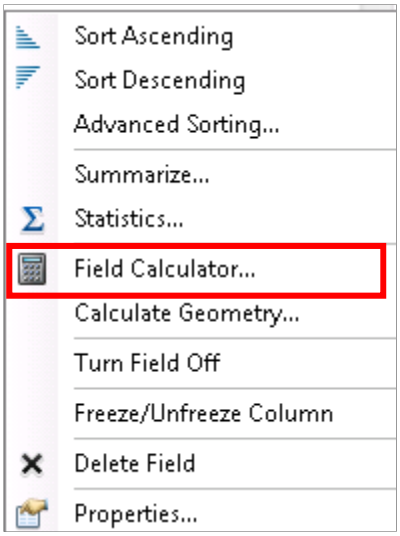
OBJECTID *	SHAPE *	ALTBMP_PY_ID *	BMP_CLASS
3	Polygon	SH17APY001533	Alternative BMP
4	Polygon	SH17APY001534	Alternative BMP
5	Polygon	SH17APY001535	Alternative BMP
6	Polygon	SH17APY001536	Alternative BMP
7	Polygon	SH17APY001537	Alternative BMP
8	Polygon	SH17APY001538	Alternative BMP
9	Polygon	SH17APY001539	Alternative BMP
10	Polygon	SH12APY000413	Alternative BMP
11	Polygon	SH12APY000412	Alternative BMP
12	Polygon	SH12APY000411	Alternative BMP
13	Polygon	SH17APY001540	Alternative BMP
14	Polygon	SH16APY001298	Alternative BMP
15	Polygon	SH16APY001297	Alternative BMP
16	Polygon	SH16APY001296	Alternative BMP
17	Polygon	SH16APY001295	Alternative BMP
18	Polygon	SH16APY001294	Alternative BMP

- Within the Select by Attributes dialog window, enter the following selection statement and click “Apply”:

[ALTBMP_TYPE] = 'VSS’



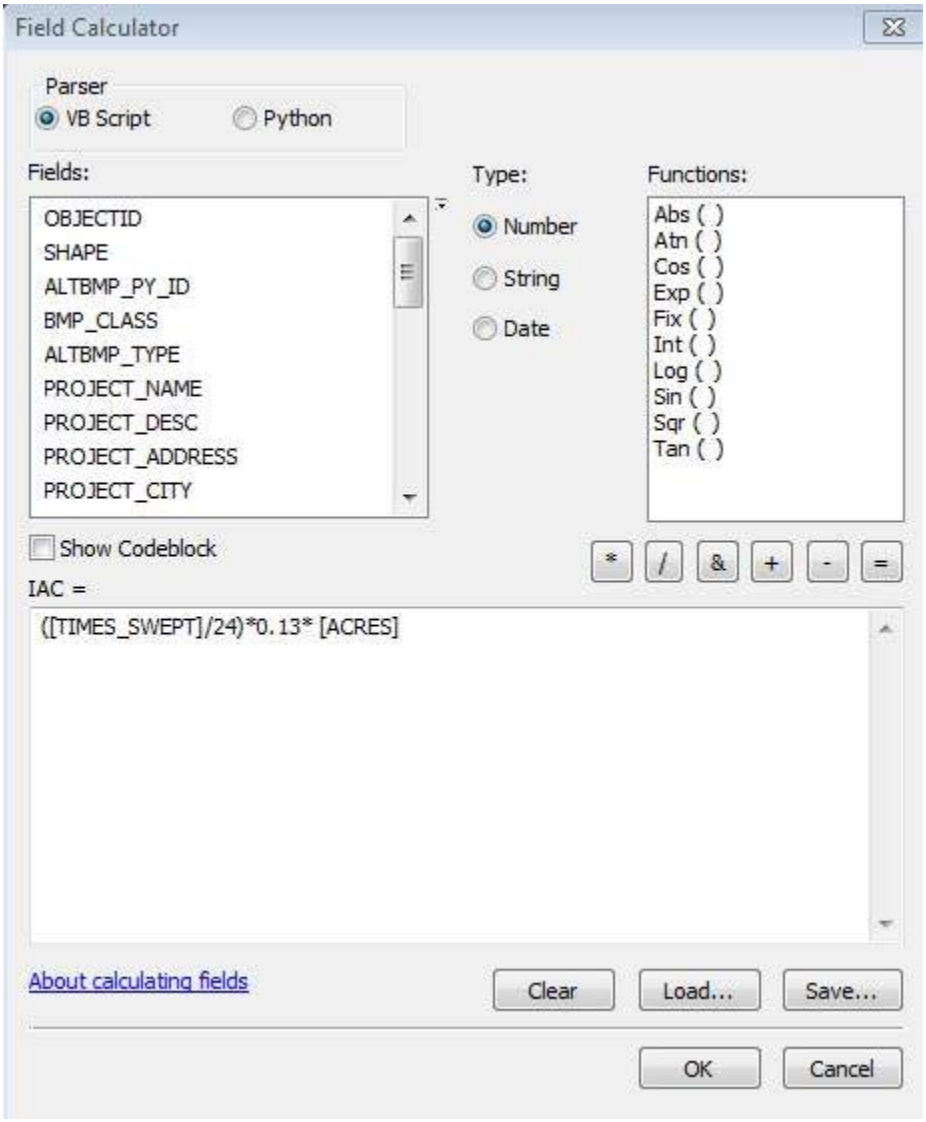
- Right click on the new IAC field, and select "Field Calculator…"



- Within the Field Calculator dialog window, enter the following calculation and click “OK”:

  ([TIMES_SWEPT]/24)*0.13* [ACRES]

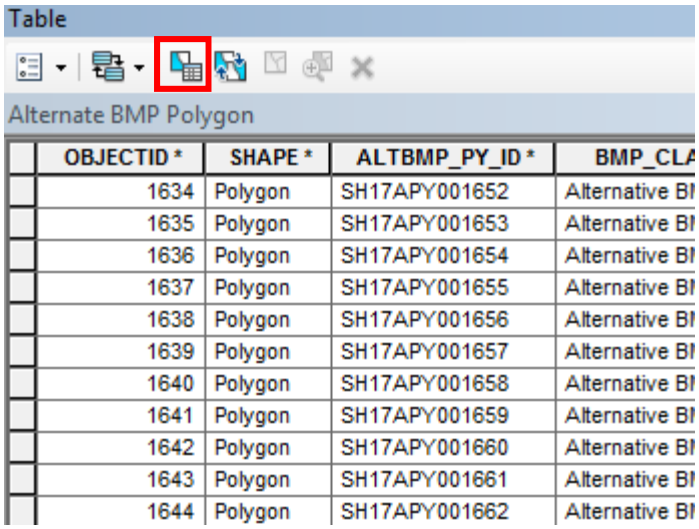
  This formula represents includes the number of biweekly sweepings, the acres swept, and factors these by the Impervious Acre Equivalent factor of 0.13. This strategy is also rounded slightly to achieve a value of 33 impervious equivalent acres. Refer to Section E in the Annual Report text for an expanded description of the street sweeping program and the capped credit achievement approach for FY17.



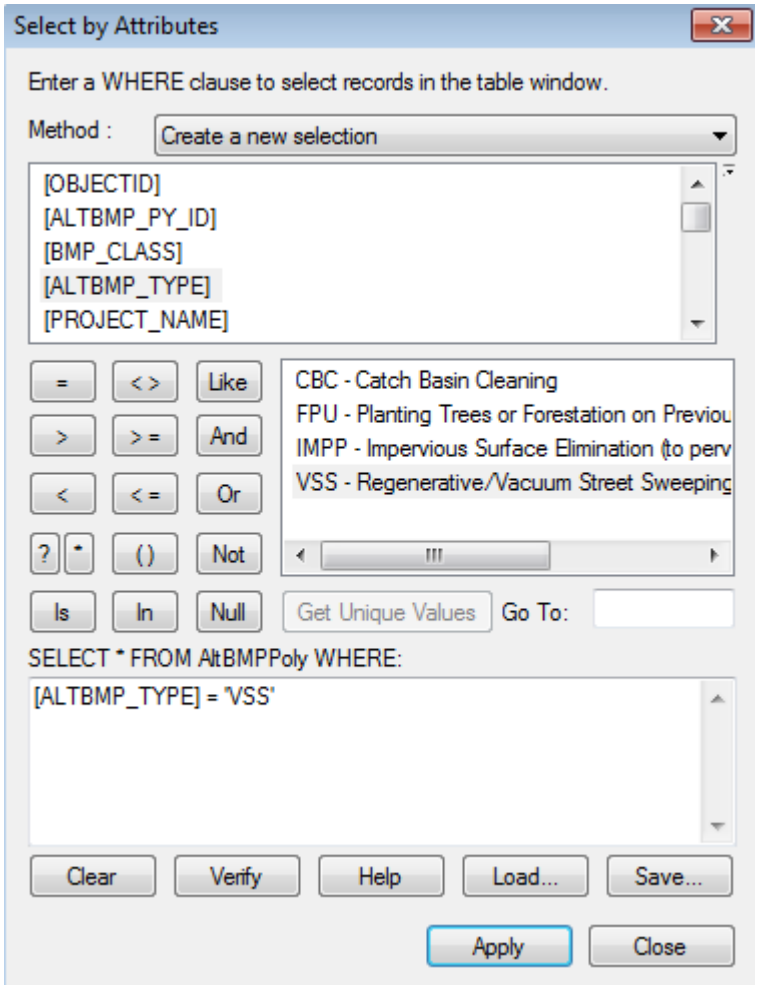
8.2 Total Street Sweeping IAC Sum

To determine street sweeping restoration IAC, select inlet cleaning, and sum the EQU_IMP_ACR:

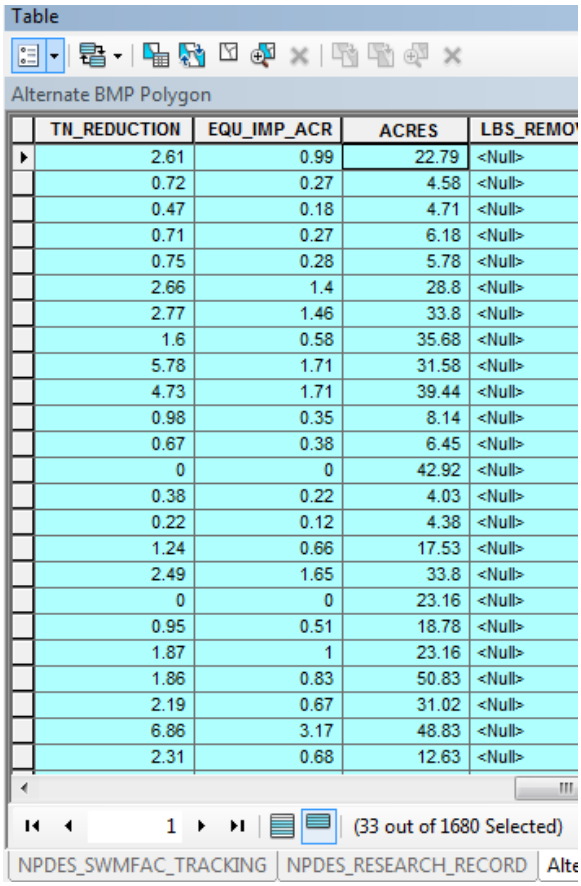
- Within the AltBMPPoly feature class, click the Select by Attributes tool.

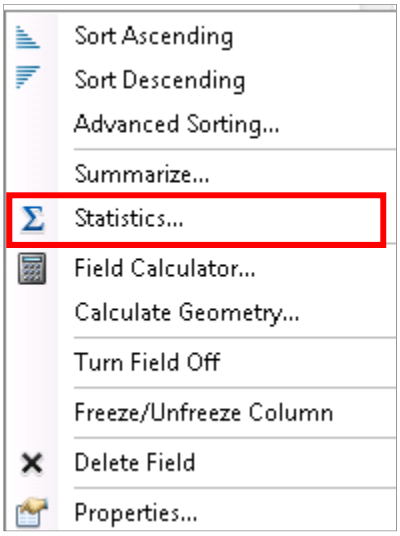


- In the statement box, enter the following selection statement and click “Apply”: [ALTBMP_TYPE] = 'VSS'

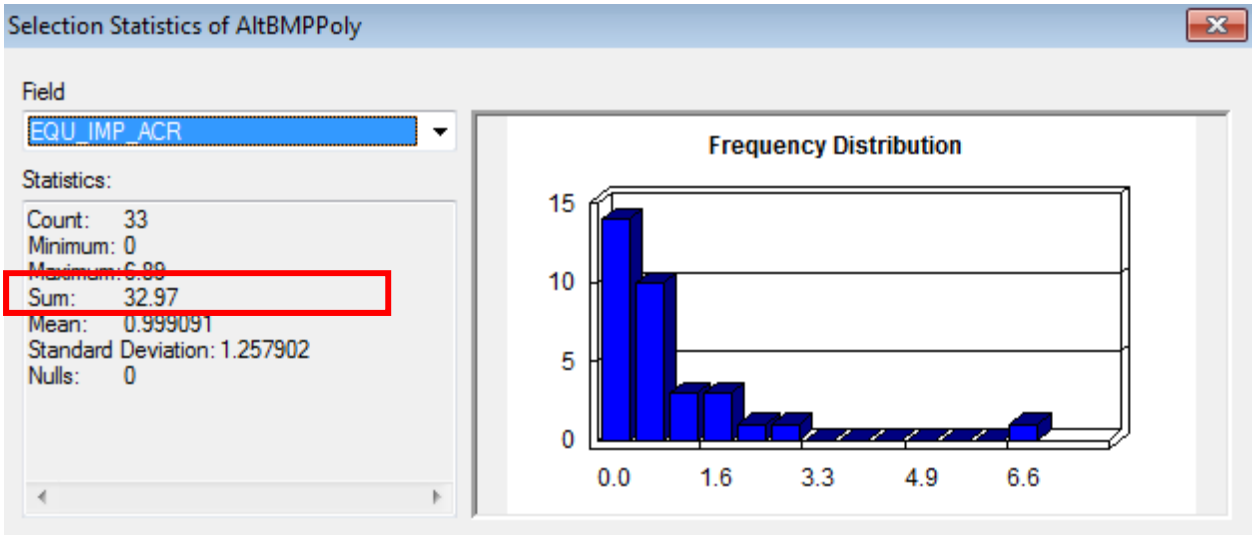


- Ensuring that the selection is retained, right click on the EQV_IMP_ACR, and select “Statistics…”





- View the “Sum” field to view the total restoration treatment credit claimed for street sweeping.



The total street sweeping treatment credit 33 acres.

Strategy	Variable Baseline Year - 2015	2016	2017	Total
	(acres)	(acres)	(acres)	(acres)
Impervious Surface Elimination (to Pervious)	0.49	0.00	1.89	2.38
New Stormwater	87.41	53.53	54.77	195.71
Grass Swales	0.00	9.07	11.60	20.67
Outfall Stabilization	0.00	2.00	16.25	18.25
Retrofit	0.00	94.43	4.78	99.21
Stream Restoration	444.04	137.24	67.00	648.28
Tree Planting	598.27	66.65	22.09	687.01
Redevelopment Credit	0.00	0.00	81.00	81.00
Inlet Cleaning	0.00	0.00	150.00	150.00
Street Sweeping	0.00	0.00	33.00	33.00
Totals	**1,130**	**363**	**442**	**1,936**
20% Restoration Target				**4709**

9.0 Redevelopment Credit

Calculating the impervious treatment credit for redevelopment requires three (3) primary inputs:

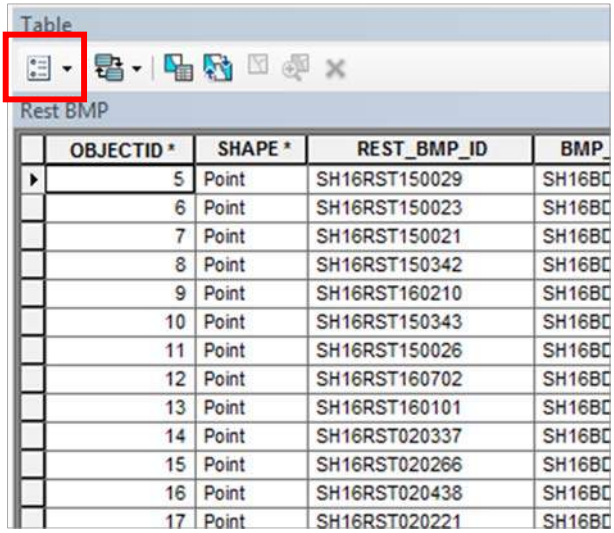
- Impervious acres, from within the MDE MS4 geodatabase (RestBMP feature class' IMP_ACRES field)
- PE treated factor, from within the MDE MS4 geodatabase (RestBMP feature class' PE_ADR field)
- Impervious Area equivalent factor, from Table 7 of MDE's August 2014 guidance (1.0 for stormwater BMPs)

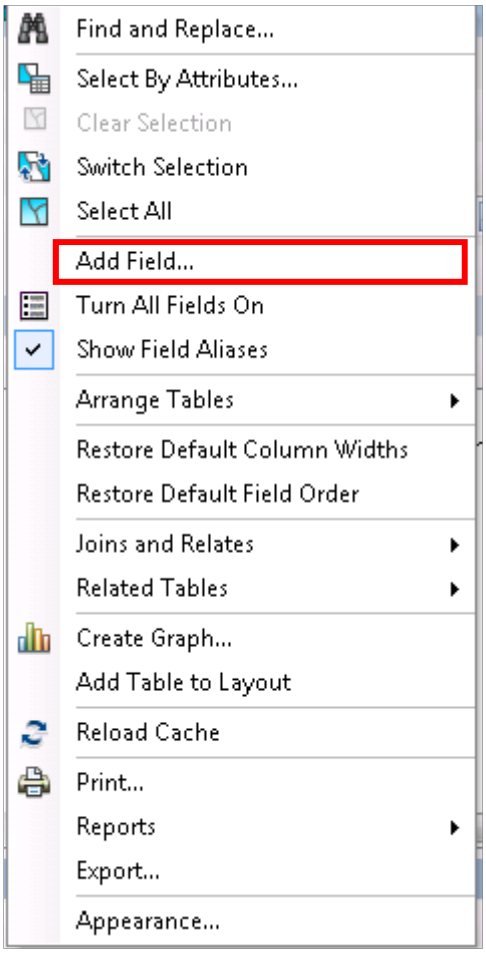
9.1 Redevelopment Credit IAC Calculation

Because multiple inputs and a complex equation are required to calculate IAC for restoration stormwater BMPs, this example will add a new, temporary field to the RestBMP feature class. This process could also be done in Excel after exporting the RestBMP feature class (the calculation of IAC in Excel is not described within this document).

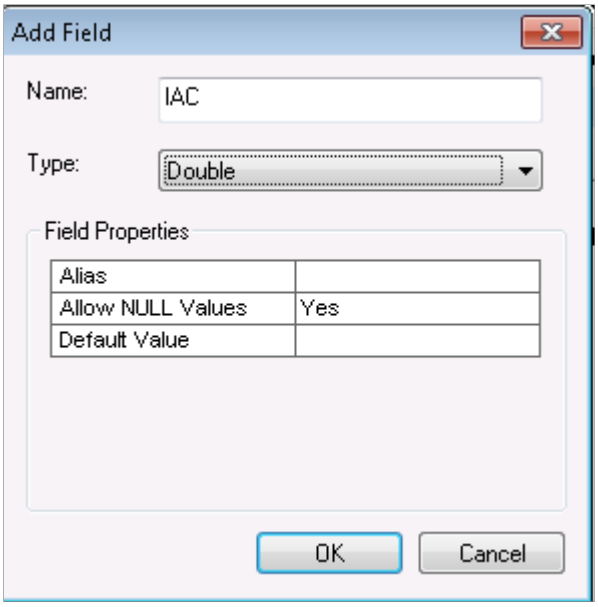
9.1.1 Add New IAC Field

- Within the RestBMP attribute table, click the Table Options button, and select "Add Field…"





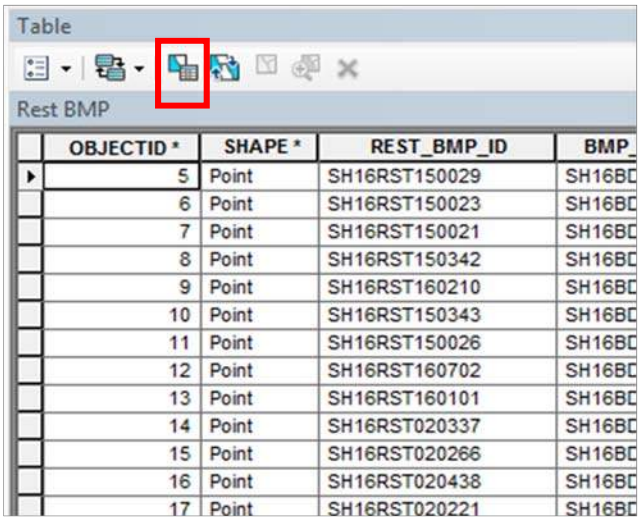
- Within the Add Field dialog window, enter the new field name – "IAC". Set Type = Double. Accept the default Allow Nulls setting. Click "OK".



9.1.2 Calculate IAC

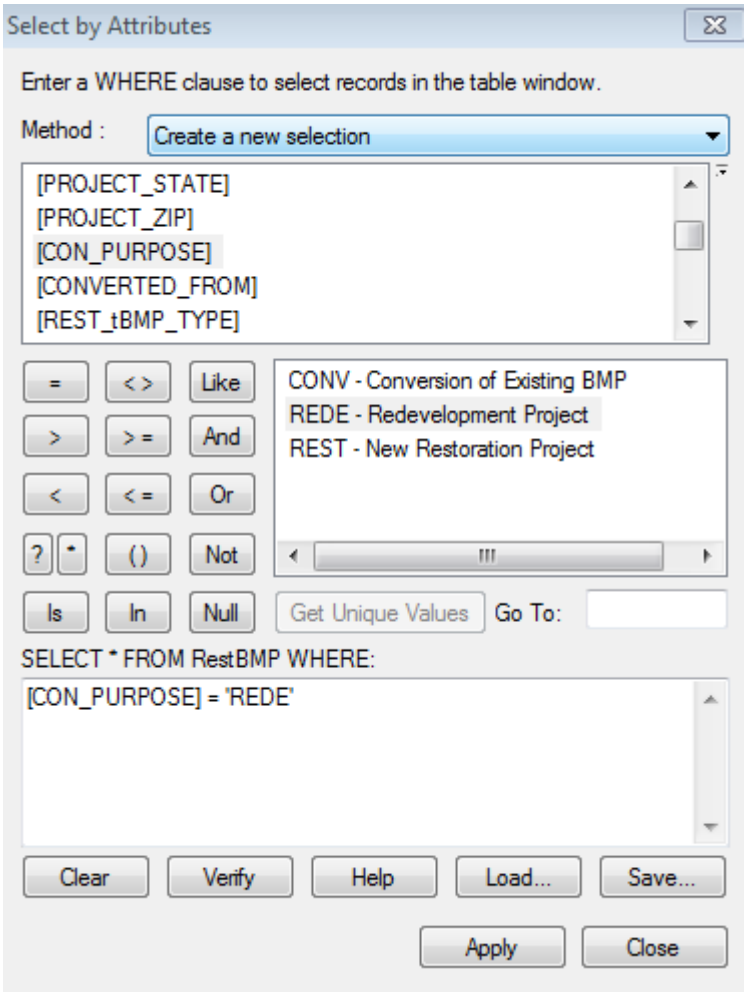
Because multiple strategies exist within the AltBMPPoly feature class, select the targeted strategy prior to obtain the sum of IAC.

- Within the RestBMP attribute table, click the Select by Attributes button.

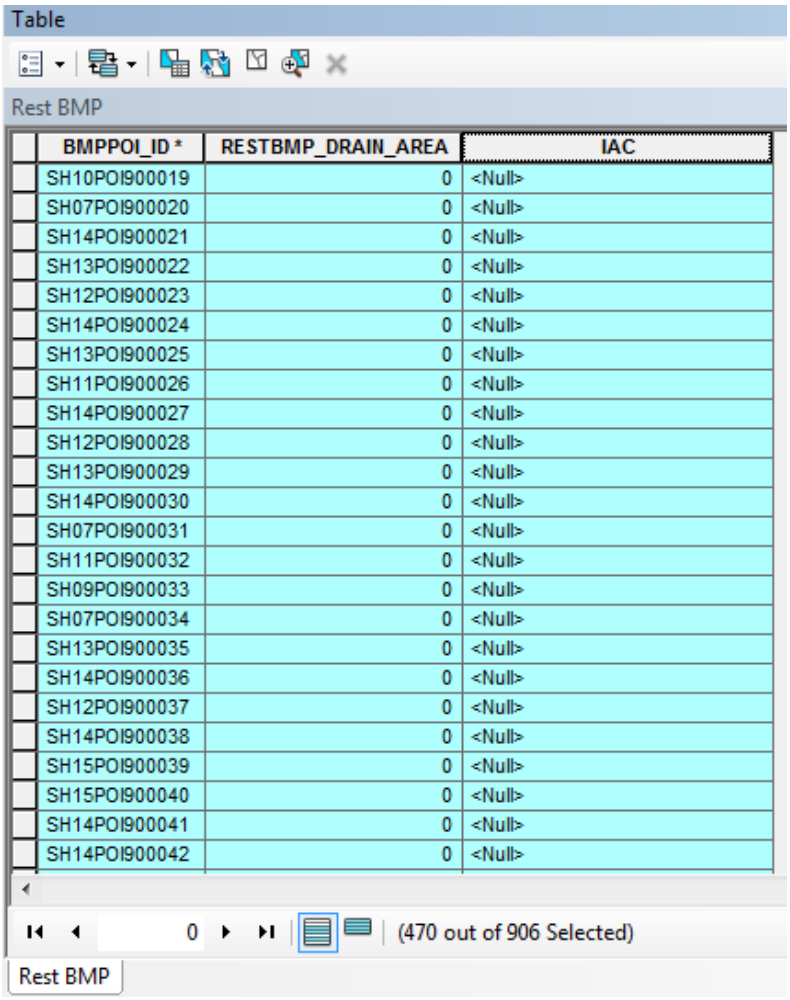


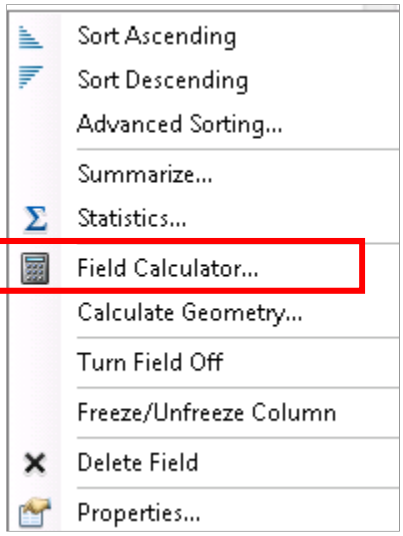
- Within the Select by Attributes dialog window, enter the following selection statement to identify BMPs for redevelopment BMPs, and click “Apply”:

  [CON_PURPOSE] = 'REDE'

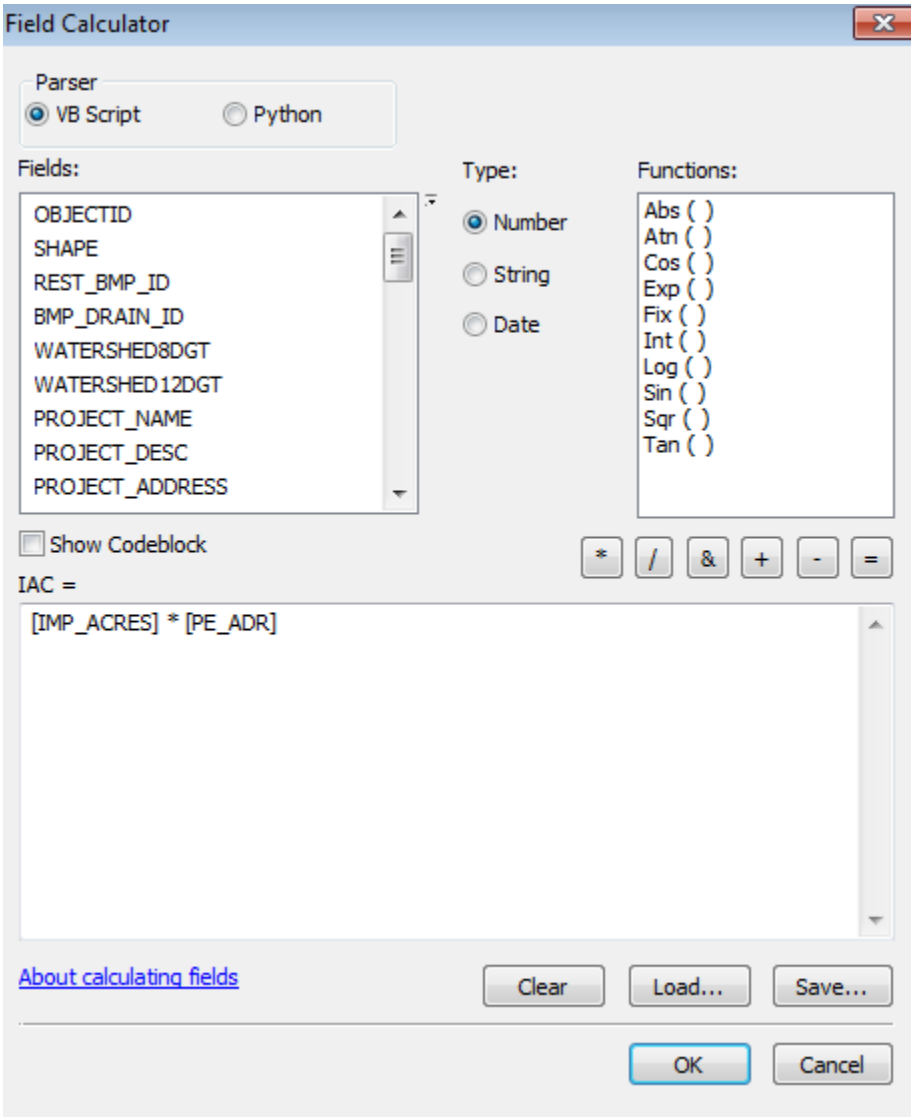


- Right click on the new IAC field, and select “Field Calculator…”





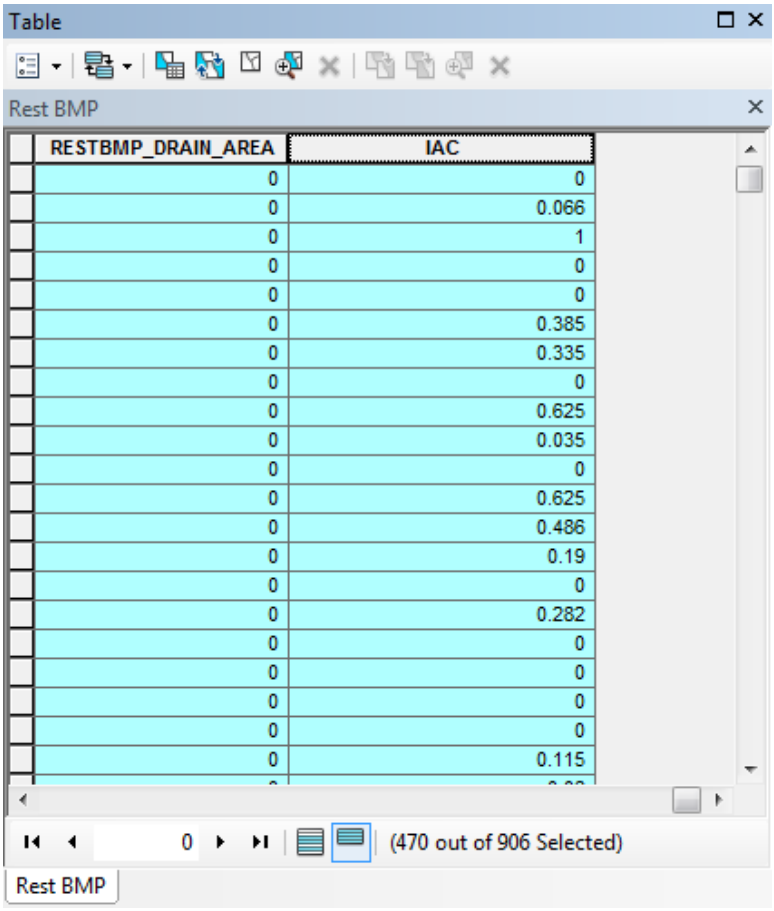
- Within the Field Calculator dialog window, enter the following calculation, and click “OK”:
  [IMP_ACRES] * [PE_ADR]



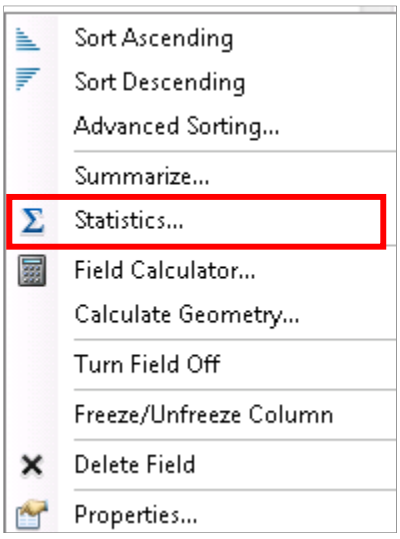
9.1.3 Calculating the Sum

Because multiple strategies exist within the AltBMPLine feature class, select the targeted strategy prior to obtain the sum of IAC.

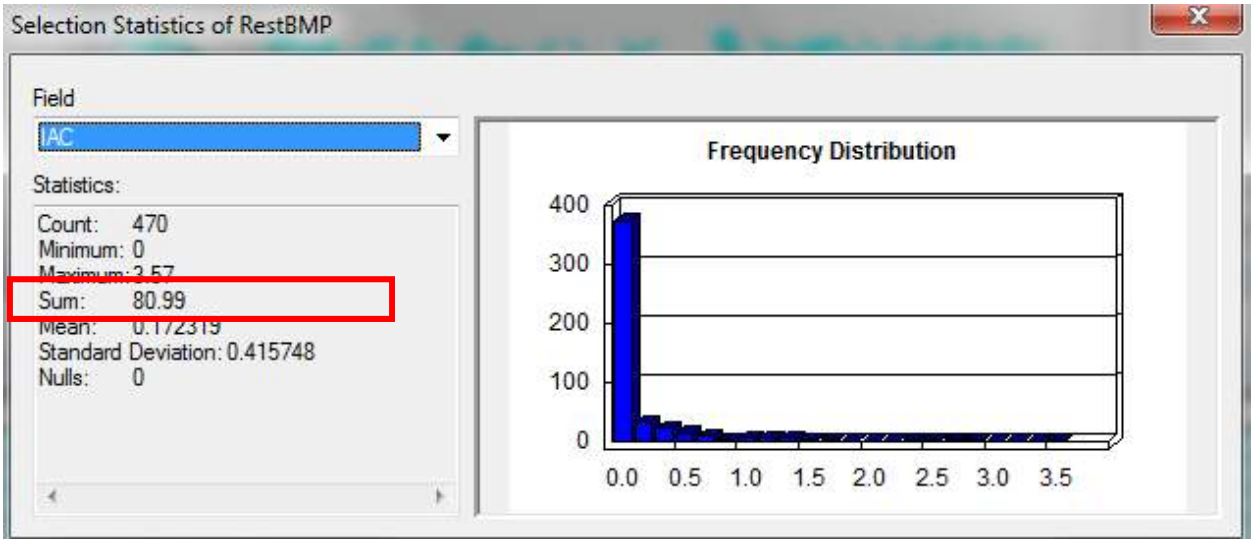
- Ensuring that the selection is retained, right click on the new IAC field, and select “Statistics…”



- Right click on the new IAC field, and select “Statistics…”



- View the “Sum” field to view the total redevelopment treatment credit claimed.



The total redevelopment treatment credit 81 acres.

Strategy	Variable Baseline Year - 2015	2016	2017	Total
	(acres)	(acres)	(acres)	(acres)
Impervious Surface Elimination (to Pervious)	0.49	0.00	1.89	2.38
New Stormwater	87.41	53.53	54.77	195.71
Grass Swales	0.00	9.07	11.60	20.67
Outfall Stabilization	0.00	2.00	16.25	18.25
Retrofit	0.00	94.43	4.78	99.21
Stream Restoration	444.04	137.24	67.00	648.28
Tree Planting	598.27	66.65	22.09	687.01
Redevelopment Credit	0.00	0.00	81.00	81.00
Inlet Cleaning	0.00	0.00	150.00	150.00
Street Sweeping	0.00	0.00	33.00	33.00
Totals	**1,130**	**363**	**442**	**1,936**
20% Restoration Target				**4709**

Appendix B

Existing Stormwater Control Structures Water Quality Treatment Determination

Appendix B

Existing Stormwater Control Structures
Water Quality Treatment Determination

Abstract:

This document presents MDOT SHA's process for researching and documenting the amount of stormwater treatment provided by each existing structural BMP for credit (including partial credit) in support of MDOT SHA baseline treatment calculations.

This document includes two attachments, both of which can be found in the digital submission of the MDOT SHA 2017 Annual Report:

- Attachment A: Historical SW BMP Design Documents
- Attachment B: Example Calculations

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STATE HIGHWAY ADMINISTRATION

Existing Stormwater Control Structures
Water Quality Treatment Determination

MARYLAND DEPARTMENT OF TRANSPORTATION™

STATE HIGHWAY ADMINISTRATION

July 31, 2017

TABLE OF CONTENTS

1 Introduction 3
1.1 Documenting Baseline Treatment for Stormwater Control Structures 3
1.2 MDE Water Quality Treatment Definition 3
1.3 Baseline Requirements for Existing WQ Treatment 4
1.4 Qualifying BMP Type, Performance, and Treatment Area 4
2 Stormwater Management Design History 7
2.1 Definition of Eras 7
2.2 Design Guidance Documents 9
3 BMP Research Elements 10
3.1 Workflow and Tasks 10
3.2 Source Documents 11
4 Calculations 11
4.1 Impervious Area Credit 11
4.2 RS Definition by Era 12
5 Source Document Research 14
6 Office Research 16
6.1 As-Built and Design Plans 16
6.2 SWM Reports 17
7 Field Investigation 19
8 Examples 21
8.1 RS Calculation Spreadsheets 21
8.2 Signoff Sheets 22
8.3 Field Report 22
8.4 P_E Calculator 22
8.5 Full Documentation 22
9 References 23

LIST OF TABLES

Table 1: BMPs with No WQ Treatment 4
Table 2: Example Triennial Inspection Ratings and MDOT SHA Actions 6
Table 3: MDOT SHA SW BMPs by Era 7

Table 4: Eras based on MDE State/Federal SW Design Guidance 9
Table 5: Establishing Impervious Acre WQ Treatment 11
Table 6: Calculations by BMP Type..... 12

LIST OF FIGURES

Figure 1: Source Document Research Flow Chart 15
Figure 2: Office Research Flow Chart..... 18
Figure 3: Field Investigation Flow Chart..... 21

ATTACHMENTS

A. Historical SW BMP Design Documents (Included on CD)
B. Example Calculations (Included on CD)

1 INTRODUCTION

1.1 Documenting Baseline Treatment for Stormwater Control Structures

This document explains accounting procedures used by MDOT SHA for one aspect of the National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit impervious restoration requirement. Specifically, it details methods to quantify treatment provided by existing stormwater control structure best management practices (SW BMPs) to be used in developing baseline treatment accounting. To develop the required impervious accounting, baseline impervious surfaces are developed and quantified; the treatment currently provided is determined; remaining untreated surfaces are computed; and the required restoration percentage is taken against the untreated surfaces. The treatment quantities determined using the methods described here for SW BMPs are used in determining treatment currently provided.

MDOT SHA Office of Environmental Design (OED) implemented a research program to determine the impervious area treatment values for its existing SW BMPs which resulted in this procedure development. Through research it was determined that for some existing SW BMPs, the existing MDOT SHA NPDES MS4 geodatabase is missing data for these parameters or identification of which era design standards were used.

The following parameters are needed to quantify existing treatment:

- Drainage area (DA) to the SW BMP
- Impervious area (IA) draining to the SW BMP
- Runoff Storage Volume (RS)
- Rainfall treated (P_E)
- Impervious area credit (IAC)

The procedures defined here include methods to prepare and document values for the following parameters:

- RS is the volume available for water quality treatment (cubic feet).
- P_E is the equivalent volume defined as the amount of rainfall in inches over the impervious area in acres.
- IAC is the computed SW BMP WQ treatment provided in units of Acres

Separate protocols and procedures for documenting DA and IA have been established and used by MDOT-SHA as well, but are not included in this document.

1.2 MDE Water Quality Treatment Definition

MDE (2014) defines the amount of impervious area treatment that can be received based on the rainfall treated or P_E value. Full treatment is achieved when P_E equals one inch, partial treatment is provided when the P_E value is less than one inch, and extra treatment is added when the P_E

equals greater than 1 inch. Partial treatment for BMPs which treat less than one inch is pro-rated based on the percent of full (one inch) treatment. Extra treatment for BMPs which treat more volume is pro-rated based on 40 percent of the extra treatment from 1.0 to 1.6 inches, for a maximum of 1.4 acre for treatment of 2.6 inches. Therefore, identifying the correct design standard and volume treated for every SW BMP is required to accurately model the existing baseline impervious treatment.

1.3 Baseline Requirements for Existing WQ Treatment

MDOT SHA adopted several methodologies to address MDE requirements for determining which existing BMPs provide impervious area WQ treatment. To be considered baseline treatment, SW BMPs must meet specific criteria including:

- Ownership – Owned by SHA
- Status – Existing
- Built / Plan Date – Constructed prior to and including baseline year
- Drainage Area – Accurate delineation of drainage boundary
- Facility Type – Identified by MDE as providing WQ treatment

1.4 Qualifying BMP Type, Performance, and Treatment Area

MDE (2014) guidance identifies SW BMP types that provide WQ treatment and require the facilities pass inspections to ensure the WQ treatment is provided. Offsite impervious areas outside of the MDOT SHA-owned right-of-way are not included in baseline treatment computations, however future efforts will evaluate these areas for inclusion.

BMP Types Providing No WQ Treatment

Several BMPs were designed and implemented prior to the MDE 2000 (Stormwater Manual) specifically to provide water quality improvements. These included grass channels, infiltration, dry and wet extended detention ponds, and oil-grit separators. Some of these early facilities may not provide WQ treatment and MDE (2014) defined the types of BMPs that are not considered to provide WQ treatment for pollutant removal and impervious area restoration. These are indicated with the prefix "X" in the list of approved BMPS as indicated in Table 1. The full list used by MDOT SHA is included in Table 4.

Table 1: BMPs with No WQ Treatment

Code	Description
XDPD	Detention Structure (Dry Pond)
XDED	Extended Detention Structure, Dry
XFLD	Flood Management Area
XOGS	Oil Grit Separator
XOTH	Other

Non-Functioning BMPs

MDE (2014) requires that all BMPs be verified, inspected, and maintained per State stormwater management regulations to ensure proper function for WQ treatment. To facilitate this requirement, inspections must occur every three years. MDOT-SHA has undertaken a robust stormwater BMP inspection program using qualified stormwater professionals to inspect and document the BMP condition. Ratings are used to determine the functional level provided by the BMP which indicates whether the SW BMP is providing WQ treatment. A failed rating indicates that the SW BMP is not providing WQ treatment.

SW BMPs may fail to varying degrees. Some may require major maintenance activities to bring it to functionally, some may require minor reconstruction, and some may require complete, structural overhaul. Because the timeframes associated with these degrees also vary, MDOT SHA uses different approaches for how the documented WQ treatment is handled. It may be kept in the dataset, or in extreme circumstances, it may need to be removed from the data and restoration reporting. Table 2 identifies the various ways MDOT SHA will handle failed BMPs for data and reporting to MDE.

This WQ treatment reporting strategy was discussed with MDE and MDE understands that a failed BMP awaiting maintenance will remain in the baseline treatment category and, unless the BMP is included in a retrofit design or construction project, will be removed if it continues to not function after three years.

Table 2: Example Triennial Inspection Ratings and MDOT SHA Actions

	Inspection Date				
SW BMP Rated	**1/15/2004**	**1/15/2007**	**1/15/2010**	**Scheduled Remediation Completion Date**	**Actual Remediation Completion Date**
1	**PASS**– WQ treatment kept in reported data	**FAIL** – Minor remediation or major maintenance needed, WQ treatment kept in reported data	**PASS** – WQ treatment kept in reported data		
2	**PASS**– WQ treatment kept in reported data	**FAIL** -- Initial failed rating, WQ treatment kept in reported data	**FAIL** -- Major remediation needed; Remediation schedule provided to MDE, WQ treatment kept in reported data	**PASS** – WQ treatment kept in reported data	
3	**PASS**– WQ treatment kept in reported data	**FAIL** -- Initial failed rating, WQ treatment kept in reported data	**FAIL** -- Major remediation needed; Remediation schedule provided to MDE, WQ treatment kept in reported data	**FAIL** – WQ treatment removed from baseline treatment or restoration credit	**PASS** – WQ treatment added back into reported data

No Credit for Treatment of Offsite Impervious Area

Currently, MDOT SHA is only claiming WQ treatment for impervious areas that are both a) located within MDOT SHA ROW and b) treated by SW BMPs which are owned and operated by MDOT SHA. MDOT SHA's jurisdiction is linear in nature, which means that it not only crosses many other jurisdictions and watersheds, but also has many changes to drainage and flow patterns. Thus, MDOT SHA SW BMPs frequently treat offsite impervious areas, and in turn, the SW BMPs from adjacent jurisdictions frequently treat MDOT SHA roadways.

MDOT SHA is actively working to establish procedures to determine the off-site impervious area treated by its SW BMPs and its impervious areas treated by SW BMPs from adjacent jurisdictions. For the 2016/Revised 2017 baseline, MDOT SHA will only take credit for its own impervious area.

2 STORMWATER MANAGEMENT DESIGN HISTORY

2.1 Definition of Eras

MDE (2014) describes an approach for determining water quality treatment called Stormwater Management by Era. The approach is based on four distinct regulatory eras where stormwater management requirements in Maryland correlate with a certain level of SW BMP performance. These eras are as follows:

- Prior to 1985: Stormwater management regulations came into effect after this era. Any development constructed in this time period is most likely untreated, unless retrofitted.
- Between 1985 and 2002: SW BMPs implemented during this time addressed quantity control; however, individual SW BMP design criteria can be used to verify whether water quality is provided.
- Between 2002 and 2010: The Manual was fully implemented during this era.
- Post-2010; Environmental site design (ESD) to the MEP is required. Any development project that complied with State regulations in the third and fourth eras is considered to have acceptable water quality treatment.

MDOT SHA's SW BMP database pre-dated MDE (2014), so the types and descriptions of SW BMPs in the database are not an exact match with the ones defined in MDE (2009) or MDE (2014). To better define SW BMP types and eras, an effort was undertaken to cross-reference the MDOT SHA SW BMP designations with the MDE (2014) classifications. The results are shown in the table below.

Table 3: MDOT SHA SW BMPs by Era

SHA NPDES D_Designation	SHA NPDES D_Desg_Sub	Description	MDE 2014	Before 1985	1985 - 2002	2002 - 2010	After 2010
ESD	A-1	Green Roof - Extensive	AGRE	--	--	--	x
ESD	A-1	Green Roof - Intensive	AGRI	--	--	--	x

Table 3: MDOT SHA SW BMPs by Era

SHA NPDES D_Designation	SHA NPDES D_Desg_Sub	Description	MDE 2014	Before 1985	1985 - 2002	2002 - 2010	After 2010
ESD	A-2	Permeable Pavement	APRP	--	--	--	x
ESD	A-3	Reinforced Turf	ARTF	--	--	--	x
ESD	N-2	Disconnection of Non-Rooftop Runoff	NDNR	--	--	--	x
ESD	N-1	Disconnection of Rooftop Runoff	NDRR	--	--	--	x
ESD	N-3	Sheetflow to Conservation Areas	NSCA	--	--	--	x
ESD	M-9	Enhanced Filters	MENF	--	--	--	x
ESD	M-4	Infiltration Berm	MIBR	--	--	--	x
ESD	M-5	Dry Well	MIDW	--	--	--	x
ESD	M-3	Landscape Infiltration	MILS	--	--	--	x
ESD	M-6	Micro-Bioretention	MMBR	--	--	--	x
ESD	M-7	Rain Gardens	MRNG	--	--	--	x
ESD	M-1	Rainwater Harvesting	MRWH	--	--	--	x
ESD	M-2	Submerged Gravel Wetland	MSGW	--	--	--	x
ESD	M-8B	Bio-Swale	MSWB	--	--	--	x
ESD	M-8A	Grass Swale	MSWG	--	--	--	x
ESD	M-8C	Wet Swale	MSWW	--	--	--	x
Pond	MEXDET	Micropool ED pond	PMED	--	--	x	x
Pond	POCKPOND	Pocket pond	PPKT	--	--	x	x
Pond	WEXDET	Wet ED pond	PWED	--	x	x	x
Pond	RETPOND	Wet pond	PWET	--	x	x	x
Wetland	EDSHWTLD	ED shallow wetland	WEDW	--	--	x	x
Wetland	POCKWTLD	Pocket wetland	WPKT	--	--	x	x
Wetland	WTLDSYS	Pond/wetland system	WPWS	--	--	x	x
Wetland	SHALMSH	Shallow marsh	WSHW	--	--	x	x
Infiltration	INFBASN	Infiltration basin	IBAS	--	x	x	x
Infiltration	INFTREN	Infiltration trench	ITRN	--	x	x	x
Filtering	BIORET	Bioretention	FBIO	--	--	x	x
Filtering	ORGFLT	Organic filter	FORG	--	--	x	x
Filtering	OTHER FILTERING	Other filtering	FPER	--	--	x	x
Filtering	OTHER FILTERING	Perimeter (sand) filter	FPER	--	--	x	x
Filtering	SSNDFLT	Surface sand filter	FSND	--	--	x	x
Filtering	UGSFLT	Underground sand filter	FUND	--	--	x	x
Open Channel	DRYSWL	Dry swale	ODSW	--	--	x	x
Open Channel	WETSWL	Wet swale	OWSW	--	--	x	x
Pond	DEXDET	Dry ED pond	XDED	--	x	--	--
Pond	DETPOND	Dry pond	XDPD	--	x	--	--
Other	OILGRIT	Oil grit separator	XOGS	--	x	--	--
Other	OTHER	Other	XOTH	--	x	--	--

Table 3: MDOT SHA SW BMPs by Era

SHA NPDES D_Designation	SHA NPDES D_Desg_Sub	Description	MDE 2014	Before 1985	1985 - 2002	2002 - 2010	After 2010
Pond	OTHER POND	Other pond	XOTH	--	x	--	--
Other	STREST	Stream Restoration	STRE	--	x	x	x
Infiltration	OTHER INFILTRATION	Other infiltration	--	--	x	--	x
Open Channel	OTHER OCS	Other open channel system	--	--	x	--	x
Other	GRSCHCRD	Grass Channel Credit	--	--	--	x	--
Other	GRSWL	Grass Swale	--	--	x	--	--
Other	PORPAU	Porous Pavement	--	--	x	--	--
Other	UGD	Underground detention	--	--	x	--	--
Wetland	OTHER WETLAND	Other wetland	--	--	--	x	x

For this purpose, MDOT SHA has defined the specific dates for the four eras based on documentation of the design guidelines which were in force at the time:

Table 4: Eras based on MDE State/Federal SW Design Guidance

Era	From	To
Before 1985	--	12/31/1984
1985 - 2002	1/1/1985	12/31/2001
2002 - 2010	1/1/2002	12/31/2009
2010 - Present	1/1/2010	Present

2.2 Design Guidance Documents

Beginning in the 1980s, MDE issued a series of documents describing design methods and criteria for stormwater management. Some of these early guidelines addressed design for water quality control prior to MDE (2000). These were used during the research phase of the SW BMP documentation to determine if older SW BMPs could meet water quality design standards. Other more recent documents were used as reference where design criteria were uncertain. The original documents are included as Appendix A. The design guidelines define the stormwater eras described in Section 3.1.

State and Federal Guidelines

- Stormwater Management Guidelines for State and Federal Projects (July 1987, Revised August 1996)
- Stormwater Management Guidelines for State and Federal Projects (July 2001)
- Stormwater Management Guidelines for State and Federal Projects (April 15, 2010)

BMP Design Guidelines

- Design Procedures for Stormwater Management Extended Detention Structures (July 1987)
- Guidelines for Constructing Wetland Stormwater Basins (March, 1987)
- Feasibility & Design of Wet Ponds to Achieve Water Quality Control (July 1986)
- Surface storage Volume Tables for Bioretention and Bioswales (October, 2012)
- Clarification on Grass swale design for State and Federal Projects – Draft (April, 2012)
- Grass Channel Credit for Parking Lots (2003, updated March, 2007)
- Grass Channel Credit (2010)
- Best Available Guidance from MDE on ESD to the MEP (February 2010)
- Best Available Guidance from MDE on ESD to the MEP as well as ESC (November 2011)
- Water Quality Inlets (Oil/Grit Separators) (January, 1991)
- Standards & Specifications for Infiltration Practices (1984)
- Half Acre Rule (July 2002)
- Storm Filter Memo (October 2004)
- Clarification on Submerged Gravel Wetlands (June 2014)
- Filterra Bioretention System Memo (February, 2013)

Guidelines for WQ Treatment

- SHA-MDE Stormwater Management Process Agreements and Interpretations (April 2003)
- SWM Meeting Conclusions (April 6, 2000 and April 19, 2000)
- Water Quality Volume How Much? (January 2002)
- Water Quality Volume (March 2003)
- Water Quality Volume (WQv) and Impervious Area Requiring Treatment (IART) (January 2005)
- Water Quality Banking Agreement (June, 1992)
- Water Quality Banking Agreement (August 2003)
- Water Quality Banking Agreement (July 2002)

3 BMP RESEARCH ELEMENTS

3.1 Workflow and Tasks

Sections 6, 7, and 8 provide flowcharts and describe the procedure for the research, including both office research and field investigation.

Section 6 describes the first step of identifying the SW BMP and locating record documents.

Section 7 shows the procedure if source documents were available and the SW BMP could be researched in the office.

Section 8 shows the procedure if ID numbers or records could not be found and the SW BMP had to be investigated in the field.

3.2 Source Documents

Several sources were used to determine RS. They were researched in order of priority based on the quality of the data, as follows. The comment field was used to describe the source of the RS calculations.

- As-Built Plans (primary option): As-builts provide field-run survey to confirm SW BMP dimensions as constructed, which can be used to calculate RS. This source is the most accurate determination of the SW BMP; however, as-built data were frequently not available.

- Stormwater Management Report (second option): For SW BMPs designed after 2000, the treatment volume presented in the SWM report was used. This report provides reliable documentation of the SW BMP as it was designed, with volumes and flow rates. However, changes during construction are not captured in this source.

- Design Plans (third option): If no as-builts or SWM report could be found, the surface and subsurface SW BMP storage volume was calculated using design plans. If a plan and a report were available and they disagreed, then the plan data was used to determine the volume since the facility was constructed using the plans. Plans, like reports, do not capture field changes.

- No information (fourth option): Perform a field investigation. If no report or plans were available, site visits were conducted to obtain the information necessary to calculate RS.

4 CALCULATIONS

4.1 Impervious Area Credit

The goal of the work is to establish the credit for impervious area treated for each existing BMP. The following parameters were used:

Table 5: Establishing Impervious Acre WQ Treatment

Variable	Description	Units	Source	Where
RS	Runoff storage volume	CF	Calculated or measured from office or field research	
R_v	Runoff coefficient	IN	$R_v = 0.05 + 0.009I$	I = percent impervious
P_E	Amount of rainfall treated	IN	$P_e = \frac{12\ RS}{Rv\ DA}$	DA = drainage area (SF)
Q	Amount of runoff treated	IN	$Q = \frac{12\ RS}{IA}$	IA = Impervious area (SF)

Table 5: Establishing Impervious Acre WQ Treatment

Variable	Description	Units	Source	Where
IAC	Impervious area credit	AC	$If\ P_e \leq 1.0; then \quad IAC = (P_e IA)/43{,}560$ $If\ 2.6 \geq P_e > 1.0; then \quad IAC = \frac{IA}{43{,}560}\left[1 + 0.1\left(\frac{P_e - 1}{0.4}\right)\right]$ $If\ P_e > 2.6; then \quad IAC = 1.4IA/43{,}560$	IAC varies by P_E depth

4.2 RS Definition by Era

RS volume varied depending on the era that the SW BMP was designed and the type of SW BMP. The table below shows how RS was derived. Methods for designing treatment volumes for Wet Storage and Infiltration were relatively constant regardless of the design era, but both Filtration and Grass Swale BMPs were more variable. Spreadsheets used for the calculations are shown in Appendix B – Section 1. The codes in parentheses refer to specific methods for each type of SW BMP, described below.

Table 6: Calculations by BMP Type

<table>
<tr><th>TYPE</th><th>Before 1985</th><th>1985 - 2002</th><th>2002 - 2010</th><th>2010 - 2013</th><th>After 2013</th></tr>
<tr><td>Dry Storage</td><td></td><td colspan="4">Flag for Retrofit (D1).</td></tr>
<tr><td>Wet Storage</td><td colspan="5"></td></tr>
<tr><td>Ponds</td><td></td><td colspan="4">Volume of Wet Storage (W1).</td></tr>
<tr><td>ED Ponds</td><td></td><td colspan="4">W1 + ED volume (W2).</td></tr>
<tr><td>ED Micro pools</td><td></td><td colspan="4">W1 + greater(ED volume, dry WQv) (W3).</td></tr>
<tr><td>Wetlands</td><td></td><td colspan="4">W1 + greater(ED volume, dry WQv) (W3).</td></tr>
<tr><td>Infiltration</td><td></td><td colspan="4">Appendix D-13 (F=0.52, T=2hours) (I1)
Assume pre-treatment volume =0 if unknown (I2).</td></tr>
<tr><td>Filtration</td><td></td><td colspan="3">Surface and subsurface storage (F2)</td><td>Surface storage (F1)</td></tr>
<tr><td rowspan="2">Grass Swales</td><td rowspan="2"></td><td colspan="2">Use drainage area, impervious area and P_E value to back calculate RS (G2).</td><td rowspan="2">Use P_E if found; otherwise use 1" as default. (G3).</td><td rowspan="2">Use Planning equation 5.3 (G1).</td></tr>
<tr><td>Volume includes storage captured by check dams (G4)</td><td></td></tr>
</table>

<u>Dry Ponds</u>

D1. After confirming the type of the SW BMP is a dry pond or one that does not provide any water quality treatment, it was flagged for retrofit and presented to the retrofit team as a potential site. No RS was determined.

Wet Ponds and Wetlands

W1. For wet ponds, RS will be the volume of wet storage provided.

W2. For Wet ED ponds; RS is the sum of the ED volume and the wet storage volume.

W3. Since the dry volume portion of an ED micro pool can be used for both the ED volume and the dry WQ_v draw down volume (50% of the WQ_v in Class I and II waters, and 66% of the WQ_v in Class III and IV waters) the RS is the wet volume plus the ED volume or the dry WQ_v draw down volume whichever is greater. It is anticipated that the ED volume will always be greater than the dry WQ_v draw down volume so in most cases the RS will be the wet volume plus the ED volume.

Infiltration:

I1. Infiltration trenches and infiltration basins RS is calculated in accordance with Appendix D-13 "Method for Designing Infiltration Structures" of MDE (2009). Infiltration trench volume includes the media thickness as measured from lowest ditch invert to the bottom of the trench. If the pretreatment volume is unknown, it is assumed to be zero.

Filtration Practices:

F1. Recent projects have been designed without allowing subsurface storage to be credited toward treatment volume. Although the change was made when MDE issued the Surface Storage Tables on October 4th, 2012, some projects were still approved after that date since they were under review at the time of issuance. In general, the subsurface credit was phased out by 2013.

F2. For older filtration practices (prior to 2013) where treatment was calculated using subsurface void volume, it was included because it because that was the accepted practice at the time.

Grass Swales:

G1. MDE issued a memo requiring the use of the planning equation 5.3 for designing grass swales on April 23, 2012 but some projects were still approved after that date since they were under review at the time of issuance, so generally the planning equation 5.3 was fully instituted by 2013.

G2. For older grass swales (prior to 2013), the drainage area, impervious area, and the P_E value will be used to back calculate the treatment volume. Grass swales under the old criteria were designed by checking the velocity associated with one inch of rainfall. For these facilities, the volume was back-calculated assuming that P_E equals one inch, with the GIS-derived impervious and drainage areas.

G3. For M8 chapter 5 swales, if the SWM report gives enough information about the Pe, that value was used to calculate RS. Otherwise P_E = 1 inch was assumed and no additional computations were performed. The RS volume provided was back-calculated.

G4. Some grass swales that pre-date the 2000 Stormwater Manual were designed as grass swales with check dams (refer to Section 3.6 of the "Standard and Specifications for Infiltration Practices" for the design criteria).

5 SOURCE DOCUMENT RESEARCH

This step involves obtaining SW BMP records from the geodatabase, then using the information in the record for each SW BMP to find or cross-reference the source documents needed to determine RS. Two ID numbers were used: the MDE number, which links to permit submittals in SHA's records, or the contract number, which links to design drawings, reports, or as-built drawings.

The procedure to locate source documents was relatively simple when there was an MDE number. In this case, the MDE database was used to retrieve the contract number.

If the MDE number was not available, the MDE mapping interface was used to identify the SW BMP spatially to recover the associated MDE number and/or contract number.

If the contract number could not be found in the MDE database, then land records were checked online for plat references to retrieve the contract number from the plat.

In the event neither ID leads to any source documents which can be researched, the only remaining step is field investigation.

Once the source documents are located and identified, the database entry for the SW BMP is reviewed to determine if the type has been entered correctly. It should match the types of SW BMPs designed during the era of the plan date.

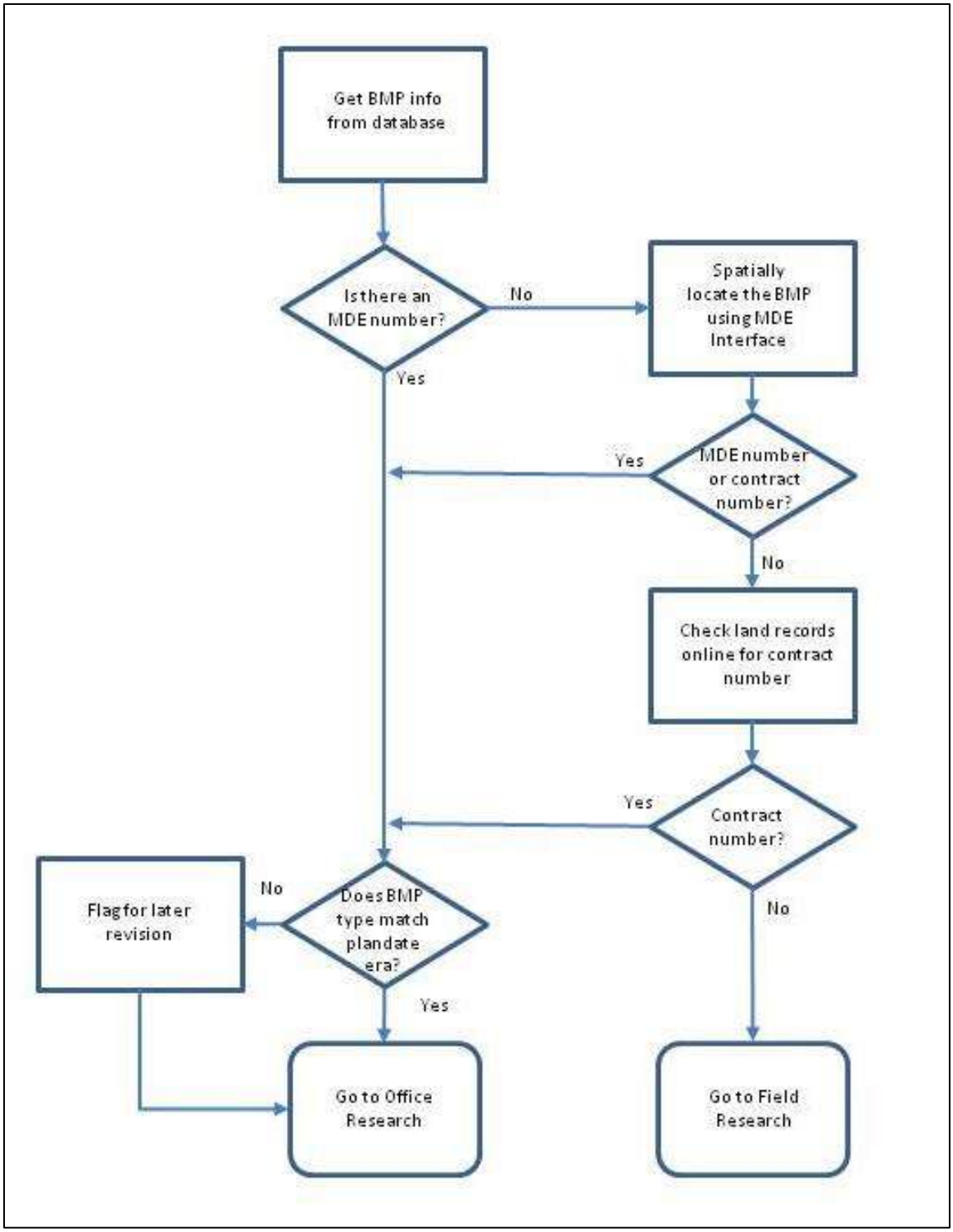

Figure 1: Source Document Research Flow Chart

6 OFFICE RESEARCH

Calculations of RS based on office research depended on the type of source documents that were available. RS data and calculations varied depending on both the type of SW BMP and available documents, as follows:

6.1 As-Built and Design Plans

Wet Ponds and Wetlands

Wet storage was calculated using as-built contours or design contours for the basin. Volumes at specific stage elevations were interpolated using the areas of the higher and lower integer contour rather that interpolating between the volume at those same higher and lower stage elevations because it was more accurate.

Wet ED Ponds

For wet ED ponds, the calculation was made for the sum of wet storage and ED volume, using the same procedure as wet ponds.

ED Micropools

For ED micropools, the calculation was made for the wet storage, using dimensions of the water surface area, height of the weir outlet, and side slopes. ED volume was calculated similarly to ED wet pond volume.

Infiltration Trench

The RS volume of infiltration trenches and infiltration basins was calculated in accordance with Appendix D-13 "Method for Designing Infiltration Structures" of MDE (2009) using an f=0.52inches/hour and a T=2 hours. The volume of an infiltration trench was taken to the void space at the minimum depth plus what can infiltrate out the bottom in 2 hours at the rate of 0.52 inches per hour. The void space was taken to be 40%. There were a few instances when check dams were used to created shallow ponding over the infiltration trench. In these cases, the surface volume was added to the void volume in the trench beneath this shallow pool. In both cases, if the pretreatment volume was unknown it was assumed to be zero.

Infiltration Basin

The volume of an infiltration basin was taken to be the surface storage plus what can infiltrate out the bottom in 2 hours at the rate of 0.52 inches per hour. The surface storage was calculated using stage storage curves using integer value contours when no record calculations were available. Volumes at specific stage elevations were interpolated using the areas of the higher and lower integer contour rather that interpolating between the volume at those same higher and lower stage elevations because it was more accurate.

Filtration

MDE issued the Surface Storage Tables on October 4th, 2012, and since that time, void storage is no longer calculated as part of the available RS. Instead the Surface Storage Tables give the percent of the RS that is stored on the surface, the rest is either in the voids or it is the leading leg of the hydrograph that has already passed through the media. When using the surface storage tables the volume is:

$$RS = \frac{surface\ storage}{\%\ of\ RS\ on\ surface\ from\ Surface\ Storage\ Table}$$

For older filtration practices where treatment was calculated using 40% void volume, it was included it because that was the accepted practice at the time. Under this older approach the volume was calculated as follows, where live storage is the void volume plus the surface storage:

$$RS = \frac{Live\ storage}{0.75}$$

Grass Swales

Grass swale calculations and RS data are based on the design era more than any other types of BMPs:

- Before 2000:
  - If a grass swale was built prior to 2000 and had no check dams, it was assumed to provide no treatment.
  - If the swale was designed with check dams, the RS is the storage volume behind the check dam plus the volume that infiltrates through the bottom in two hours. The infiltration volume was ignored since there was no required infiltration rate.
- 2000 to 2012: Grass swales prior to 2012 were designed by checking the velocity associated with 1" of rainfall rather than designing to a volume. For these swales, P_E was assumed equal to 1" and the drainage area, impervious area, and P_E was used to calculate R_v and back into the treatment volume:

$$RS = \frac{R_v\ DA}{12}$$

- After 2013: MDE issued a memo requiring the use of planning equation 5.3 for designing grass swales on April 23, 2012.

6.2 SWM Reports

For all types of SW BMPs, when SWM reports were available and determined to be accurate, RS was recorded as the designed treatment volume of the SW BMP, either WQ_v or ESD_v. Variations for specific types of SW BMP are discussed below.

Filtration

For dry swales, if the original design included subsurface storage and SWM reports are available, then subsurface storage volume was counted as part of the total treatment volume.

Grass Swales

When a WQ_v was provided in the report and the GIS drainage area was larger than the one in the report, the WQ_v was prorated (DA in report)/(GIS DA). Using this reduced P_E the WQ_v was calculated using the GIS DA. When the drainage area was given in the report and that drainage area was greater than the GIS drainage area, the P_E was 1.0.

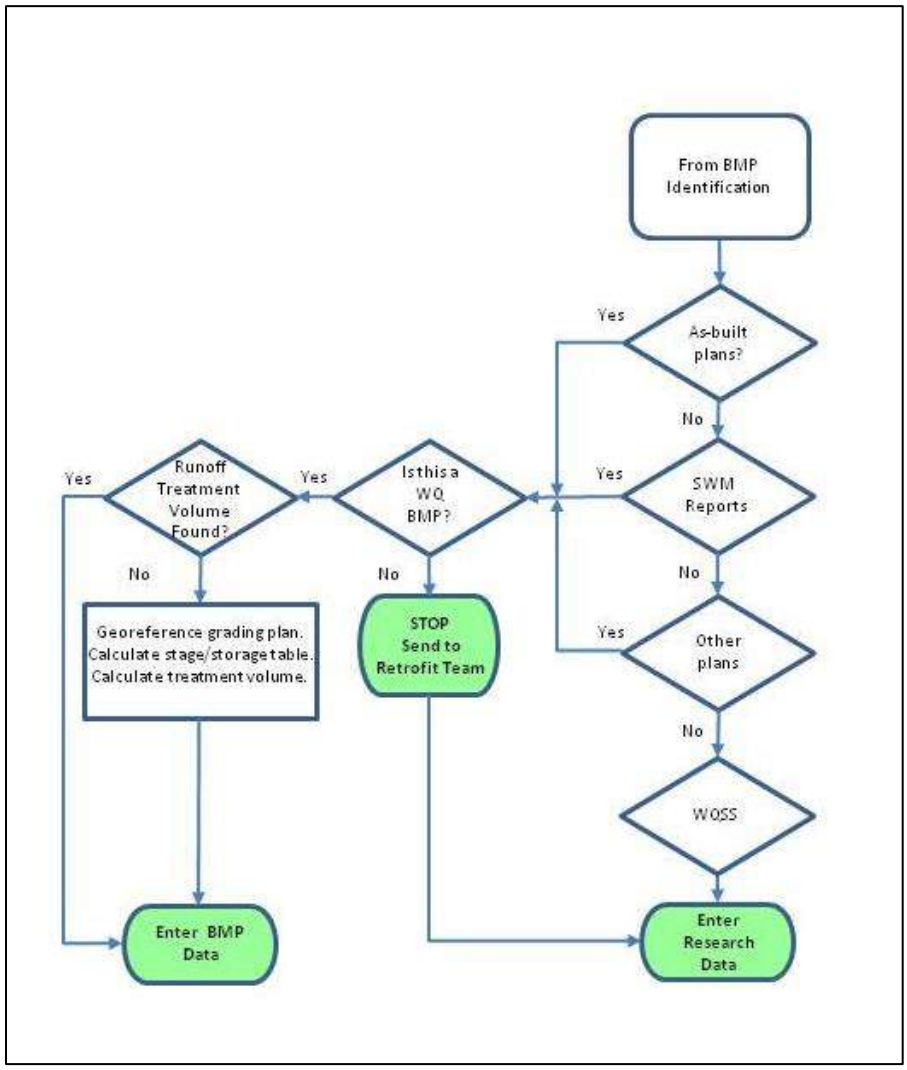

Figure 2: Office Research Flow Chart

7 FIELD INVESTIGATION

Field research was performed in cases where research into source documents showed that the sw BMPs had insufficient or no design documentation such as SWM reports or design/as-built plans. The goal of the field work was to provide sufficient information to calculate the Runoff Storage Volume (RS), through field measurements, or a combination of researched documentation and field measurements.

At the conclusion of the source document research, SW BMPs were classified into three groups:

- Group A – Complete, no measurements needed;
- Group B – Need some measurements, quick field check;
- Group C – Have nothing, need measurement of all pertinent items

In general, facilities visited by field personnel for the purpose of these guidelines were given the designation of Group B or C.

Once field measurements were completed, calculations of RS and P_E were made in the same manner as SW BMPs which were researched in the office.

General measurements and observations were recorded for all SW BMPs:

- Measurements were confirmed on any critical control points of the facility (e.g. outlet control structure/weir, volume/depth) and documented.
- The presence of water quality SW BMPs was documented and measured. This may include: forebay, grass channel, bioretention, wet pool, extended detention wet pool, infiltration, or dry storage.
- For projects constructed prior to 2002, the field team judged whether the intent of the original design was to address water quality and if so, it was documented.
- Field teams confirmed drainage area and facility footprints with the GIS data provided.

Specific field measurement requirements were laid out for each type of SW BMPs. In general, the following items were measured in the field for Group C SW BMPs:

<u>Wet Ponds and Wetlands</u>

When field measurements were required, aerials were used to get the footprint. Depths were measured at random locations. Using these depths and area, a volume was calculated. Side slopes were also measured and taken into consideration. Riser openings, emergency spillway dimensions, and outfall pipes dimensions were measured. These dimensions included relative elevations.

<u>Infiltration</u>

When field measurements were required for infiltration trenches the length and width were measured. The observation well was used to measure depth at the well. A lock level was used to

calculate depth at low end of trench. If there was no observation well a depth of four feet was assumed. When field measurements were required for infiltration basins, aerials were used to get the foot print. Depths were measured at random locations. Using these depths and area a volume was calculated. Side slopes were also measured and taken into consideration.

Filtration

When field measurements were required for polygon shaped filtration practices (sand filter, bioretention, microbioretention), the footprint was measured from aerials. A post hole digger was used to measure media thickness. The surface ponding depth was measured as the vertical distance between lowest overflow point and the mean surface elevation. For linear shaped filtration practices (bioswale, dry swale, wet swale), the slope was determined using a lock level to get fall and tape to get distance. A_f was measured in field as length times width. Maximum ponding depth measured in field.

Grass Swales

When field measurements were required for grass swales, the slope determined using a lock level to get fall and tape to get distance. The bottom width was measured in field. The side slope was measured in the field with a digital level.

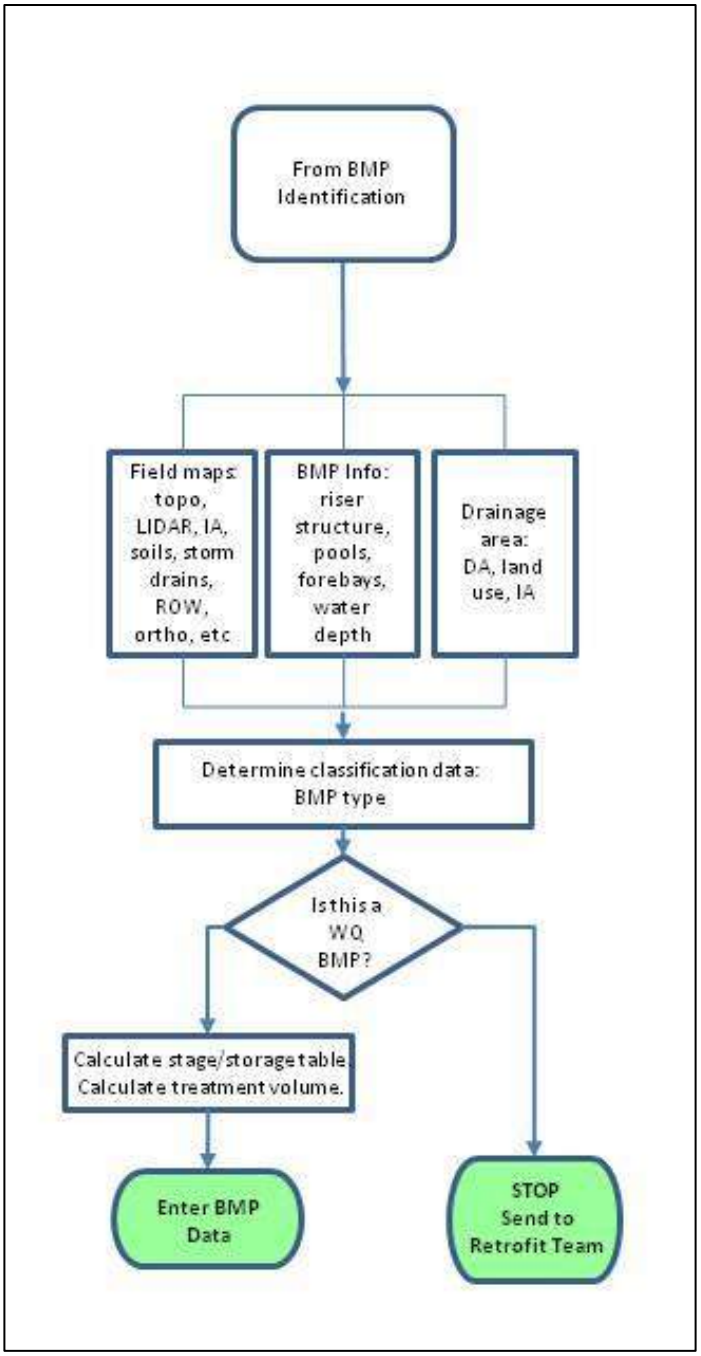

Figure 3: Field Investigation Flow Chart

8 EXAMPLES

8.1 RS Calculation Spreadsheets

To ensure consistent calculations for RS, fifteen spreadsheet templates were prepared for the different types of SW BMPs, as follows:

- Wet Storage: Wet Pond, Wet ED Pond, ED Micropool
- Infiltration: Infiltration Basin, Infiltration Trench, Infiltration Trench with Check Dam
- Filtration: Bioretention, Microbioretention, Surface Sand Filter
- Swales: Bioswale, Dry Swale with Check Dam, Grass Swale, Grass Swale with Check Dam, Velocity Check for Grass Swale, Wet Swale

Examples of each spreadsheet are shown in Appendix B – Section 1. The spreadsheets were used for the computation of the RS only, and the impervious area credit indicators on the spreadsheets were for reference only.

8.2 Signoff Sheets

As each SW BMP was researched, the results were reviewed by a licensed Water Resources Engineer, with the approval documented on a signoff sheet for three different types of facilities.

- Grass swales
- Dry detention
- Water quality facilities with calculated RS volume

Examples are shown in Appendix B – Section 2.

8.3 Field Report

Each SW BMP researched in the field was documented with an individual Field Report. The report described the location and any plans or office records that were used as part of the investigation. A field checklist was used to record measurements such as shape, length, width, depth, side slopes, and control structure features. A field sketch was also made. GIS maps of the SW BMP were attached along with photos taken during the investigation. A sample field report is shown in Appendix B – Section 3.

8.4 P_E Calculator

The calculation of P_E and IAC is performed within ArcGIS and Microsoft Excel. The method details the steps the user will perform to define and pre-process source layers for each SW BMP, including drainage area, impervious area, ROW boundary, and SWM facility, along with the formulas for computing the associated treatment variables. Documentation of variables and calculations for both P_E and IAC is provided in Appendix B – Section 4.

8.5 Full Documentation

Full documentation for each SW BMP researched includes the information described above, assembled as a single PDF document:

- Signoff sheet certifying RS volume with SWM facility ID
- Data used to calculate P_E, Q, and impervious area treated for credit
- GIS map showing footprint of SWM facility
- Excel spreadsheet calculations

- Annotated source documents (plan sheets, SWM report)
- Field map of SW BMP drainage area delineation
- Examples of each spreadsheet are shown in Appendix B – Section 1

An example of the full documentation for a SW BMP is shown in Appendix B – Section 5.

9 REFERENCES

Maryland Department of the Environment (MDE, 2009). Maryland Stormwater Design Manual, Volumes I & II. MDE, Baltimore MD, 2000, Updated 2009.

Maryland Department of the Environment (MDE, 2014). *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated, Guidance for National Pollutant Discharge Elimination System Stormwater Permits*. MDE, Baltimore, MD, August 2014. Retrieved from http://www.mde.state.md.us/programs/Water/StormwaterManagementProgram/Documents/NPDES%20MS4%20Guidance%20August%2018%202014.pdf

Maryland Department of the Environment (MDE, 2015). *NPDES MS4 Phase I Permit for Maryland State Highway Administration*. MDE, Baltimore, MD, October 9, 2015. Retrieved from http://www.mde.state.md.us/programs/Water/StormwaterManagementProgram/SedimentandStormwaterHome/Documents/SHA%20Final%20Permit%20complete%2010_9_2015.pdf

Attachment A

Historical SW BMP Design Documents

MARYLAND DEPARTMENT OF TRANSPORTATION™

STATE HIGHWAY ADMINISTRATION

Stormwater Management Guidelines for State and Federal Projects (7/1/87)

Stormwater Management Guidelines
for
State and Federal Projects

issued by

Maryland Department of the Environment
Stormwater Management Administration
TEL: (301) ~~974-2224~~ 631-3543

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Table of Contents

		Page
1.0	Purpose and Authority	1
2.0	Applicability	2
	2.1 Scope	2
	2.2 Exemptions	2
	2.3 Waivers	2
	2.4 Variances	3
3.0	Stormwater Management Plans	4
	3.1 Contents of the Stormwater Management Plan	4
	3.2 Format of the Stormwater Management Report and Plan	5
4.0	Stormwater Management Criteria	8
	4.1 Minimum Control Requirements	8
	4.2 Stormwater Management Measures	8
	4.3 Specific Design Criteria	9

STORMWATER MANAGEMENT GUIDELINES FOR STATE AND FEDERAL PROJECTS

1.0 PURPOSE AND AUTHORITY

The purpose of these Guidelines is to protect, maintain, and enhance the public health, safety, and general welfare by establishing minimum requirements and procedures to control the adverse impacts associated with increased stormwater runoff. Proper management of stormwater runoff will minimize damage to public and private property, reduce the effects of development on land and stream channel erosion, assist in the attainment and maintenance of water quality standards, reduce local flooding, and maintain after development, as nearly as possible, the pre-development runoff characteristics.

The provisions of these Guidelines are pursuant to 4-205 of the Environment Article, Annotated Code of Maryland, 1983 replacement volume and the Stormwater Management Regulations, COMAR 08.05.05.01 thru 08.05.05.10.

It is intended that these Guidelines provide the necessary supplemental information to the Stormwater Management Regulations for submittal of projects to the Administration for review and approval by State and federal agencies. These Guidelines shall not affect the validity of any portion of either the Environment Article or Stormwater Management Regulations in any manner.

2.0 APPLICABILITY

2.1 Scope.

No State or federal agency shall develop any land without having provided appropriate stormwater management measures that control or manage runoff, except as provided within this section.

2.2 Exemptions.

Developments that do not disturb over 5,000 square feet of total land area are exempt from the provisions of these Guidelines and the requirements of providing stormwater management.

2.3 Waivers.

The Administration may grant a waiver of the stormwater management requirements for State and federal projects provided that a Stormwater Management Waiver Application is submitted by the applicant. The Stormwater Management Waiver Application shall specifically state the item of this section for which the project is eligible. The applicant shall provide sufficient descriptions, drawings, and other information that is necessary to evaluate the proposed project and confirm the waiver request. A separate Stormwater Management Waiver Application may be required in accordance with the provisions of this section if there are subsequent additions, extensions, or modifications to a project receiving a waiver. Any waiver shall be valid only after written notice of granting such waiver is received from the Administration. A copy of the Stormwater Management Waiver Application shall be found on page 2A of these Guidelines.

(a) A project is eligible for a waiver of stormwater management for both quantitative and qualitative control if the applicant can demonstrate to the Administration that:

(i) the proposed project generates a 2-year post-development peak discharge rate of less than five (5) cubic feet per second and the increases in post-development peak discharge rate cannot be managed according to the Maryland Standards and Specifications for Infiltration Practices; or

(ii) the proposed project shall return the disturbed area to a pre-development runoff condition at the conclusion of the project (i.e., pipeline projects, bridge deck replacements, resurfacing of existing roadways, certain underground projects); or

(iii) the proposed project consists of a linear disturbance of less than six (6) feet in width, (i.e., bike paths, sidewalks, shoulder work on highways, etc.).

(b) A project is eligible for a waiver of stormwater management for quantitative control if the applicant can conclusively demonstrate to the Administration that the first one-half inch of runoff shall be managed according to the Maryland Standards and Specifications for Infiltration Practices promulgated by the Administration.

Additionally, the applicant shall demonstrate that:

(i) the proposed project shall not generate an increase in the 2-year post-development peak discharge rate of more than ten (10) percent above the 2-year pre-development peak discharge rate and will not cause an adverse impact on the receiving wetland, watercourse, or waterbody; or

(ii) a site is completely surrounded by existing developed areas which are served by an existing network of public storm drainage systems of adequate capacity to accommodate the runoff from the additional development; or

(iii) provisions for a stable conveyance system to tidewater by either a closed drainage system or by open channel flow are provided.

2.4 Variances.

The Administration may grant a written variance from any requirement of Section 4.0 Stormwater Management Criteria of these Guidelines if there are exceptional circumstances applicable to the site such that strict adherence to the provisions of these Guidelines will result in unnecessary hardship and not fulfill the intent of these Guidelines. A written request for variance shall be provided to the Administration and shall state the specific variances sought and reasons for their granting. The Administration shall not grant a variance unless and until sufficient specific reasons justifying the variance are provided.

3.0 STORMWATER MANAGEMENT PLANS

3.1 Contents of the Stormwater Management Plan.

The State or federal agency is responsible for submitting a stormwater management plan which meets the design requirements provided by these Guidelines. The plan shall include sufficient information to evaluate the environmental characteristics of the affected areas, the potential impacts of the proposed development on water resources, and the effectiveness and acceptability of measures proposed for managing stormwater runoff. The State or federal agency shall certify on the drawings that all clearing, grading, drainage, construction, and development shall be conducted in strict accordance with the plan. The minimum information submitted for support of a stormwater management plan shall be as follows:

(a) Site characteristics:

(1) Topographic survey showing existing and proposed drainage areas, including areas necessary to determine downstream analysis for the proposed stormwater management facility.

(2) Soils investigation, including borings, for construction of small ponds and infiltration practices.

(3) Description of all watercourses, impoundments, and wetlands on or adjacent to the site or into which stormwater flows.

(4) Delineation of 100-year floodplains, if applicable. Projects with waterways which require Waterway Construction Permits from the Administration shall delineate the floodplain as determined by the hydrologic/hydraulic analysis performed for the permit application. The 100-year floodplain may be shown for other waterways for illustrative purposes.

(b) Computations:

(1) Hydrology;

(2) Hydraulic; and

(3) Structural.

In addition to the information listed above stormwater management design plans shall include:

(c) Stormwater management plans:

(1) Vicinity map.

(2) Drainage area map showing the watershed boundaries, drainage areas, and stormwater flow paths.

(3) Proposed improvements including location of buildings or other structures, impervious surfaces, and storm drainage facilities, if applicable.

(4) Location of utilities.

(5) Structural details for all components of the proposed drainage systems and stormwater management facilities.

(6) Timing schedules and sequence of development clearing, including stripping, rough grading, construction, final grading, and vegetative stabilization.

(7) Maintenance schedule.

(8) Notes on drawings specifying materials to be used.

(9) Construction specifications.

(10) Location of easements.

(d) Estimate of stormwater management construction cost. For projects which require competitive bidding it is not required to submit an estimate of the stormwater management construction cost.

(e) Other information as required.

3.2 Format of the Stormwater Management Report and Plan.

The format of stormwater management reports and plans submitted to the Administration shall be as follows:

(a) Report

The stormwater management report shall be on 8 1/2" x 11" paper. The report shall be typed; however, certain computational sheets may be handwritten. The report shall be bound in an acceptable hard cover binder. Any maps, diagrams, or figures (except computer printouts) which are larger than 8 1/2" x 11" shall be folded to a size of 8 1/2" x 11" or smaller and shall be placed in a pocket within the report binder. Fold-outs or bound maps, diagrams, or figures are not acceptable unless the document is 8 1/2" x 11". All maps, diagrams, or figures shall be clearly labled.

~~The report shall be submitted in a good technical report form.~~ At a minimum each report shall contain the following:

(1) Title on outside of binder.

(2) Title Sheet.

(3) Table of Contents.

(4) List of Figures or Tables.

(5) Body of Report.

i. Introduction

ii. Methodologies Used

iii. Analysis

iv. Summary

v. Conclusions

(6) Appendices

The Appendices shall include all the background information used in the stormwater management analysis. The background information shall be sufficient to facilitate a straightforward review and will typically include: drainage area maps, soil type maps, land use maps, drainage area computations, runoff curve number computations, time of concentration computations, elevation-storage computations, TR-55 worksheets, schematic diagrams, any and all hydraulic computations, and any and all structural computations. All computer input computations shall be included as part of the Appendices. Schematic diagrams showing reach lengths, curve numbers, drainage areas and structure locations, shall be included for all computer printouts and shall be included as part of the Appendices. The Appendices shall be bound as part of the report.

(b) Computer Printouts

Computer printouts shall be original computer printouts or clear, legible, and comlete photostatic copies or reduced size copies. Original computer printouts shall be bound in a data processing binder. The data processing binder shall be of a design which permits the binder to be placed in a file hanger. Reduced photostatic copies shall be 8 1/2" x 11" in size and bound with the Appendices or in an additional bound volume. All computer printouts shall be clearly labeled throughout the printout. The data processing binder or additional bound volume shall be labeled with a complete title block including the file number of the Administration.

The computer printouts shall include all input data, output data, hydrographs at critical sections where appropriate, and summary output.

(c) Plans, Special Provisions, and other Contract Documents

Plans, special provisions, and other contract documents shall be submitted in the same manner as used for advertisement purposes. The plans shall include all of the details necessary to construct the stormwater management structure. In the event the advertised plans do not contain the minimum information for stormwater management plans as outlined under section 3.1, Contents of the Stormwater

Management Plans, it is acceptable to submit the additional information as part of the report and in compliance with Section 3.2(a).

(d) File Numbers

All Reports, Computer Printouts, Plans, Special Provisions, and other Contract Documents shall be accompanied by a transmittal letter. The transmittal letter shall list the contents of the submittal, the purpose of the submittal, and shall include the file number of the Administration. Failure of any submittal, beyond the initial submittal, to include the file number of the Administration may result in the return of the submittal without benefit of review or comment. If it is unclear whether a project has been assigned a file number, the Administration may be contacted via phone to obtain the proper file number.

4.0 STORMWATER MANAGEMENT CRITERIA

4.1 Minimum Control Requirements.

(a) The minimum stormwater quantitative control requirements for Caroline, Dorchester, Queen Anne's, Somerset, Talbot, Wicomico, and Worcester Counties shall be that all projects provide management measures necessary to maintain the post-development peak discharge for a 24-hour, 2-year frequency storm event at a level that is equal to or less than the 24-hour, 2-year pre-development peak discharge rate, through stormwater management practices that control the volume, timing, and rate of flows. Where runoff is discharged into an off-site stormwater management facility, the control requirements and procedures shall be in accordance with subsection 4.3 (c).

(b) The minimum stormwater quantitative control requirements for the City of Baltimore, Allegany, Anne Arundel, Baltimore, Calvert, Carroll, Cecil, Charles, Frederick, Garrett, Harford, Howard, Kent, Montgomery, Prince George's, St. Mary's, and Washington Counties shall be that all projects provide management measures necessary to maintain the post-development peak discharges for a 24-hour, 2- and 10-year frequency storm event at a level that is equal to or less than the respective, 24-hour 2- and 10-year pre-development peak discharge rates, through stormwater management practices that control the volume, timing, and rate of flows. Where runoff is discharged into an off-site stormwater management facility, the control requirements and procedures shall be in accordance with subsection 4.3 (c).

(c) Stormwater management and development plans where applicable, shall be consistent with adopted and approved watershed management plans or flood management plans as approved by the Water Resources Administration in accordance with the Flood Hazard Management Act of 1976 (§8-9A-01 et seq., Natural Resources Article).

4.2 Stormwater Management Measures.

(a) Stormwater management measures shall be required to satisfy the minimum control requirements. The stormwater management practices to be utilized in developing a stormwater management plan shall be according to the following order of preference:

(1) Infiltration of runoff on-site;

(2) Flow attenuation by use of open vegetated swales and natural depressions;

(3) Stormwater retention structures; and

(4) Stormwater detention structures.

(b) Infiltration practices shall be utilized to reduce volume increases to the extent possible as determined in accordance with infiltration standards and specifications established by the Water Resources Administration. A combination of successive practices may be used to

achieve the applicable minimum control requirements. Justification shall be provided for rejecting each practice based on site conditions.

4.3 Specific Design Criteria.

(a) Infiltration systems shall be designed in accordance with the Maryland Standards and Specifications for Infiltration Practices and shall meet the following requirements:

(1) Infiltration systems greater than 3 feet deep shall be located at least 10 feet from any basement wall;

(2) Infiltration systems designed to handle runoff from commercial or industrial impervious parking areas shall be a minimum of 100 feet from any water supply well;

(3) Infiltration systems may not receive runoff until the entire contributary drainage area to the infiltration system has received final stabilization; and

(4) The stormwater management facility design shall provide an overflow system with measures to provide a non-erosive velocity of flow along its length and at the outfall.

(b) Retention and detention ponds shall be designed and constructed in accordance with the criteria of the Soil Conservation Service and shall include the following items:

(1) Velocity dissipation devices shall be placed at the outfall of all detention or retention structures and along the length of any outfall channel as necessary to provide a non-erosive velocity of flow from the structure to a water course.

(2) Where deemed necessary by the Administration, the State or federal agencies shall submit to the Administration an analysis of the impacts of stormwater flows downstream in the watershed. The analysis shall include hydrologic and hydraulic calculations necessary to determine the impact of hydrograph timing modifications of the proposed development upon a dam, highway, structure, or natural point of restricted streamflow, established with the concurrence of the Administration, downstream of a tributary of the following size:

(i) The first downstream tributary whose drainage area equals or exceeds the contributing area to the pond; or

(ii) The first downstream tributary whose peak discharge exceeds the largest designed release rate of the pond.

(3) The designed release rate of the structure shall be modified if any increase in flooding or stream channel erosion would result at the downstream dam, highway, structure, or natural point of

restricted streamflow. The release rate of the structure shall:

(i) Be reduced to a level that will prevent any increase in flooding or stream channel erosion at the downstream control point;

(ii) Be not less than 1-year pre-development peak discharge rate; and

(iii) Meet the requirements established in section 4.1.

(4) Small pond approval shall be obtained from the Water Resources Administration pursuant to Natural Resources Article §8-803(b).

(c) Off-site structures to be considered:

(1) Shall have a contributary drainage area not in excess of 400 acres unless, on a case by case basis, a larger drainage area is approved by the Water Resources Administration;

(2) Shall provide for a permanent pool of water or provide for 24-hour detention period for detaining and releasing the volume of runoff from the 1-year frequency storm;

(3) Shall manage the increase in peak discharges for the 2- and 10- and possibly the 100-year frequency storm events; and

(4) May not be located so as to discharge to Class III Natural Trout Waters identified in COMAR 10.50.01.02I, unless authorized by the Administration.

(d) The pre-development peak discharge rate shall be computed assuming that all land uses in the site to be developed are in good hydrologic condition.

(e) The State or federal agency shall give consideration to incorporating the use of natural topography and land cover such as wetlands, ponds, natural swales, and depressions as they exist prior to development to the degree that they can accommodate the additional flow of water.

(f) The Administration shall give preference to the use of swales in place of the traditional use of curbs and gutters based on a case by case review of stormwater management plans.

(g) Where a stormwater management plan involves direction of some or all runoff off of the site, it shall be the responsibility of the State or federal agency to obtain from adjacent property owners any easements or other necessary property interests concerning flowage of water. Approval of a stormwater management plan does not create or affect any such rights.

(h) The basic design criteria, methodologies, and construction specifications, subject to the approval of the Administration, be those of the Soil Conservation Service, generally found in t most current edition of the following publications or subsequent revisions:

(1) "Urban Hydrology for Small Watersheds", Technical Release No. 55, January, 1975. Revised Addition, 1986.

(2) "Soil Conservation Service Engineering Field Manual", latest edition, as applicable.

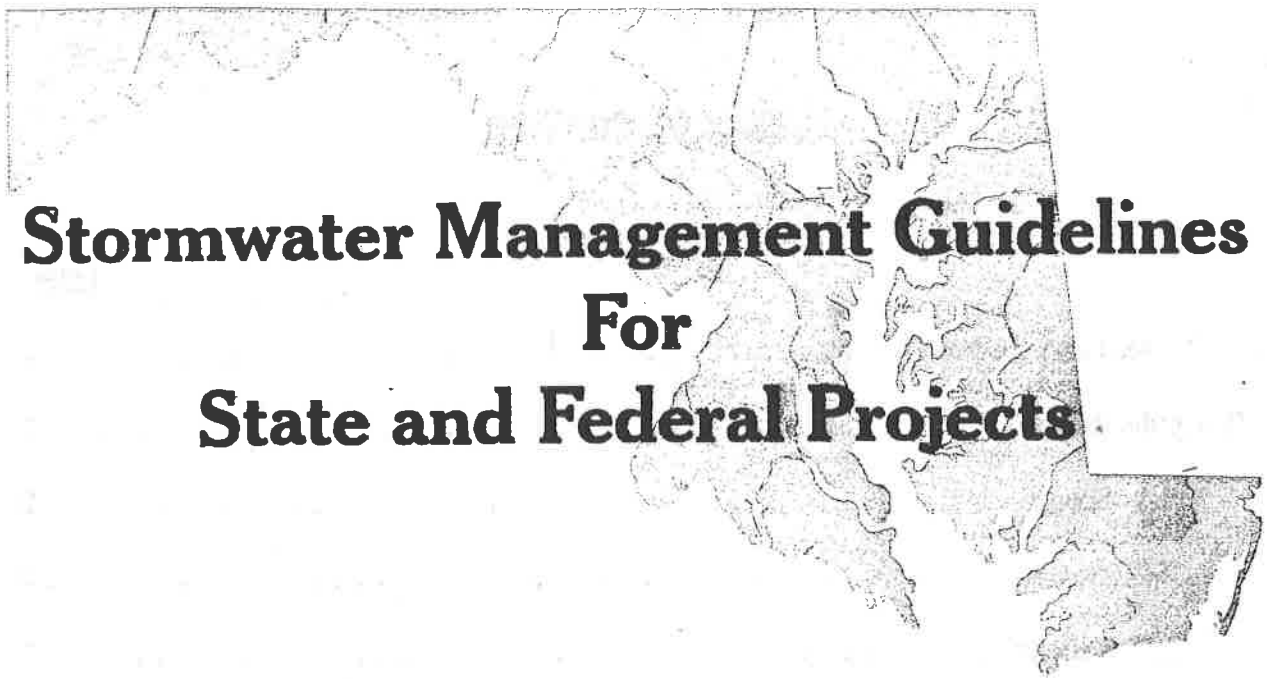
(3) "Soil Conservation Service Standard and Specification for Ponds", Specification No. 378, July, 1981.

(4) "Soil Conservation Service National Engineering Handbook 4 & 5," latest editions, as applicable.

(5) "Soil Conservation Service, TR-20 Computer Model," latest version.

(6) "Maryland Standards and Specifications for Stormwater Management Infiltration Practices", Water Resources Administration, February, 1984.

Stormwater Management Guidelines for State and Federal Projects (7/1/87) revised August 1996)



Stormwater Management Guidelines For State and Federal Projects

Effective:
July 1, 1987
(Revised August 1996)

MDE

Maryland Department of the Environment
Water Management Administration
2500 Broening Highway • Baltimore, Maryland 21224

The Sediment and Stormwater Administration (SSA) was incorporated into the Water Management Administration (WMA) in October, 1992. For additional information concerning this publication, please contact WMA at (410) 631-3543

SWM GUIDELINES
FOR STATE AND FEDERAL PROJECTS

TABLE OF CONTENTS

	Page
1.0 Purpose and Authority	1
2.0 Applicability	2
2.1 Scope	2
2.2 Exemptions	2
2.3 Waivers	2
2.4 Variances	3
3.0 Stormwater Management Plans	4
3.1 Contents of the Stormwater Management Plan	4
3.2 Format of the Stormwater Management Report and Plan	5
4.0 Stormwater Management Criteria	8
4.1 Minimum Control Requirements	8
4.2 Stormwater Management Measures	8
4.3 Specific Design Criteria	9
5.0 Stormwater Management Waiver Application	12

STORMWATER MANAGEMENT GUIDELINES FOR STATE AND FEDERAL PROJECTS

1.0 PURPOSE AND AUTHORITY

The purpose of these Guidelines is to protect, maintain, and enhance the public health, safety, and general welfare by establishing minimum requirements and procedures to control the adverse impacts associated with increased stormwater runoff. Proper management of stormwater runoff will minimize damage to public and private property, reduce the effects of development on land and stream channel erosion, assist in the attainment and maintenance of water quality standards, reduce local flooding, and maintain after development, as nearly as possible, the pre-development runoff characteristics.

The provisions of these Guidelines are pursuant to the Annotated Code of Maryland, Environment Article, Title 4, Subtitle 2 and the Stormwater Management Regulations, COMAR 26.09.02.01 through 26.09.02.10.

These Guidelines supplement the Stormwater Management Regulations, and provide information necessary for submittal of stormwater management plans by State and federal agencies. These Guidelines shall not affect the validity of any portion of either the Environment Article or Stormwater Management Regulations in any manner.

Wherever the word "Administration" appears in these Guidelines it shall refer to the Water Management Administration of the Maryland Department of the Environment.

15+10 to 15+60
17+20 to 17+65
18+75 to 21+90

2.0 APPLICABILITY

2.1 Scope.

No State or federal agency shall develop any land without having provided appropriate stormwater management measures that control or manage runoff, except as provided within this section.

2.2 Exemptions.

Developments that do not disturb over 5,000 square feet of total land area are exempt from the provisions of these Guidelines and the requirements of providing stormwater management.

2.3 Waivers.

The Administration may grant a waiver of the stormwater management requirements for State and federal projects provided that a Stormwater Management Waiver Application is submitted by the applicant. The Stormwater Management Waiver Application shall specifically State the item of this section for which the project is eligible. The applicant shall provide sufficient descriptions, drawings, and other information that is necessary to evaluate the proposed project and confirm the waiver request. A separate Stormwater Management Waiver Application may be required in accordance with the provisions of this section if there are subsequent additions, extensions, or modifications to a project receiving a waiver. Any waiver shall be valid only after written notice of granting such waiver is received from the Administration. A copy of the Stormwater Management Waiver Application shall be found on page 12 of these Guidelines.

(a) A project is eligible for a waiver of stormwater management for both quantitative and qualitative control if the applicant can demonstrate to the Administration that:

(1) the proposed project generates an unmanaged 2-year post-development peak discharge rate of less than five (5) cubic feet per second and the increases in post-development peak discharge rate cannot be infiltrated in accordance with the Maryland Standards and Specifications for Infiltration Practices; or

(2) the proposed project shall return the disturbed area to a pre-development runoff condition at the conclusion of the project (i.e., pipeline projects, bridge deck replacements, resurfacing of existing roadways, certain underground projects); or

(3) the proposed project consists of a linear disturbance of less than six (6) feet in width, (i.e., bike paths, sidewalks, shoulder work on highways, etc.).

(b) A project is eligible for a waiver of stormwater management for quantitative control if the applicant can conclusively demonstrate to the Administration that water quality treatment shall be provided in accordance with appropriate Best Management Practice (BMP) design guidelines provided by the Administration. Additionally, the applicant shall demonstrate that:

(1) the proposed project shall not generate an increase in the 2-year post-development peak discharge rate of more than ten (10) percent above the 2-year pre-development peak discharge rate and will not cause an adverse impact on the receiving wetland, watercourse, or waterbody; or

(2) a site is completely surrounded by existing developed areas which are served by an existing network of public storm drainage systems of adequate capacity to accommodate the runoff from the additional development; or

(3) provisions for a stable conveyance system to tidewater by either a closed drainage system or by open channel flow are provided.

2.4 Variances.

The Administration may grant a written variance from any requirement of Section 4.0 Stormwater Management Criteria of these Guidelines if there are exceptional circumstances applicable to the site such that strict adherence to the provisions of these Guidelines will result in unnecessary hardship and not fulfill the intent of these Guidelines. A written request for variance shall be provided to the Administration and shall state the specific variance sought, the reasons for the granting of the variance, and any evidence necessary to support the variance request. The Administration shall not grant a variance unless and until sufficient specific reasons justifying the variance are provided.

3.0 STORMWATER MANAGEMENT PLANS

3.1 Contents of the Stormwater Management Plan.

The State or federal agency is responsible for submitting a stormwater management plan which meets the design requirements provided by these Guidelines. The plan shall include sufficient information to evaluate the environmental characteristics of the affected areas, the potential impacts of the proposed development on water resources, and the effectiveness and acceptability of measures proposed for managing stormwater runoff. The State or federal agency shall certify on the drawings that all clearing, grading, drainage, construction, and development shall be conducted in strict accordance with the plan. The minimum information submitted for support of a stormwater management plan shall be as follows:

(a) Site characteristics

(1) Topographic survey showing existing and proposed drainage areas, including areas necessary to determine downstream analysis for the proposed stormwater management facility.

(2) Soils investigation, including borings, for construction of small ponds and infiltration practices.

(3) Description of all watercourses, impoundments, and wetlands on or adjacent to the site or into which stormwater flows.

(4) Delineation of 100-year floodplains, if applicable.

(b) Computations:

(1) Hydrologic;

(2) Hydraulic; and

(3) Structural.

In addition to the information listed above stormwater management design plans shall include:

(c) Stormwater management plans:

(1) Vicinity map.

(2) Drainage area map showing the watershed boundaries, drainage areas, and stormwater flow paths.

(3) Proposed improvements including location of buildings or other structures, impervious surfaces, and storm drainage facilities, if applicable.

(4) Location of utilities.

(5) Structural details for all components of the proposed drainage systems and stormwater management facilities.

(6) Timing schedules and sequence of development clearing, including stripping, rough grading, construction, final grading, and vegetative stabilization.

(7) Maintenance schedule.

(8) Notes on drawings specifying materials to be used.

(9) Construction specifications.

(10) Location of easements.

(d) Estimate of stormwater management construction cost. For projects which require competitive bidding it is not required to submit an estimate of the stormwater management construction cost.

(e) Other information as required.

3.2 Format of the Stormwater Management Report and Plan.

The format of stormwater management reports and plans submitted to the Administration shall be as follows:

(a) Report

The stormwater management report shall be on 8 1/2" x 11" paper. The report shall be typed; however, certain computational sheets may be handwritten. The report shall be bound in a hard cover binder. Any maps, diagrams, or figures (except computer printouts) which are larger than 8 1/2" x 11" shall be folded to a size of 8 1/2" x 11" or smaller and shall be placed in a pocket within the report binder. Fold-outs or bound maps, diagrams, or figures are not acceptable unless the document is 8 1/2" x 11". All maps, diagrams, or figures shall be clearly labeled.

The report shall be submitted in a good technical report form. At a minimum each report shall contain the following:

(1) Title on outside of binder.

(2) Title Sheet.

(3) Table of Contents.

(4) List of Figures or Tables.

(5) Body of Report

(i) Introduction

(ii) Methodologies Used

(iii) Analysis

(iv) Summary

(v) Conclusions

(6) Appendices

The Appendices shall include all the background information used in the stormwater management analysis. The background information shall be sufficient to facilitate a straightforward review and will typically include drainage area maps for both pre-development and post-development conditions. Those maps should typically show the soil types, the current land uses, point(s) of investigation, and Tc flow paths. Other information to be included: drainage area computations; runoff curve number computations; time of concentration computations; elevation-discharge-storage data, which shall include the discharge computations, storage computations, and any details necessary to confirm those computations, i.e., contour maps, pipe, culverts, and bridge profiles; TR-55 worksheets, schematic diagrams, any and all hydraulic computations, and any and all structural computations. All computer input computations shall be included as part of the Appendices. Schematic diagrams showing reach lengths, curve numbers, drainage areas, and structure locations shall be included for all computer printouts and shall be included as part of the Appendices. The Appendices shall be bound as part of the report.

(b) Computer Printouts

Computer printouts shall be original computer printouts or clear, legible, and complete photostatic copies or reduced size copies. Original computer printouts shall be bound in a data processing binder. The data processing binder shall be of a design which permits the binder to be placed in a file hanger. Reduced photostatic copies shall be 8 1/2" x 11" in size and bound with the Appendices or in an additional bound volume. All computer printouts shall be clearly labeled throughout the printout. The data processing binder or additional bound volume shall be labeled with a complete title block. The computer printouts shall include all input data, output data, hydrographs at critical sections where appropriate, and summary output. Labels shall be placed throughout the printouts for the various conditions of analyses, at critical sections, and for critical structures, such as stormwater management structures.

(c) Plans, Special Provisions, and other Contract Documents

Plans, special provisions, and other contract documents shall be submitted in the same manner as used for advertisement purposes. The plans shall include all of the details necessary to construct the stormwater management structure. In the event the advertised plans do not contain the minimum information for stormwater management plans as outlined under section 3.1, Contents of the Stormwater Management Plans, it is acceptable to submit the additional information as part of the report and in compliance with Section 3.2(a).

(d) File Numbers

All Reports, Computer Printouts, Plans, Special Provisions, and other Contract Documents shall be accompanied by a transmittal letter. The transmittal letter shall list the contents of the submittal, the purpose of the submittal, and shall include the file number of the Administration. Failure of any submittal, beyond the initial submittal, to include the file number of the Administration may result in the return of the submittal without benefit of review or comment. If it is unclear whether a project has been assigned a file number, the Administration may be contacted via phone to obtain the proper file number.

4.0 STORMWATER MANAGEMENT CRITERIA

4.1 Minimum Control Requirements.

(a) The minimum stormwater quantitative control requirements for Caroline, Dorchester, Queen Anne's, Somerset, Talbot, Wicomico, and Worcester counties shall be that all projects provide management measures necessary to maintain the post-development peak discharge for a 24-hour, 2-year frequency storm event at a level that is equal to or less than the 24-hour, 2-year pre-development peak discharge rate, through stormwater management practices that control the volume, timing, and rate of flows. Where runoff is discharged into an off-site stormwater management facility, the control requirements and procedures shall be in accordance with subsection 4.3 (c).

(b) The minimum stormwater quantitative control requirements for the City of Baltimore, Allegany, Anne Arundel, Baltimore, Calvert, Carroll, Cecil, Charles, Frederick, Garrett, Harford, Howard, Kent, Montgomery, Prince George's, St. Mary's and Washington counties shall be that all projects provide management measures necessary to maintain the post-development peak discharges for a 24-hour, 2- and 10-year frequency storm event at a level that is equal to or less than the respective, 24-hour 2- and 10-year pre-development peak discharge rates, through stormwater management practices that control the volume, timing, and rate of flows. Where runoff is discharged into an off-site stormwater management facility, the control requirements and procedures shall be in accordance with Subsection 4.3 (c).

(c) Stormwater management and development plans where applicable, shall be consistent with adopted and approved watershed management plans or flood management plans as approved by the Department of Natural Resources, Water Resources Administration in accordance with the Flood Hazard Management Act of 1976, Annotated Code of Maryland, Natural Resources Article, Title 8, Subtitle 9A.

4.2 Stormwater Management Measures

(a) Stormwater management measures are required to satisfy the minimum control requirements. The stormwater management practices to be utilized in developing a stormwater management plan shall be according to the following order of preference:

(1) Infiltration of runoff on-site;

(2) Flow attenuation by use of open vegetated swales and natural depressions;

(3) Stormwater retention structures; and

(4) Stormwater detention structures.

(b) Infiltration practices shall be utilized to reduce volume increases to the extent possible as determined in accordance with infiltration standards and specifications established by the Water Management Administration. A combination of successive practices may be used to achieve the applicable minimum control requirements. Justification shall be provided for rejecting each practice based on site conditions.

4.3 Specific Design Criteria

(a) Infiltration systems shall be designed in accordance with the Maryland Standards and Specifications for Infiltration Practices and shall meet the following requirements:

(1) Infiltration systems greater than 3 feet deep shall be located at least 10 feet from any basement wall;

(2) Infiltration systems designed to handle runoff from commercial or industrial impervious parking areas shall be a minimum of 100 feet from any water supply well;

(3) Infiltration systems may not receive runoff until the entire contributory drainage area to the infiltration system has received final stabilization; and

(4) The stormwater management facility design shall provide an overflow system with measures to provide a non-erosive velocity of flow along its length and at the outfall.

(b) Retention and detention ponds shall be designed and constructed in accordance with the criteria of the Natural Resource Conservation Service (formerly the Soil Conservation Service) and shall include the following items:

(1) Velocity dissipation devices shall be placed at the outfall of all detention or retention structures and along the length of any outfall channel as necessary to provide a non-erosive velocity of flow from the structure to a water course.

(2) Where deemed necessary by the Administration, the State or federal agencies shall submit to the Administration an analysis of the impacts of stormwater flows downstream in the watershed. The analysis shall include hydrologic and hydraulic calculations necessary to determine the impact of hydrograph timing modifications of the proposed development upon a dam, highway, structure, or natural point of restricted streamflow, established with the concurrence of the Administration, downstream of a tributary of the following size:

(i) The first downstream tributary whose drainage area equals or exceeds the contributing area to the pond; or

(ii) The first downstream tributary whose peak discharge exceeds the largest designed release rate of the pond.

(3) The designed release rate of the structure shall be modified if any increase in flooding or stream channel erosion would result at the downstream dam, highway, structure, or natural point of restricted streamflow. The release rate of the structure shall:

(i) Be reduced to a level that will prevent any increase in flooding or stream channel erosion at the downstream control point;

(ii) Be not less than 1-year pre-development peak discharge rate; and

(iii Meet the requirements established in Section 4.1.

(4) Small pond approval shall be obtained from the Administration pursuant to the Annotated Code of Maryland, Natural Resources Article Title 8, Subtitle 8.

(c) Off-site structures to be considered:

(1) Shall have a contributory drainage area not in excess of 400 acres unless, on a case by case basis, a larger drainage area is approved by the Administration;

(2) Shall provide for a permanent pool of water or provide for 24-hour detention period for detaining and releasing the volume of runoff from the 1-year frequency storm;

(3) Shall manage the increase in peak discharges for the 2- and 10- and possibly the 100-year frequency storm events; and

(4) May not be located so as to discharge to Class III Natural Trout Waters identified in COMAR 26.08.02.08C, unless authorized by the Administration.

(d) The pre-development peak discharge rate shall be computed assuming that all land uses in the site to be developed are in good hydrologic condition.

(e) The State or federal agency shall give consideration to incorporating the use of natural topography and land cover, such as wetlands, ponds, natural swales, and depressions as they exist prior to development to the degree that they can accommodate the additional flow of water.

(f) The Administration shall give preference to the use of swales in place of the traditional use of curbs and gutters based on a case by case review of stormwater management plans.

(g) Where a stormwater management plan involves direction of some or all runoff off of the site, it shall be the responsibility of the State or federal agency to obtain from adjacent property owners any easements or other necessary property interests concerning flowage of water. Approval of a stormwater management plan does not create or affect any such rights.

(h) The basic design criteria, methodologies, and construction specifications, subject to the approval of the Administration, shall be those of the Natural Resource Conservation Service, (formerly the Soil Conservation Service), and the Maryland Department of the Environment, generally found in the most current edition of the following publications or subsequent revisions:

(1) "Urban Hydrology for Small Watersheds", Technical Release No. 55, January, 1975. Revised Addition, 1986.

(2) "Soil Conservation Service Engineering Field Manual", latest edition.

(3) "Soil Conservation Service Standard and Specification for Ponds", Specification No. 378, Revised January, 1991.

(4) "Soil Conservation Service National Engineering Handbook 4 & 5," latest editions.

(5) "Soil Conservation Service, TR-20 Computer Model," latest version.

(6) "Maryland Standards and Specifications for Stormwater Management Infiltration Practices", February, 1984.

(7) "Guidelines for Constructing Wetland Stormwater Basins"

(8) "Design Procedures for Stormwater Management Extended Detention Structures"

(9) "Design Procedures for Stormwater Management Detention Structures"

DEPARTMENT OF THE ENVIRONMENT
WATER MANAGEMENT ADMINISTRATION

STORMWATER MANAGEMENT WAIVER APPLICATION

OWNER: _____ MDE NO.: _____
ADDRESS: _____ PROJECT NO.: _____
_____
CONSULTANTS: _____ DESCRIPTION: _____
_____ _____
LOCATION: _____

I/We, the Owner/Owners hereby request a Waiver be granted for the above referenced project in accordance with the following section(s) of the Stormwater Management Guidelines for State and Federal Projects:

Section	Minimum Evidence Required
___ 2.3 (a)(1)	Contract plans and provisions, stormwater management report, infiltration investigation.
___ 2.3 (a)(2)	Contract plans and provisions.
___ 2.3 (a)(3)	Contract plans and provisions.
___ 2.3 (b)(1)	Contract plans and provisions, stormwater management report, infiltration investigation, downstream impact investigation.
___ 2.3 (b)(2)	Contract plans and provisions, stormwater management report, infiltration investigation, downstream impact investigation.
___ 2.3 (b)(3)	Contract plans and provisions, infiltration investigation, downstream impact investigation.

Other evidence submitted: _____
_____
_____

_____ _____
(Owner's Signature) (Date)

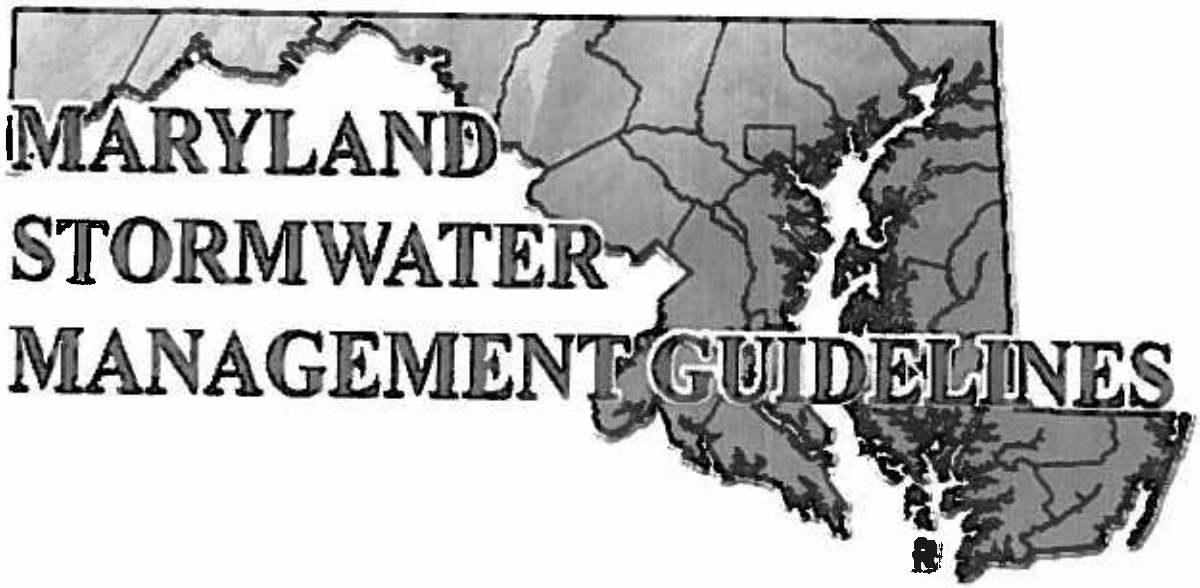
_____ Approved _____ Denied Reason: _____
_____

By: _____ _____
(Water Resources Engineer) (Date)

SUBMIT TO: Nonpoint Source Program
Water Management Administration
Maryland Department of the Environment
2500 Broening Highway
Baltimore, MD 21224

(NOTE: If a project involves a waiver request for more than one drainage area, please submit a separate Stormwater Management Waiver Application for each drainage area.)

Stormwater Management Guidelines for State and Federal Projects (7/2001)



MARYLAND STORMWATER MANAGEMENT GUIDELINES

for

State and Federal Projects

July 2001

MARYLAND
Department of the Environment

1800 Washington Boulevard | Baltimore, MD 21230-1718 | www.mde.state.md.us
410-537-3000 | 800-633-6101 | TTY Users: 800-735-2258
Martin O'Malley, *Governor* | Anthony G. Brown, *Lt. Governor* | Shari T. Wilson, *Secretary*

MARYLAND DEPARTMENT OF THE ENVIRONMENT

SWM GUIDELINES
FOR STATE AND FEDERAL PROJECTS

Table of Contents

Page

1.0 Purpose and Authority 1
1.1 Incorporation by Reference

2.0 Definitions 1

3.0 Applicability 4
3.1 Scope
3.2 Exemptions
3.3 Waivers
3.4 Institutional Management Plan
3.5 Redevelopment
3.6 Variance

4.0 Stormwater Management Criteria 8
4.1 Minimum Control Requirements
4.2 Stormwater Management Measures
4.3 Specific Design Criteria

5.0 Stormwater Management Plans 15
5.1 Review and Approval of Stormwater Management Plans
5.2 Preparation of the Stormwater Management Plan
5.3 Contents of the Stormwater Management Plan

6.0 Inspection Requirements During Construction for As-Built Certification 18

7.0 Maintenance 20

Stormwater Management Waiver Application 21

As Built Certification 22

Design Certification 22

1.0 PURPOSE AND AUTHORITY

The purpose of these Guidelines is to protect, maintain and enhance the public health, safety, and general welfare by establishing minimum requirements and procedures to control the adverse impacts associated with increased stormwater runoff. Proper management of stormwater runoff will minimize damage to public and private property, reduce the effects of development on land, control stream channel erosion, pollution and sediment deposition, reduce local flooding, and, in some instances, maintain the pre-development runoff characteristics.

The provisions of these Guidelines are pursuant to the Annotated Code of Maryland, Environment Article, Title 4, Subtitle 2 and the Stormwater Management Regulations, Code of Maryland Regulation (COMAR) 26.17.02.01 through 26.17.02.12.

These Guidelines supplement the Stormwater Management Regulations and the "2000 Maryland Stormwater Design Manual". They provide information necessary for submittal of stormwater management plans by State and federal agencies to the Maryland Department of the Environment (MDE), Water Management Administration (WMA) for review and approval. These Guidelines shall not affect the validity of any portion of either the Environment Article or Stormwater Management Regulations in any manner.

1.1 Incorporation By Reference.

For the purpose of these Guidelines, the following documents are incorporated by reference:

A. The 2000 Maryland Stormwater Design Manual Volumes I & II (Maryland Department of the Environment, April 2000) is incorporated by reference and shall serve as the official guide for stormwater principles, methods, and practices.

B. USDA Natural Resources Conservation Service-Maryland, Conservation Practice Standard, Pond- Code 378 (January 2000).

2.0 DEFINITIONS

A. For the purpose of these Guidelines, the following definitions describe the meaning of the terms used in these Guidelines:

(1) "Administration" means the Maryland Department of the Environment, Water Management Administration.

(2) "Adverse impact" means any deleterious effect on waters or wetlands, including their quality, quantity, surface area, species composition, aesthetics or usefulness for human or natural uses which are or may potentially be harmful or injurious to human health, welfare, safety or property, to biological productivity, diversity, or stability or which unreasonably interfere with the enjoyment of life or property, including outdoor recreation.

(3) "Agricultural land management practices" means those methods and procedures used in the cultivation of land in order to further crop and livestock production and conservation of related soil and water resources.

(4) "Applicant" means any State or federal governmental agency that executes the necessary forms to procure official approval to carry out construction of a project.

(5) "Channel Protection Storage Volume (Cp_v)" means the volume used to design structural management practices to control stream channel erosion. Methods for calculating the channel protection storage volume are specified in the 2000 Maryland Stormwater Design Manual, Volumes I & II.

(6) "Clearing" means the removal of trees and brush from the land but shall not include the ordinary mowing of grass.

(7) "Design Manual" means the 2000 Maryland Stormwater Design Manual, Volumes I & II, that serves as the official guide for stormwater management principles, methods, and practices.

(8) "Direct discharge" means the concentrated release of stormwater to tidal waters or vegetated tidal wetlands from new development or redevelopment projects in the Critical Area.

(9) "Drainage area" means that area contributing runoff to a specific location, measured in a horizontal plane, which is enclosed by a ridge line.

(10) "Easement" means a grant or reservation by the owner of land for the use of such land by others for a specific purpose or purposes, and which must be included in the conveyance of land affected by such easement.

(11) "Exemption" means those land development activities that are not subject to the stormwater management requirements contained in these Guidelines.

(12) "Grading" means any act by which soil is cleared, stripped, stockpiled, excavated, scarified, filled or any combination thereof.

(13) "Grubbing" means exposing the earth by removal of the root mat.

(14) "Infiltration" means the passage or movement of water through the soil into the underlying soil profile.

(15) "Institutional Management Plan" means an MDE approved plan for any State or federal agency that provides stormwater management for the entire site that considers all watersheds affected by institution.

(16) "On-site stormwater management" means the design and construction of systems necessary to control stormwater within an immediate project facility.

(17) "Overbank flood protection volume (Q_p)" means the volume controlled by structural practices to prevent an increase in the frequency of out of bank flooding generated by development. Methods for calculating the overbank flood protection volume are specified in the Design Manual.

(18) "Recharge volume (Re_v)" means that portion of the water quality volume used to maintain groundwater recharge rates at development sites. Methods for calculating the recharge volume are specified in the Design Manual.

(19) "Redevelopment" means any construction, reconstruction, alteration, or improvement of, or on, existing impervious area exceeding 5000 square feet.

(20) "Retention structure" means a permanent structure that provides for the storage of runoff by means of a permanent pool of water.

(21) "Sediment" means soils or other surficial materials transported and/or deposited by the action of wind, water, ice, or gravity as a product of erosion.

(22) "Site" means any tract, lot or parcel of land or combination of tracts, lots, or parcels of land, which are in one ownership, or are contiguous and in diverse ownership where development is to be performed as part of a unit, subdivision, or project.

(23) "Stabilization" means the prevention of soil movement by covering exposed earth using any of various vegetative and/or structural means.

(24) "Stormwater management" means:

a. For quantitative control, a system of vegetative and structural measures that control the increased volume and rate of surface runoff caused by man-made changes to the land; and

b. For qualitative control, a system of vegetative, structural, and other measures that reduce or eliminate pollutants that might otherwise be transported by surface runoff.

(25) "Stormwater Management Plan" means a set of drawings and/or other documents which contain all of the information and specifications pertaining to stormwater management, submitted by an applicant as a prerequisite to obtaining a stormwater management approval.

(26) "Variance" means the modification of the minimum stormwater management requirements for specific circumstances such that strict adherence to the requirements would result in unnecessary hardship and not fulfill the intent of these Guidelines.

(27) "Waiver" means the relinquishment of the Applicant from stormwater management requirements for a specific project on a case-by-case review basis.

(28) "Watercourse" means any natural or artificial stream, river, creek, ditch, channel, canal, conduit, culvert, drain, waterway, gully or ravine, in and including any adjacent area that is subject to inundation from overflow or flood water.

(29) "Watershed" means the total drainage area contributing runoff to a single point.

(30) "Watershed Management Plan" means an MDE approved plan for a county or local municipality.

(31) "Water quality volume (WQ_v)" means the volume needed to capture and treat 90 percent of the average annual runoff volume at a development site. Methods for calculating the water quality volume are specified in the Design Manual.

3.0 APPLICABILITY

3.1 Scope.

No State or federal agency shall develop any land without having provided stormwater management measures that control or manage runoff from such development, except as provided within this section. The stormwater management measures must be designed consistent with the Design Manual and constructed according to the project plan approved by the Administration.

3.2 Exemptions.

The following are exempt from the provisions of these Guidelines and the requirements of providing stormwater management:

A. Agricultural land management practices;

B. Projects that do not disturb over 5,000 square feet of land area.

3.3 Waivers

A. The Administration may grant a waiver of the stormwater management QUANTITY and QUALITY control requirements where the Applicant can demonstrate to the satisfaction of the Administration that:

1. the project shall return the disturbed area to a predevelopment runoff condition (no hydrologic change and/or redevelopment occurs), i.e., pipeline or conduit projects, certain landscaping projects, certain maintenance projects, certain underground projects; or

2. the project lies within an area with an approved watershed management plan; or

3. the project lies within an approved institutional management plan that has been developed consistent with Section 3.4.

B. The Administration may grant a waiver of the stormwater management QUANTITY control requirements where the Applicant can demonstrate to the satisfaction of the Administration that:

1. the impervious area created by the project does not exceed six (6) feet in width, is linear in nature, i. e., bike paths, walkways, highway noise barriers, etc., and retains the predevelopment drainage patterns; or

2. the project is served by an existing public storm drain system of adequate capacity to accommodate the runoff from the proposed development; or

3. the project generates a maximum channel protection volume (Cp_v) of 2 cfs; or

4. the project has direct discharge to tidally influenced receiving waters; or

5. the project discharges directly to a major waterway (see Table 2). [channel protection volume (Cp_v) may be required]; or

6. historical downstream flooding problems do not exist, AND: the local jurisdiction does not require management of the overbank flood protection volume within the watershed (see Table 1.) [Channel Protection Volume (Cp_v) SHALL be provided as required by the Design Manual].

C. A Stormwater Management Waiver Application, submitted by the applicant, shall specifically state the item of this section for which the project is eligible. The applicant shall provide sufficient descriptions, drawings, and other information necessary to evaluate the proposed project and confirm the applicability of the waiver request. A separate Stormwater Management Waiver Application may be required in accordance with the provisions of this section if there are subsequent additions, extensions, or modifications to a project receiving a waiver. Any waiver shall be valid only after written notice of granting such waiver is received from the Administration. A copy of the Stormwater Management Waiver Application may be found on page 21 of these Guidelines.

D. A Stormwater Management Waiver Application shall be required for each eligible drainage area where runoff leaves the project site.

E. Waivers granted shall:

1. be on a case-by-case basis;

2. consider the cumulative effects of the waiver policy; and

3. ensure no adverse impact on the downstream watercourse.

F. Redevelopment projects shall be in accordance with Section 3.5 of these guidelines.

3.4 Institution/Agency Management Plan

An Institution/Agency Management Plan developed for the purpose of implementing site–wide stormwater management practices shall:

A. Include detailed hydrologic and hydraulic analyses to determine hydrograph timing;

B. evaluate both quantity and quality management;

C. include cumulative impact assessment of institutional development;

D. identify existing flooding and receiving stream channel conditions;

E. be presented at a reasonable scale (dictated by the size of area in the analysis);

F. specify where on-site or off-site quantitative and qualitative stormwater management practices and watershed improvement are (to be) implemented;

G. be consistent with the General Performance Standards for Stormwater Management in Maryland found in Section 1.2 of the Design Manual;

H. be consistent with local watershed management plan(s), and

I. be approved by the Administration.

3.5 Redevelopment

Any reconstruction of, or new construction on, existing impervious area, exceeding 5000 square feet, shall be considered redevelopment. Stormwater management requirements for redevelopment shall be in accordance with the following:

A. Stormwater management plans for redevelopment shall be consistent with the Design Manual except that the recharge, channel protection storage volume, and overbank flood protection volume requirements do not apply unless required by the Administration. Examples of redevelopment projects are: construction of a building on an existing parking lot; demolition of a building and the construction of a new structure.

B. All redevelopment projects shall reduce existing impervious areas impacted within project limits by a minimum of 20 percent. Where project site conditions prevent the reduction of impervious area, then stormwater management practices shall be implemented to provide qualitative control for a minimum of 20 percent of the project's predevelopment impervious area. When a combination of impervious area reduction and stormwater practice implementation is used, the combined reduction and treated areas shall be equal to, or exceed, 20 percent of the predevelopment impervious area within the project limits.

C. Where conditions prevent impervious area reduction or on-site stormwater management, practical alternatives may be considered, including but not limited to:

1. off-site BMP implementation within the project watershed for an impervious area equal to 24 percent of the project impervious area impacted;

2. watershed or stream restoration;

3. retrofitting an existing BMP; or

4. other practices approved by the Administration.

D. If a net increase in impervious area occurs for the project, the increased impervious area shall be considered new development and shall follow Stormwater Management Criteria, Section 4.0 of these Guidelines. Additionally, water quality shall be provided for 20 percent of the project's predevelopment impervious area.

EXAMPLE #1: A new building and parking garage are constructed on an existing, one (1) acre paved parking lot. The footprint of the new building and parking garage is one and a half (1.5) acres and completely covers the footprint of the *existing 1.0 acre parking lot. The total water quality required equals 0.7 acres [0.5 acres for the new impervious, plus 0.2 acres for redevelopment (20 percent of the predevelopment impervious area)].*

EXAMPLE #2: A new building and parking garage are constructed on an existing, paved parking lot. The footprint of the new building and parking garage is one and a half (1.5) acres and covers one half (1/2) acre of the existing 1.0 acre parking lot (the remaining ½ acre parking lot will remain undisturbed). The total water quality required equals 1.1 acres [1.0 acre for the new impervious, plus 0.1 acres for redevelopment (20 percent of the ½ acre predevelopment impervious area replaced by new impervious)].

E. When a redevelopment project changes the site runoff characteristics, in a manner that increases the discharge rate, channel protection volume and overbank flood protection volume may be required by the Administration.

F. When redevelopment reduces the impervious area by a minimum of twenty (20) percent, qualitative control is not required for the redevelopment portion of the project.

G. Pavement overlay and/or patching are considered maintenance practices, therefor redevelopment criteria is not applicable.

3.6 Variance.

The Administration may grant a written variance from any requirement of Section 4.0, "Stormwater Management Criteria" of these Guidelines if there are exceptional circumstances applicable to the site such that strict adherence will result in unnecessary hardship and not fulfill the intent of the Guidelines. A written request for variance shall be provided to the Administration and shall state the specific variance sought and any evidence necessary to

support the request. A variance may be granted upon consideration and as deemed appropriate by the Administration.

4.0 STORMWATER MANAGEMENT CRITERIA

4.1 Minimum Control Requirements.

A. The minimum control requirements established in this section and the Design Manual are as follows:

1. For projects in Caroline, Cecil (south of the Chesapeake and Delaware [C&D] Canal), Dorchester, Kent, Queen Anne's, Somerset, Talbot, Wicomico, and Worcester counties and their incorporated municipalities, the water quality volume, the recharge volume, and the overbank flood protection volume (the 2-year frequency storm event) criteria shall be used to design BMP's according to the Design Manual; and

2. For projects in Baltimore City, Allegany, Anne Arundel, Baltimore, Calvert, Carroll, Cecil (north of the C&D canal), Charles, Frederick, Garrett, Harford, Howard, Montgomery, Prince George's, St. Mary's, and Washington counties and their incorporated municipalities, the water quality volume, the recharge volume, and the channel protection storage volume sizing criteria shall be used to design BMP's according to the Design Manual. Control of the 24-hour, 10-year frequency storm event is required according to the Design Manual.

3. Designated Inter-jurisdictional Flood Hazard Watersheds shall require management measures necessary to maintain the post-development peak discharges for the 24-hour, 100-year frequency storm events at a level that is equal to, or less than, the 24-hour 100-year pre-development peak discharge rates. The stormwater management practices shall control the volume, timing, and rate of flows necessary to maintain a "no increase" in the downstream peak discharge for the 100-year frequency storm event.

4. The Administration may require more than the minimum control requirements specified in these Guidelines if hydrologic or topographic conditions warrant, or if flooding, stream channel erosion, or water quality problems exist downstream from a proposed project.

B. Stormwater management and development plans, where applicable, shall be consistent with adopted and approved institutional management plans, watershed management plans or flood management plans as approved by the Maryland Department of the Environment in accordance with the Flood Hazard Management Act of 1976.

4.2 Stormwater Management Measures.

The structural and nonstructural stormwater management measures established in these Guidelines shall be used, either alone or in combination, in developing a stormwater management plan.

A. Nonstructural Stormwater Management Measures.

1. The following nonstructural stormwater management practices shall be applied according to the Design Manual to minimize increases in new development runoff:

    a. natural area conservation;

    b. disconnection of rooftop runoff;

    c. disconnection of non-rooftop runoff;

    d. sheet flow to buffers;

    e. grass channels; and

    f. environmentally sensitive development.

2. The use of nonstructural stormwater management practices shall be strongly encouraged to minimize the reliance on structural BMP's.

3. The minimum control requirements listed in Section 4.1 of these Guidelines may be reduced in accordance with the Design Manual, when nonstructural stormwater management practices are incorporated into site designs.

4. The use of nonstructural stormwater management practices may not conflict with existing State laws, regulations, or policies.

5. Nonstructural stormwater management practices used to reduce the minimum control requirements must remain unaltered by owners. Approval from the Administration shall be obtained prior to alteration of nonstructural stormwater practices.

6. Alternative structural and nonstructural stormwater management practices may be used for new development water quality control if they meet the performance criteria established in the Design Manual and are approved by the Administration. Practices used for redevelopment projects shall be approved by the Administration.

7. For the purposes of modifying the minimum control requirements or design criteria, the applicant shall submit to the Administration an analysis of the impacts of stormwater flows downstream in the watershed. The analysis shall include hydrologic and hydraulic calculations necessary to determine the impact of hydrograph timing modifications of the proposed development upon a dam, highway, structure, or natural point of restricted streamflow. The point of investigation is to be established, with the concurrence of the Administration, at the first downstream tributary whose drainage area equals, or exceeds, the contributing area to the project or stormwater management facility.

B. Structural Stormwater Management Measures.

1. The following structural stormwater management practices shall be designed according to the Design Manual to satisfy the applicable minimum control requirements established in Section 4.1 of these Guidelines:

   a. Stormwater management ponds;

   b. Stormwater management wetlands;

   c. Stormwater management infiltration;

   d. Stormwater management filtering systems; and

   e. Stormwater management open channel systems.

2. The performance criteria specified in the Design Manual with regard to general feasibility, conveyance, pretreatment, treatment and geometry, environment and landscaping, and maintenance shall be considered when selecting structural stormwater management practices.

3. Structural stormwater management practices shall be selected to accommodate the unique hydrologic or geologic regions of the State.

4.3 Specific Design Criteria.

The basic design criteria, methodologies, and construction specifications, subject to the approval of the Administration, shall be those of the Design Manual.

A. Infiltration systems shall be designed in accordance with the Design Manual and shall meet the following requirements:

1. The facility design shall provide an overflow system with measures to provide a non-erosive velocity of flow along its length and at the outfall.

2. Infiltration trenches shall be provided with observation wells in accordance with the Design Manual.

B. Ponds, wetlands, filtering systems and open channel systems shall be designed and constructed in accordance with the Design Manual and shall include the following items:

1. Velocity dissipation devices shall be placed at the outfall of all detention or retention structures and along the length of any outfall channel as necessary to provide a non-erosive velocity of flow from the structure to a water course.

2. Where deemed necessary by the Administration, the applicant shall submit an analysis of the impacts of stormwater flows downstream in the watershed. The analysis shall include hydrologic and hydraulic calculations necessary to

determine the impact of hydrograph timing modifications resulting from the proposed development upon a dam, highway, structure, or natural point of restricted stream flow, established with the concurrence of the Administration, and shall extend downstream:

a. to the first downstream tributary whose drainage area equals or exceeds the contributing area to the pond; or

b. to the first downstream tributary whose peak discharge exceeds the largest designed release rate of the pond.

3. The designed release rate of the facility shall be modified if any increase in flooding or stream channel erosion would result at the downstream dam, highway, structure, or natural point of restricted stream flow. The release rate of the facility shall:

a. Be reduced to a level that will prevent any increase in flooding or stream channel erosion at the downstream control point;

b. Be not less than 1-year pre-development peak discharge rate; and

c. Meet the requirements established in Section 4.1.

4. Where the selected BMP is a pond, small pond approval shall be obtained from the Administration pursuant to the Environmental Article, Annotated Code of Maryland, Title 5, Subtitle 5.

C. Off-site structures to be considered:

1. Shall have a contributory drainage area not in excess of 400 acres unless, on a case by case basis, a larger drainage area is approved by the Administration;

2. Shall provide for a permanent pool of water or provide for 24-hour detention period (a 12-hour detention period may be approved, at the discretion of the Administration, for Use III or Use IV streams) for detaining and releasing the volume of runoff from the 1-year frequency storm;

3. Shall manage the increase in peak discharges for the 2 and 10 and possibly the 100-year frequency storm events; and

4. May not be located so as to discharge to Use III Natural Trout Waters identified in COMAR 26.08.02.08C, unless authorized by the Administration (see 4.3.C.2).

D. When calculating the overbank flood protection (Qp2, Qp10) the pre-development peak discharge rate shall be computed assuming that all land uses within the project site are in good hydrologic condition.

1. Design considerations shall be given for incorporating the use of natural topography and land cover, such as wetlands, ponds, natural swales, and depressions, as they exist prior to development, to the degree that they can accommodate the increased flow of water.

2. Where deemed necessary, due to increased volume or rate of discharge from the project site, the Administration may require easements or other necessary property interests, concerning flowage of water, from adjacent property owners. It shall be the responsibility of the applicant to provide said easements or other necessary property interests. Approval of a stormwater management plan does not create or affect any such rights.

E. Water quality treatment for roadway and/or parking lot construction shall be in accordance with the Design Manual and the following:

1. Grassed Channel Water Quality Credit.

a. When computing the discharge for the water quality storm for grassed channel credit, the out-of-project (off-site) drainage area contributing runoff to the grassed channel must be included.

b. Credit may be applied only for that portion of the impervious area that reaches the grassed channel via sheet flow or approved pretreatment practice.

c. When expanding the limits of paving, grassed channel credit will be applied as follows:

(1) the length of the post-development vegetative buffer (the grassed area between the edge of the paving and the centerline of the channel) shall be proportional to the ratio of the pre-development buffer/paving lengths; for EXAMPLE:

the pre-development buffer length (the length of vegetated buffer receiving sheet flow from the existing paved area) equals 50 feet. The pre-development paving length sheet flowing to the buffer equals 25 feet. The pre-development ratio of buffer/paving equals 50/25 or 2/1. The post-development paving length (the length of paving that sheet flows to the grassed buffer) equals 35 feet. Therefore, maintaining the2/1 ratio, the post-development vegetated buffer length must equal 70 feet minimum.

(2) where the buffer/paving length ratio cannot be provided, the Administration may consider, on a case by case basis, mitigation for reduced buffer length in the form of landscaping and/or grading.

2. Conversion of open section paving to closed section.

a. Quantifying efficiency of water quality treatment provided by existing conditions.

The presence of an existing vegetated filter strip through which runoff sheet flows is an effective water quality measure for the runoff from existing open section paving. Likewise, the presence of an existing vegetated conveyance (swale or channel) that transports the runoff from a "one-inch rainfall" event, at a velocity of 1 fps or less, is an effective water quality measure. When converting open section paving to closed section, the quality of runoff may be negatively impacted due to the loss of these vegetative filtering and/or infiltration measures. This existing water quality value shall be quantified as follows:

(1) Step 1

- Enter Figure 1 with the appropriate slope and read the filter length required to achieve removal goals for total suspended solids (TSS).
- Determine the length of the existing filter.
- The ratio of the existing filter length to the filter length obtained from Figure 1 is the efficiency.

(2) Step 2

- Determine the velocity of the runoff from the one-inch rainfall event in the existing swale/channel.
- Determine the filter efficiency as follows: a velocity of 1 fps or less, equals 100% water quality (WQ) efficiency; a velocity of 3 fps or greater equals 0% water quality efficiency. The efficiency is directly proportional to the velocities of the one-inch rainfall within the existing conveyance.

(3) Step 3

- The greater of the Step 1/Step 2 efficiencies is the percent of water quality provided by the existing conditions.

b. Compensation for the percent of water quality provided by the existing conditions shall be as follows: The area of the existing impervious surface converted from open section to closed section shall be multiplied by the percent of water quality provided by the existing conditions (as

determined in Step 3 above). Water quality shall be provided for this area of existing paving due to the conversion of open section to closed section.

3. Conversion of closed section pavement to open section.

   Water quality compensation for conversion of closed section paving to open section paving may be quantified by use of Steps 1 through 3 in Subsection 4.3.E.2.

4. Compensating Water Quality Treatment (WQ_v and Re_v)

   a. Projects may have drainage areas where it is not possible to provide water quality treatment for all new paved areas. Compensating water quality treatment of existing paving, equal to 120% of the untreated new paved area, may be provided elsewhere within the same watershed. Provision of the compensating water quality treatment shall be included within the project.

   b. In order for existing paving to qualify as compensating water quality treatment, there must be no, or substandard, existing water quality treatment for said existing paving. Substandard means less than 100 percent (%), as determined by the method in Subsection 4.3.E.2.a. of these Guidelines.

5. On-Line BMPs

   Water quality practices that are placed On-Line (in medians or side channels/ditches/swales) shall include offsite impervious area in the calculation of the water quality requirements.

F. Channel Protection Volume (Cp_v)

Channel Protection Volume (Cp_v) shall be derived in accordance with the Design Manual. Extended detention facilities for projects that include combined redevelopment and new development, shall be in accordance with the following:

1. Cp_v shall be computed using the new development drainage area only.

2. The extended detention facility may be designed to control the Cp_v, as computed in accordance with Subsection 4.3.F.1. of these Guidelines, and by-pass the excess runoff contribution from the redevelopment portion of the contributing drainage area.

5.0 STORMWATER MANAGEMENT PLANS

5.1 Review and Approval of Stormwater Management Plans.

A. For any proposed project, the applicant shall submit a stormwater management plan and/or waiver application to the Administration for review and approval, unless otherwise exempted in accordance with Section 3.2 of these Guidelines. The stormwater management plan shall contain supporting computations, drawings, and sufficient information describing the manner, location, and type of measures in which stormwater runoff will be managed from the entire project. The Administration shall review the plan to determine compliance with the requirements of these Guidelines prior to approval. The plan shall serve as the basis for all subsequent construction.

B. The stormwater management plan shall not be considered approved until it has been signed and dated by the Administration's Sediment and Stormwater Plan Review Division Chief and the Administration has issued written approval for the project.

5.2 Preparation of the Stormwater Management Plan.

A. The stormwater management plan shall be prepared by any individual whose qualifications are acceptable to the Administration. The Administration may require that the design be prepared by either a professional engineer, professional land surveyor, or landscape architect licensed in the State of Maryland, as necessary to protect the public or the environment.

B. If a stormwater "Best Management Practice" (BMP), requires either a dam safety permit or small pond approval from the Administration, the design shall be prepared by an engineer licensed in the State of Maryland.

5.3 Contents of the Stormwater Management Plan.

The applicant is responsible for submitting a stormwater management plan that meets the design requirements of these Guidelines. The plan shall be accompanied by a report that includes sufficient information to evaluate the environmental characteristics of affected areas, the potential impacts of the proposed development on water resources, and the effectiveness and acceptability of measures proposed for managing stormwater runoff. The applicant shall certify on the drawings that all clearing, grading, drainage, construction, and development shall be conducted in strict accordance with the plan. The minimum information submitted, for support of a stormwater management plan, or application for a waiver, shall be in accordance with the following:

A. Reports submitted for stormwater management plan approval shall include:

1. A brief narrative description of the project;

2. Geotechnical investigations including soil maps, borings, site specific recommendations, and any additional information necessary for the proposed stormwater management design;

3. Descriptions of all water courses, impoundments, and wetlands on or adjacent to the site or into which stormwater directly flows;

4. Hydrologic computations, including drainage area maps depicting pre development and, where appropriate, the post development runoff flow path segmentation and land use;

5. Hydraulic computations;

6. Structural computations;

7. Unified sizing criteria volume computations according to the Design Manual; and

8. Any other information required by the Administration.

C. Format of the Report.

1. The stormwater management report shall be on 8 1/2" x 11" paper. The report shall be typed; however, certain computational sheets may be handwritten. Any maps, diagrams, or figures (except computer printouts) which are larger than 8 1/2" x 11" shall be folded to a size of 8 1/2" x 11" or smaller and shall be placed within the report. Fold-outs or bound maps, diagrams, or figures are not acceptable unless the document is 8 1/2" x 11". All maps, diagrams, or figures shall be clearly labeled.

2. At a minimum each report shall contain the following:

   a. Title Sheet.

   b. Table of Contents.

   c. List of Figures or Tables.

   d. Body of Report.

      (1) Introduction.

      (2) Methodologies Used.

      (3) Analysis.

      (4) Summary.

      (5) Conclusions.

e. Appendices

The Appendices shall include all the background information used in the stormwater management analysis. The background information shall be sufficient to facilitate a straightforward review and will include drainage area maps showing drainage areas, soil types, land uses, point(s) of investigation, and Time of Concentration (Tc) flow paths. Other information to be included: drainage area computations; runoff curve number computations; time of concentration computations; sizing criteria computations; elevation-discharge-storage data, which shall include the discharge computations, storage computations, and any details necessary to confirm those computations, i.e., contour maps, pipe, culverts, and bridge profiles; TR-55 worksheets; schematic diagrams; any and all hydraulic computations; any and all structural computations; including areas necessary to determine downstream analysis for the proposed stormwater management facility. In addition, projects in Cecil (south of the Chesapeake and Delaware Canal), Kent, Queen Anne's, Caroline, Dorchester, Talbot, Wicomico, Somerset and Worcester Counties, inter-jurisdictional watersheds and watersheds with a history of downstream flooding problems shall provide topographic survey maps showing existing drainage areas.
Schematic diagrams showing reach lengths, curve numbers, drainage areas, and structure locations shall be included for all computer printouts and shall be included as part of the Appendices. The Appendices shall be bound as part of the report.

D. Computer Printouts

Computer printouts shall be original printouts or clear, legible, and complete photostatic copies and shall be 8 1/2" x 11" in size and bound with the Appendices or in an additional bound volume. All computer printouts shall be clearly labeled throughout the printout for the various conditions of analyses, at critical sections, and for critical structures, such as stormwater management control structures. Additional bound volume(s) shall be labeled with a complete title block. The computer printouts shall include all input data, output data, hydrographs at critical sections where appropriate, and summary output.

E. Construction Drawings

Construction drawings submitted for stormwater management plan approval shall include the following:

1. A vicinity map

2. Site characteristics

   a. A topographic survey showing all contours and existing features.

b. All watercourses, impoundments, and wetlands adjacent to the project which receive site stormwater runoff.

3. All proposed improvements including location of buildings or other structures, impervious surfaces, storm drainage facilities, and all grading;

4. The location of existing and proposed structures and utilities;

5. Any easements and rights-of-way;

6. The delineation, if applicable, of the 100-year floodplain and any on site wetlands;

7. Structural and construction details for all components of the proposed drainage system or systems, and stormwater management facilities;

8. All necessary construction specifications;

9. A sequence of construction which includes, in the appropriate order;

   a. Notification of the Maryland Department of the Environment (MDE) Compliance Program, a minimum of seven (7) days in advance of any earth disturbance activity.

   b. Installation of perimeter erosion/sediment controls.

   c. Development clearing, grubbing, rough grading.

   d. Construction.

   e. Final grading.

   f. Vegetative stabilization.

   g. Installation of stormwater management practices.

   h. Removal, with MDE approval, of the erosion/sediment controls.

10. Data for total site area, disturbed area, new impervious area, and total impervious area;

11. A table showing the unified sizing criteria volumes required in the Design Manual;

12. A table of materials to be used for stormwater management facility planting;

13. All soil boring logs and locations;

14. A maintenance schedule;

15. Certification by the owner/developer that all stormwater management construction will be done according to this plan;

16. An As-Built certification signature block to be executed after project completion; and

17. Any other information required by the Administration.

6.0 INSPECTION REQUIREMENTS DURING CONSTRUCTION FOR AS-BUILT CERTIFICATION

A. At a minimum, regular inspections shall be made and documented at the following specified stages of construction:

1. Ponds:
   (a) Upon completion of excavation to sub-foundation and when required, installation of structural supports or reinforcement for structures, including but not limited to:
      (i) Core trenches for structural embankments.
      (ii) Inlet and outlet structures, anti-seep collars or diaphragms, and watertight connectors on pipes; and
      (iii) Trenches for enclosed storm drainage facilities.
   (b) During placement of structural fill, concrete, and installation of piping and catchbasins;
   (c) During backfill of foundations and trenches;
   (d) During embankment construction; and
   (e) Upon completion of final grading and establishment of permanent stabilization.

2. Wetlands – at the stages specified for pond construction in 6.0. A (1) of this section, during and after wetland reservoir area planting, and during the second growing season to verify a vegetation survival rate of at least 50 percent.

3. Infiltration trenches:
   (a) During excavation to subgrade;
   (b) During placement and backfill of underdrain systems and observation wells;
   (c) During placement of geotextiles and all filter media;
   (d) During construction of appurtenant conveyance systems such as diversion structures, pre-filters and filters, inlets, outlets, and flow distribution structures; and
4. Upon completion of final grading and establishment of permanent stabilization.

5. Infiltration basins – at the stages specified for pond construction in 6.0. A (1) of this section and during placement and backfill of underdrain systems.

6. Filtering systems:
   (a) During excavation to subgrade;
   (b) During placement and backfill of underdrain systems;

(c) During placement of geotextiles and all filter media;
(d) During construction of appurtenant conveyance systems such as flow diversion structures, pre-filters and filters, inlets, outlets, orifices, and flow distribution structures; and
(e) Upon completion of final grading and establishment of permanent stabilization.

7. Open channel systems:
   (a) During excavation to subgrade;
   (b) During placement and backfill of under drain systems for dry swales;
   (c) During installation of diaphragms, check dams, or weirs; and
   (d) Upon completion of final grading and establishment of permanent stabilization.

8. Nonstructural practices – upon completion of final grading and after the establishment of permanent stabilization.

B. Once construction is complete, As-Built Plan Certification shall be submitted to the Administration by either a professional engineer or professional land surveyor licensed in the State of Maryland to ensure that constructed stormwater management practices and conveyance systems comply with the specifications contained in the approved plans. At a minimum, As-Built certification shall include a set of drawings comparing the approved stormwater management plan with what was constructed. The Administration may require additional information. A copy of the As-Built Certification may be found on page 23 of these Guidelines.

7.0 MAINTENANCE

A. The owner of the property, or any other person or agent in control of such property, on which work has been done pursuant to these Guidelines, shall maintain in good condition and promptly repair and restore all grade surfaces, walls, drains, dams and structures, vegetation, erosion and sediment control measures, and other protective devices. Such repairs or restoration and maintenance shall be in accordance with approved plans.

B. A maintenance schedule shall be developed for the life of any stormwater management facility and shall state the maintenance to be completed, the time period for completion, and who shall perform the maintenance. This maintenance schedule shall be printed on the approved stormwater management plan.

MARYLAND DEPARTMENT OF THE ENVIRONMENT
Water Management Administration. • Sediment, Stormwater & Dam Safety Program
1800 Washington Blvd. • Baltimore Maryland 21230
(410) 537-3543 • 1-800-633-6101 • http://www.mde.state.md.us

STORMWATER MANAGEMENT WAIVER APPLICATION

OWNER: _____ MDE NO.: _____

ADDRESS: _____ PROJECT NO.:_____

_____ LOCATION:_____

CONSULTANT: _____

DESCRIPTION: _____

I/We, the Owner/Owners hereby request a stormwater management waiver be granted for the above referenced project in accordance with the following section of the Stormwater Management Guidelines for State and Federal Projects:

____ 3.3.A.1. Contract plans and provisions, stormwater management report.

____ 3.3.A.2. Contract plans and provisions, stormwater management report.

____ 3.3.A.3. Contract plans and provisions, stormwater management report.

____ 3.3.B.1. Contract plans and provisions, stormwater management report.

____ 3.3.B.2. Contract plans and provisions, stormwater management report, downstream impact investigation.

____ 3.3.B.3. Contract plans and provisions, stormwater management report.

____ 3.3.B.4. Contract plans and provisions, stormwater management report, downstream impact investigation

____ 3.3.B.5. Contract plans and provisions, stormwater management report, downstream impact investigation.

____ 3.3.B.6 Contract plans and provisions, stormwater management report, downstream impact investigation.

Other evidence submitted: _____

_____ _____ _____
Owner's Name Signature Date

____ Approved ____ Denied/Reason_____

By _____ _____
Water Resources Reviewer Date

Submit to: Maryland Department of the Environment
Water Management Administration
Sediment and Stormwater Plan Review Division
1800 Washington Boulevard, 4th Floor
Baltimore, MD 21230

If a project involves a waiver request for more than one (1) drainage area, a Stormwater Management Waiver Application is required for each drainage area.

AS BUILT CERTIFICATION

I hereby certify that the stormwater management facility shown on the plans has (have) been constructed in accordance with the plans approved by the Maryland Department of the Environment, except as noted in red on the "AS BUILT" drawings.

Name _____ Signature _____

Maryland registration number _____ Date _____

MDE No. _____ Facility Identification (number and/or type) _____

"Certify" means to state or declare a professional opinion based on sufficient and appropriate onsite inspections and material tests conducted during construction.

Professional Certification. I hereby certify that these documents were prepared or approved by me, and that I am a duly licensed professional engineer under the laws of the State of Maryland, License No. _____ Expiration Date:_____

DESIGN CERTIFICATION:

"I hereby certify that this plan has been designed in accordance with the 1994 Standards and Specifications for Soil Erosion and Sediment Control, the 2000 Maryland Stormwater design Manual, Volumes I & II and The Maryland Department of the Environment Stormwater Management Regulations.

Name _____ Signature _____

Maryland registration number _____ Date _____
P.E., R.L.S. or R.L.A. (circle)

Professional Certification. I hereby certify that these documents were prepared or approved by me, and that I am a duly licensed professional engineer under the laws of the State of Maryland, License No. _____ Expiration Date:_____

TABLE 1

For the purposes of Section 3.3 B.6 of these Guidelines, the following are Minimum County Flood Control Requirements:

COUNTY	QP_2	QP_{10}
Allegany	NO	OPTIONAL[2]
Anne Arundel	NO	OPTIONAL[1]
Baltimore	NO	OPTIONAL[2]
Calvert	NO	OPTIONAL[2]
Caroline	YES	NO
Carroll	NO	OPTIONAL[2]
Cecil	YES[3]	OPTIONAL[1]
Charles	NO	OPTIONAL[1]
Dorchester	YES	NO
Frederick	NO	MANDATORY
Garrett	NO	OPTIONAL[2]
Harford	NO	MANDATORY
Howard	NO	OPTIONAL[2]
Kent	NO	OPTIONAL[2]
Montgomery	NO	OPTIONAL[2]
Prince George's	NO	OPTIONAL[2]
Queen Anne's	YES	NO
St. Mary's	NO	OPTIONAL[2]
Somerset	YES	NO
Talbot	YES	NO
Washington	NO	MANDATORY
Wicomico	YES	NO
Worcester	YES	NO

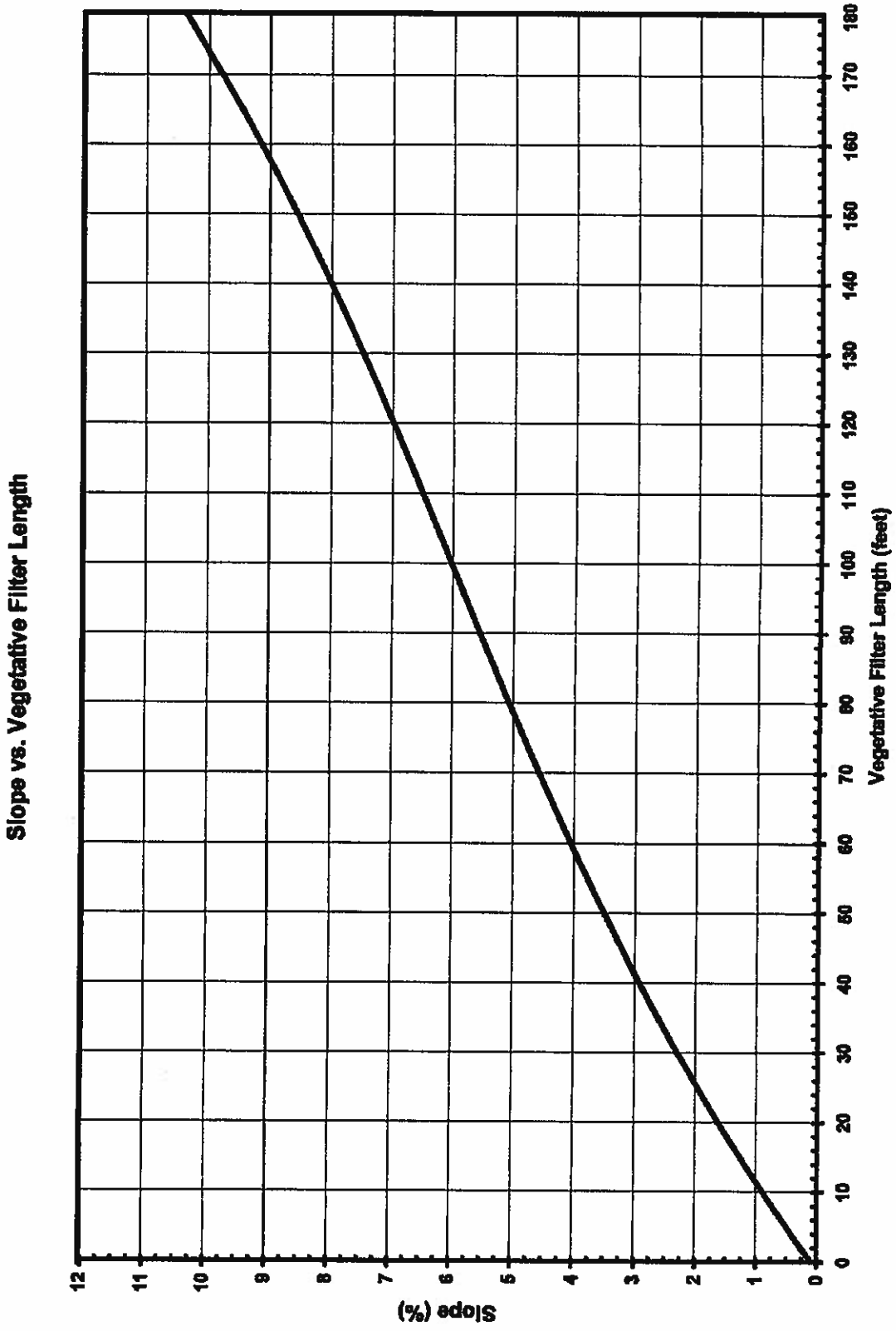
1. **Where applicant demonstrates that downstream flooding is not an issue and conveyance is adequate, Q_{p10} is not required.**
2. **Where downstream flooding problems exist or conveyance is inadequate, Q_{p10} is required.**
3. **Q_{p2} is required in the Coastal Plain (south of the Chesapeake & Delaware Canal).**

TABLE 2

For the purposes of Section 3.3 B.5 of these Guidelines, the following are considered MAJOR WATERWAYS:

WATERWAY	LIMITS
Susquehanna River	mainstem from mouth to Pennsylvania line
Pocomoke River	mainstem from mouth to MD 12
Nanticoke River	mainstem from mouth to Delaware line
Choptank River	mainstem from mouth to MD 404
Chester River	mainstem from mouth to MD 290
Elk River	mainstem from mouth to US 40
Bush River	mainstem from mouth to US 40
Gunpowder River	mainstem from mouth to US 40
Patapsco River	mainstem from mouth to US 1
Patuxent River	mainstem from mouth to MD 4
Potomac River	mainstem from mouth to I 81
Youghiogheny River	mainstem from Pennsylvania line to I 68
Wicomico River (Wicomico Co.)	mainstem from mouth to US 50

Figure 1. Minimum Vegetative Filter Length Requirements
To Meet TSS Removal Goals
(Manning's "n" = 0.20)



STORMWATER MANAGEMENT "AS-BUILT" CERTIFICATION

I hereby certify that the stormwater management facility (facilities) shown on the plans and individually identified below has (have) been constructed in accordance with the plans included under the Maryland Department of the Environment Approval, Number __ __ - SF - __ __ __ __, except as noted in red on the "AS BUILT" drawings. Furthermore, the red-noted exceptions do not adversely affect the intended performance of the facility (facilities).

_____ _____

_____ _____

_____ _____

Facility Identification (Identify Each Facility Individually)

_____ _____

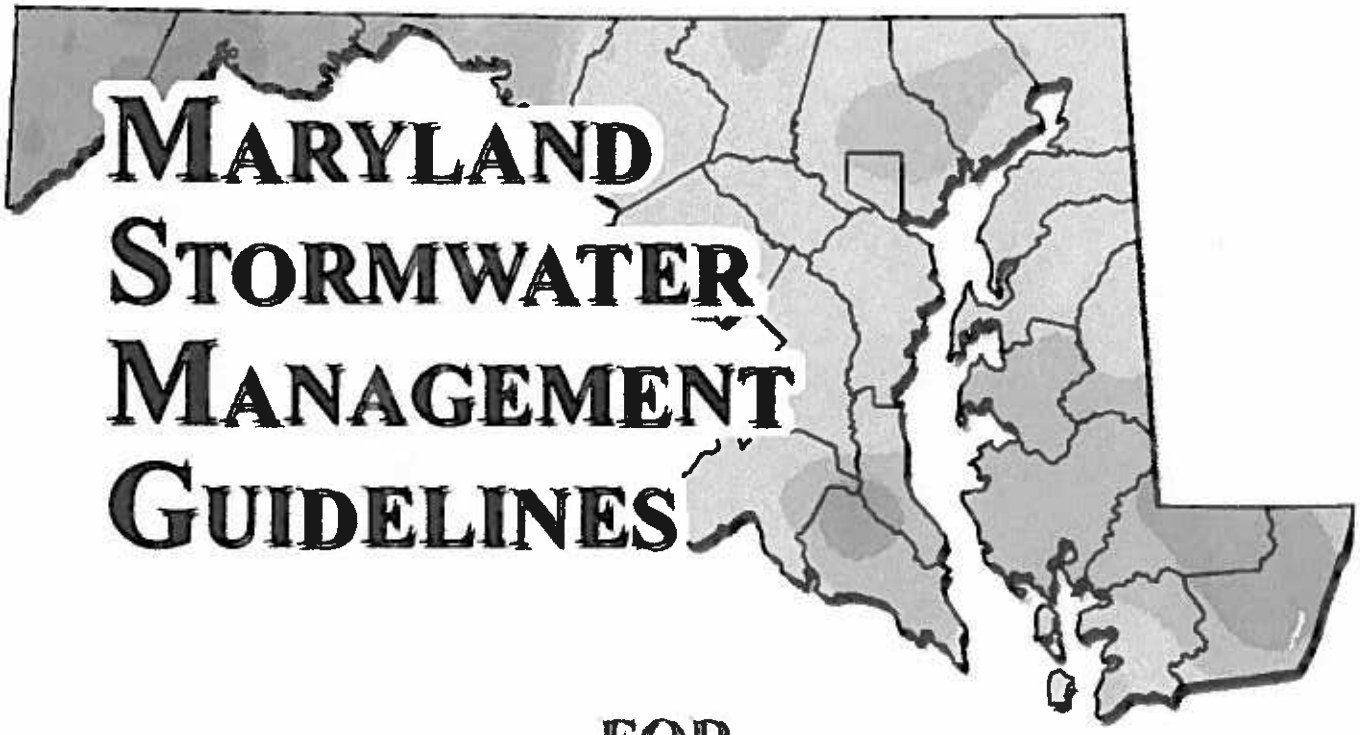
Name (Printed) Signature

_____ _____

Maryland Registration Number Date

"Certify" means to state or declare a professional opinion based on sufficient and appropriate onsite inspections and material tests conducted during construction

Stormwater Management Guidelines for State and Federal Projects (4/15/2010)



MARYLAND STORMWATER MANAGEMENT GUIDELINES

FOR

STATE & FEDERAL PROJECTS

APRIL 15, 2010

MARYLAND
Department of the Environment

1800 Washington Boulevard | Baltimore, MD 21230-1718 | www.mde.state.md.us
410-537-3000 | 800-633-6101 | TTY Users: 800-735-2258
Martin O'Malley, *Governor* | Anthony G. Brown, *Lt. Governor* | Shari T. Wilson, *Secretary*

INTRODUCTION

The Environment Article, Title 4, Subtitle 2 requires the Maryland Department of the Environment (MDE) to implement a statewide stormwater management program to control runoff from development. To meet this mandate, MDE has adopted regulations that establish criteria and procedures for managing stormwater throughout Maryland.

The Stormwater Management Act of 2007 (Act) further requires that the Code of Maryland Regulations (COMAR) be modified and guidance and ordinances be developed for the purpose of implementing environmental site design (ESD) to the maximum extent practicable (MEP). The Act defines ESD as "...using small-scale stormwater management practices, nonstructural techniques, and better site planning to mimic natural hydrologic runoff characteristics and minimize the impact of land development on water resources." ESD also promotes conserving natural features, drainage patterns, and vegetation; minimizing impervious surfaces; slowing down runoff; and increasing infiltration. Significant changes to COMAR and the 2000 Maryland Stormwater Design Manual, Volumes I & II (Design Manual) were adopted in May 2009. These changes specify how ESD is to be implemented, how the MEP standard is to be met, and how the review of erosion and sediment control and stormwater management plans is to be integrated. The Maryland Stormwater Management Guidelines for State and Federal Projects represent the next step toward meeting MDE's obligations under current law and serves as guidance for developing, reviewing, and approving stormwater management plans for State and federal projects.

The changes required to implement the Act are significant and will force developers and designers to consider runoff control from the start of the land development process. The definition of ESD, the modifications to COMAR, and the procedures and minimum plan contents specified herein will guide all State and federal agencies submitting stormwater management plans to MDE. Because stormwater management for new development and redevelopment will be conceived, designed, reviewed, and built differently from procedures used prior to passage of the Act, transitioning to the new methods will take some time, and obstacles may be encountered. However, implementing ESD to the MEP must be the overriding goal that pervades each step.

Guidance for preparing an erosion and sediment control plan is provided separately in the Maryland Erosion and Sediment Control Guidelines for State and Federal Projects. If there are any questions or comments regarding these guidelines, please contact the Sediment & Stormwater Plan Review Division in the Water Management Administration of MDE at 410-537-3563.

MARYLAND DEPARTMENT OF THE ENVIRONMENT
SWM GUIDELINES
FOR STATE AND FEDERAL PROJECTS

Table of Contents

Page

1.0 Purpose and Authority 3

1.1 Incorporation by Reference

2.0 Definitions 3

3.0 Applicability 7

3.1 Scope
3.2 Exemptions
3.3 Waivers
3.4 Variance
3.5 New Development
3.6 Redevelopment
3.7 Combination of New Development and Redevelopment
3.8 Alternative Management Measures
3.9 Compensatory Stormwater Management
3.10 Agency/Institutional Management Plan

4.0 Stormwater Management Criteria 12

4.1 Minimum Control Requirements
4.2 Stormwater Management Measures
4.3 Specific Design Criteria

5.0 Stormwater Management Plans 17

5.1 Review and Approval of Stormwater Management Plans
5.2 Preparation of Stormwater Management Plan
5.3 Contents of Stormwater Management Plan

6.0 Inspection 24

6.1 Inspection Schedule and Reports
6.2 Inspection Requirements during Construction for As-Built Certification

7.0 Maintenance 26

Table of Contents (continued)

Page

8.0 Appendix.

Application for Sediment Control/Stormwater Management Plan Approval 27
Stormwater Management Waiver Application 28
Owner/Developer Certification 29
Design Certification 29
Minimum County Flood Control Requirements (Table 1) 30
Major Waterways (Table 2) 31
Small Pond Summary Sheet 32
As Built Certification 33
As-Built Tabulations 34-41
Stormwater Maintenance Schedules 42-60

1.0 PURPOSE AND AUTHORITY

The purpose of these Guidelines is to protect, maintain and enhance the public health, safety, and general welfare by establishing minimum requirements and procedures to reduce the adverse impacts associated with increased stormwater runoff. The goal is to manage stormwater by using environmental site design (ESD) to the maximum extent practicable (MEP) to reduce stream channel erosion, pollution, siltation, sedimentation, and local flooding, and to use appropriate structural best management practices (BMPs) only when necessary. This will restore, enhance, and maintain the chemical, physical, and biological integrity of streams, minimize damage to public and private property, and reduce the impacts of land development.

The provisions of these Guidelines are pursuant to the Annotated Code of Maryland, Environment Article, Title 4, Subtitle 2 and the Stormwater Management Regulations, COMAR 26.17.02.01 through 26.17.02.12. These Guidelines supplement the 2000 Maryland Stormwater Design Manual and all subsequent revisions. They provide the minimum stormwater management requirements for plans submitted by State and federal agencies to the Maryland Department of the Environment (MDE), for review and approval. These Guidelines do not affect the validity of any portion of either the Environment Article or COMAR and apply to all new and redevelopment projects.

1.1 Incorporation by Reference

For the purpose of these Guidelines, the following documents are incorporated by reference:

A. The 2000 Maryland Stormwater Design Manual Volumes I & II (Maryland Department of the Environment, April 2000), Supplement No. 1, and all subsequent revisions serve as the official guide for stormwater principles, methods, and practices.

B. USDA Natural Resources Conservation Service Maryland, Conservation Practice Standard, Pond- Code 378 (January 2000) or latest revision.

2.0 DEFINITIONS

For the purpose of these Guidelines, the definitions below describe the meaning of the following terms:

1. "Administration" means the Maryland Department of the Environment, Water Management Administration.

2. "Adverse impact" means any deleterious effect on waters or wetlands, including changes to quality, quantity, surface area, species composition, aesthetics or usefulness for human or natural uses which are or may potentially be harmful or injurious to human health, welfare, safety or property, to biological productivity, diversity, or stability or which unreasonably interfere with the enjoyment of life or property, including outdoor recreation.

3. "Agricultural land management practices" means those methods and procedures used in the cultivation of land in order to further crop and livestock production and conservation of related soil and water resources.

4. "Applicant" means any State or federal governmental agency that executes the necessary forms to procure official approval to carry out construction of a project (i.e., the entity responsible for the project, not necessarily the land owner).

5. "Best management practice (BMP)" means a structural device or nonstructural practice designed to temporarily store or treat stormwater runoff in order to mitigate flooding, reduce pollution, or provide other amenities.

6. "Channel Protection Storage Volume (Cpv)" means the volume used to design management practices to control stream channel erosion. Methods for calculating the channel protection storage volume are specified in the 2000 Maryland Stormwater Design Manual, Volumes I and II and Supplement No. 1.

7. "Clearing" means the removal of trees and brush from the land.

8. "Concept plan" means the first of three required plan approvals that includes the information necessary to allow an initial evaluation of a proposed project.

9. "Design Manual" means the 2000 Maryland Stormwater Design Manual, Supplement Number 1, and all subsequent revisions, that serve as the official guide for stormwater management principles, methods, and practices.

10. "Direct discharge" means the concentrated release of stormwater to tidal waters or vegetated tidal wetlands in the Critical Area from new development or redevelopment projects.

11. "Disturbance" means exposing the soil.

12. "Drainage area" means that area, measured in a horizontal plane, that contributes runoff to a specific location.

13. "Easement" means a grant or reservation by the owner of land for the use of such land by others for a specific purpose or purposes, and which must be included in the conveyance of land affected by such easement.

14. "Environmental site design (ESD)" means using small-scale stormwater management practices, nonstructural techniques, and better site planning to mimic natural hydrologic runoff characteristics and minimize the impact of land development on water resources. Methods for designing ESD practices are specified in the Design Manual.

15. "Exemption" means those land development activities that are not subject to the stormwater management requirements contained in these Guidelines.

16. "Final stormwater management plan" means the last of three required plan approvals that includes the information necessary to allow all approvals and permits to be issued by the Administration.

17. "Grading" means any act by which soil is stripped, stockpiled, excavated, scarified, filled, or any combination thereof.

18. "Grubbing" means exposing the earth by removal of the root mat.

19. "Impervious area" means any surface that does not allow stormwater to infiltrate into the underlying soil. Examples include pavement and gravel surfaces used for vehicular traffic.

20. "Infiltration" means the passage or movement of water into the soil.

21. "Institutional Management Plan" means an Administration approved plan developed by a State or federal agency that addresses stormwater management for an institution with respect to the associated watersheds.

22. "Maintenance" with regard to disturbance of impervious surfaces means pavement overlay and/or patching and replacement of deteriorated impervious surfaces.

23. "Maximum extent practicable (MEP)" means designing stormwater management systems so that all reasonable opportunities for using ESD planning techniques and treatment practices are exhausted and only where absolutely necessary, a structural BMP is implemented.

24. "Off-site stormwater management" means the design and construction of a BMP located outside the project limits to control stormwater from one or more sites.

25. "On-site stormwater management" means the design and construction of systems necessary to control stormwater within the limits of the project.

26. "Overbank flood protection volume (Qp)" means the volume of stormwater runoff controlled by structural practices to prevent an increase in the frequency of out of bank flooding generated by development. Methods for calculating the overbank flood protection volume are specified in the Design Manual.

27. "Predevelopment" means existing, prior to conception of a proposed project.

28. "Planning techniques" means a combination of strategies employed early in project design to reduce the impact from development and to incorporate natural features into a stormwater management plan.

29. "Point of Investigation (POI)" means the location where runoff from the drainage area leaves the project site.

30. "Project Site" means the area bounded by the limit of disturbance or as approved by the Administration.

31. "Recharge volume (Rev)" means that portion of the water quality volume used to maintain groundwater recharge rates for new development. Methods for calculating the recharge volume are specified in the Design Manual.

32. "Redevelopment" means any construction, alteration, removal, or improvement performed on existing impervious area at a site where existing land use is commercial, industrial, institutional, or multifamily residential and existing project site impervious area exceeds 40 percent.

33. "Retention structure" means a permanent structure that provides for the storage of runoff by means of a permanent pool of water.

34. "Sediment" means soils or other surficial materials transported or deposited by the action of wind, water, ice, or gravity as a product of erosion.

35. "Site" means any tract, lot, or parcel of land, or combination of tracts, lots, and parcels of land that are in one ownership or are contiguous and in diverse ownership, where development is to be performed as part of a unit, subdivision, or project.

36. "Site development plan" means the second of three required plan approvals that includes the information necessary to allow a detailed evaluation of a proposed project.

37. "Stabilization" means the prevention of soil movement by covering exposed earth using any of various vegetative and/or structural means.

38. "Stormwater" means water that originates from a precipitation event.

39. "Stormwater management" means, for:
    a. Quantitative control, a system of vegetative and structural measures that control the increased volume and rate of surface runoff caused by man-made changes to the land; and
    b. Qualitative control, a system of vegetative, structural, and other measures that reduce or eliminate pollutants that might otherwise be carried by runoff.

40. "Stormwater management system" means ESD practices, BMPs, and any other structural or nonstructural measures through which stormwater is detained, filtered, or infiltrated prior to discharge from a site.

41. "Variance" means the modification of the minimum stormwater management requirements for specific circumstances such that strict adherence to the requirements would result in unnecessary hardship and would not fulfill the intent of these Guidelines.

42. "Waiver" means the reduction of stormwater management requirements for a specific project on a case-by-case review basis.

43. "Watercourse" means any natural or artificial stream, river, creek, ditch, swale, gutter, channel, canal, conduit, culvert, drain, waterway, gully, or ravine in and including any adjacent area that is subject to inundation from overflow or flood water.

44. "Water quality volume (WQv)" means the volume needed to capture and treat 90 percent of the average annual runoff volume at a development site. Methods for calculating the water quality volume are specified in the Design Manual.

45. "Watershed" means the total drainage area contributing runoff to a single point.

46. "Watershed Management Plan" means a county or local municipality approved plan that is acceptable to the Administration.

3.0 APPLICABILITY

3.1 Scope

A State or federal agency shall not develop any land without having provided stormwater management measures that control or manage runoff from such development, except as provided within this Section. Stormwater management measures for new development and redevelopment must be consistent with the Design Manual and constructed according to an approved plan.

3.2 Exemptions

The following are exempt from the provisions of these Guidelines and the requirements of providing stormwater management:

A. Agricultural land management practices; and

B. Any project that does not disturb over 5,000 square feet of land area.

3.3 Waivers

The 2007 Stormwater Management Act restricts stormwater management waivers because ESD must be implemented to the MEP. There will be, however, development situations that warrant relaxing management obligations due to site specific circumstances. The goal is to use the clear mandate found in the Act for implementing ESD to the MEP to change the prevailing mindset of seeking a waiver for a project before considering management.

A Stormwater Management Waiver Application must be submitted by the Applicant or authorized representative and specifically indicate the appropriate waiver category. The application must include sufficient descriptions, drawings, and other information necessary to evaluate the proposed project and confirm the applicability of the waiver request. A new Stormwater Management Waiver Application may be required in accordance with the provisions of this Section if there are subsequent additions, extensions, or modifications to a project receiving a waiver. A written notice from the Administration must be received for a waiver to be valid. A Stormwater Management Waiver Application must be required for each eligible point of investigation where runoff leaves the project site. A copy of the Stormwater Management

Waiver Application may be found in the Appendix of these Guidelines.

For projects with multiple points of investigation (POI), the waiver applies to the POI and not to the entire project.

A. The Administration may grant a waiver of all quality and quantity stormwater management control requirements where an Applicant can demonstrate to the satisfaction of the Administration that the disturbed area for certain pipeline projects, conduit projects, underground projects, landscaping projects, maintenance projects, etc. will be returned to the existing condition and will have no hydrologic change.

B. The Administration may grant a waiver of the stormwater management quantity control requirements where the Applicant can demonstrate to the satisfaction of the Administration that the cumulative effects of the waiver policy ensure no adverse impact to the downstream watercourse, that ESD has been implemented for a minimum of one inch of rainfall, and that:

1. The POI discharges to tidally influenced receiving waters:
   a. For direct discharges (Cpv and Qp);
   b. For discharges (Cpv and Qp) within property boundaries with stable conveyance [see Section 4.1.A.4];
   c. For discharges (Qp) within property boundaries for which Cpv is provided; or

2. The POI discharges into a major waterway (see Table 2):
   a. For direct discharges (Cpv and Qp);
   b. For discharges (Cpv and Qp) within property boundaries with stable conveyance [see Section 4.1.A.4.];
   c. For discharges (Qp) within property boundaries for which Cpv is provided; or

3. The POI discharges into an existing closed storm sewer system that outfalls directly to a major waterway or tidally influenced waters with:
   a. Adequate capacity for Q10-year (Cpv and Qp);
   b. Adequate capacity for Q1-year (Cpv); or

4. Historical downstream flooding problems do not exist and the local jurisdiction does not require management of the overbank flood protection (Qp) volume within the watershed (see Table 1). Cpv must be provided as required by the Design Manual.

3.4 Variance

The Administration may grant a written variance from any requirement of Section 4.0, Stormwater Management Criteria of these Guidelines if there are exceptional circumstances applicable to the site such that strict adherence will result in unnecessary hardship and not fulfill the intent of the Guidelines. A written request for variance must be provided to the Administration and must state the specific variance sought and any evidence necessary to support the request. A variance may be granted upon consideration and as deemed appropriate by the Administration.

3.5 New Development

New development projects have an increase in impervious surfaces and/or change the site's hydrologic conditions. New development projects must be designed in accordance with Section 4.0 Stormwater Management Criteria. New development management requirements extend to areas of redevelopment where the impervious area of the existing project site is less than 40 percent.

3.6 Redevelopment

Redevelopment is the construction, alteration, removal, or improvement performed to existing impervious area at a site where the existing project site impervious area exceeds 40 percent. Redevelopment projects have no net increase in impervious surfaces. When calculating site imperviousness, the lands protected by forest preservation, conservation easements, or other mechanism may be subtracted from the site area. This will create an incentive to preserve and protect natural resources in redevelopment projects.

The stormwater management goal for redevelopment is to gain water quality treatment on existing developed lands while supporting initiatives to improve urban areas. All options for ESD must be exhausted during planning and site design of redevelopment projects; however, it is recognized that a wide range of site constraints may limit effective implementation of ESD. Alternative management options after compliance with the ESD to the MEP are available.

Stormwater management for redevelopment must be in accordance with the following:

A. ESD must be implemented to the MEP to provide water quality treatment for a minimum of 50 percent of the existing impervious area within the LOD. To meet stormwater management requirements for redevelopment using ESD, treatment must be provided for the runoff from 1 inch of rainfall (i.e., P_E = 1 inch) for 50 percent of the redeveloped impervious area. Quantity management, including Cpv treatment, is not required for redevelopment.

B. The redevelopment designs must reduce existing impervious areas within the project limit of disturbance (LOD) by a minimum of 50 percent. When a combination of impervious area reduction and ESD implementation is used, the combined reduction and treated areas must be equal to, or exceed, 50 percent of the existing impervious area within the LOD. When redevelopment reduces the impervious area within the LOD by 50 percent or more, water quality treatment is satisfied.

C. Where conditions prevent impervious area reduction and/or the implementation of ESD

to the MEP, alternative management practices may be considered in accordance with Section 3.8 Alternative Management Measures.

D. If a redevelopment activity changes the site runoff characteristics in a manner that creates points of concentrated flow where previously there was sheet flow or increases discharge rates for 1-year, 2-year, and 10-year 24-hour frequency storms, Cpv and Qp may be required by the Administration.

E. The Administration may determine that certain practices that do not involve earth disturbance such as pavement overlay and/or patching and sidewalk replacement are considered maintenance and redevelopment requirements may not be applicable.

F. When existing impervious areas drain to an existing BMP meeting previously approved requirements, these areas are considered treated. Redevelopment requirements will apply to the remaining unmanaged existing impervious areas within the LOD. The performance of an existing BMP will need to be verified, and if the BMP is not functioning as designed, necessary improvements to meet appropriate standards must be provided.

3.7 Combination of New Development and Redevelopment

A project that includes both new development and areas of redevelopment must manage the new development portion in accordance with Section 3.5 New Development and the redevelopment portion in accordance with Section 3.6 Redevelopment. If a net increase in impervious area occurs, stormwater management for the increased impervious area must be addressed according to new development requirements and must follow Section 4.0 Stormwater Management Criteria.

3.8 Alternative Management Measures

Where conditions prevent impervious area reduction and/or the implementation of ESD to the MEP, alternative management measures may be considered in the following order of preference:

A. An on-site structural BMP designed in accordance with Chapter 3 of the Design Manual:
   1. Stormwater filtering systems, open channel systems, and stormwater infiltration;
   2. Stormwater ponds;

B. An off-site structural BMP designed in accordance with Chapter 3 of the Design Manual, located within the project watershed, and included as part of the project:
   1. Stormwater filtering systems, open channel systems, and stormwater infiltration;
   2. Stormwater ponds;

C. Retrofitting an existing BMP;

D. Watershed or stream restoration; or

E. Other practices approved by the Administration.

3.9 Compensatory Stormwater Management

The Administration may allow compensatory stormwater management when ESD cannot be implemented on a specific site and:

A. Compensatory stormwater management will be implemented in accordance with a Memorandum of Agreement (MOA) between MDE and the State or federal agency; or

B. The Compensatory stormwater management MOA incorporates a locally approved watershed management plan that is acceptable to the Administration.

3.10 Agency/Institutional Management Plan

An Agency/Institutional Management Plan developed for the purpose of implementing stormwater management practices to address existing and future development within the contiguous lands of a State or federal agency shall:

A. Evaluate both quantity and quality management and opportunities for ESD implementation;

B. Include detailed hydrologic and hydraulic analyses to determine hydrograph timing;

C. Include cumulative impact assessment of current and future development;

D. Identify existing flooding areas and receiving stream channel conditions;

E. Include a detailed site map indicating the location of all existing and future stormwater management practices as well as the delineated drainage area to each practice, presented at a reasonable scale;

F. Specify where on-site or off-site quantitative and qualitative stormwater management practices and watershed improvements are or will be implemented;

G. Be consistent with the General Performance Standards for Stormwater Management in Maryland found in Section 1.2 of the Design Manual;

H. Be consistent with any relevant local watershed management plan(s) and/or include compensatory stormwater management;

I. Be signed by the Applicant;

J. Be signed by the Applicant's engineer; and

K. Be approved by the Administration.

4.0 STORMWATER MANAGEMENT CRITERIA

4.1 Minimum Control Requirements

The primary standard of ESD is to reduce post development runoff to levels found in natural, forested conditions. This requires capturing and treating from 1 inch to 2.6 inches of rainfall depending on the design and site conditions (e.g., proposed imperviousness, soils). ESD must be used to treat runoff from 1 inch of rainfall (WQv, and Rev). This is a minimum level of compliance. When the entire target rainfall is treated using ESD, the Cpv requirements, in addition to WQv, and Rev, are satisfied. Designers are responsible for determining specific rainfall targets using the methods outlined in Section 5.2 of the Design Manual.

The Administration will enforce the MEP standard for State and federal projects. Professional judgment will be needed to determine whether site constraints prevent the reasonable implementation of ESD.

A. The minimum control requirements are as follows:

1. The Administration must require that the planning techniques, nonstructural practices, and design methods specified in Chapter 5 of the Design Manual be used to implement ESD to the MEP. The use of ESD planning techniques and treatment practices must be exhausted before any structural BMP from Chapter 3 of the Design Manual is implemented. Stormwater management plans must be designed using ESD sizing criteria for Re_v, WQ_v, Cp_v, according to the Design Manual. The ESD standard is met when post-development hydrology is restored to woods in good condition assuring that channel stability is maintained, that predevelopment groundwater recharge is replicated, nonpoint source pollution is minimized, and that structural stormwater management practices are used only when determined to be absolutely necessary.

2. Refer to Table 1 of these guidelines to determine whether control of the 2-year and 10-year 24-hour frequency storm events is required. When management is required, the design must be in accordance with the Design Manual and all subsequent revisions.

3. Projects located in designated Inter-jurisdictional Flood Hazard Watersheds (Jones Falls, Gwynns Falls, and Herring Run in Baltimore City/County and Carroll Creek in Frederick City/County) will be required to provide management measures necessary to maintain the post-development peak discharges for the 100-year 24-hour frequency storm event at a level that is equal to, or less than, the 100-year 24-hour pre-development peak discharge rates. The stormwater management practices must control the volume, timing, and rate of flow necessary to maintain "no increase" in the downstream peak discharge for the 100-year 24-hour frequency storm event.

4. Stable and safe conveyance of the 10-year 24-hour frequency storm must be provided for all points of discharge from the project. Discharge velocities for the 10-year storms must be non-erosive. The downstream impact analysis must extend to the first downstream tributary whose drainage area equals or exceeds

the contributory drainage area to the POI; or to the downstream point where the flow rate is a minimum of twice the discharge rate from the POI;

5. The Administration may require more than the minimum control requirements specified in these Guidelines if hydrologic or topographic conditions warrant or if historical downstream flooding or receiving channel degradation exists or has the potential to occur as a result of the project.

B. Alternate minimum control requirements may be adopted subject to Administration approval. The Administration shall require that alternative requirements include ESD to the MEP and control flood damages, accelerated stream erosion, water quality, and sedimentation. Comprehensive watershed studies may also be required.

C. Where applicable, stormwater management plans must be consistent with adopted and approved institutional management plans, watershed management plans, or flood management plans as approved by MDE in accordance with the Flood Hazard Management Act of 1976.

D. Identify and provide any additional protection measures for Tier II streams, Critical Areas, and impaired waters or waters with an established Total Maximum Daily Load (TMDL) above the required ESD to the MEP.

4.2 Stormwater Management Measures

The ESD planning techniques and practices and structural stormwater management measures established in the Design Manual must be used either alone or in combination. An applicant must demonstrate that ESD has been implemented to the MEP before using any structural BMP.

A. ESD Planning Techniques.

1. The following planning fundamentals must be applied according to the Design Manual to satisfy the applicable minimum control requirements established in Section 4.1 of these Guidelines:

   a. Preserving and protecting natural resources;

   b. Conserving natural drainage patterns;

   c. Minimizing impervious area;

   d. Using green roofs, permeable pavement, reinforced turf, and other alternative surfaces;

   e. Reducing runoff volume;

   f. Maintaining 100 percent of the annual predevelopment groundwater recharge volume;

   g. Clustering development;

h. Limiting soil disturbance, mass grading, and compaction; and

i. Other techniques approved by the Administration.

2. The following ESD treatment practices must be designed in accordance with the Design Manual to satisfy the applicable minimum control requirements established in Section 4.1 of these Guidelines:

a. Disconnection of rooftop runoff;

b. Disconnection of non-rooftop runoff;

c. Sheetflow to conservation areas;

d. Rainwater harvesting;

e. Submerged gravel wetlands;

f. Landscape infiltration;

g. Infiltration/filtration berms;

h. Dry wells;

i. Micro-bioretention;

j. Rain gardens;

k. Vegetated swales;

l. Enhanced filters; and

m. Other practices approved by the Administration.

3. The use of ESD planning techniques and treatment practices specified in this Section must not conflict with existing State law or local ordinances, regulations, or policies.

B. Structural Stormwater Management Measures.

1. If Cpv has not been fully provided after implementing ESD to the MEP, the following structural stormwater management practices must be designed in accordance with the Design Manual to satisfy the applicable minimum control requirements established in Section 4.1 of these Guidelines:

a. Stormwater management ponds;

b. Stormwater management wetlands;

c. Stormwater management infiltration;

d. Stormwater management filtering systems; and

e. Stormwater management open channel systems.

2. The performance criteria specified in the Design Manual with regard to general feasibility, conveyance, pretreatment, treatment and geometry, environment and landscaping, and maintenance must be considered when selecting structural stormwater management practices.

3. Structural stormwater management practices must be selected to accommodate unique hydrologic or geologic conditions, such as Karst topography and high groundwater, encountered within certain regions of the State.

C. Alternative ESD planning techniques, ESD treatment practices, and structural stormwater measures may be used for managing stormwater if they meet the performance criteria established in the Design Manual, and all subsequent revisions, and are approved by the Administration.

D. In situations where the minimum control requirements or design criteria may adversely impact the hydrology or hydraulics downstream of the project, the owner/developer must submit to the Administration an analysis of the impacts of stormwater flows downstream in the watershed. The analysis must include hydrologic and hydraulic calculations necessary to determine the impact of hydrograph timing due to the proposed development upon a dam, highway, structure, or natural point of restricted streamflow. The point of analysis is to be established with the concurrence of the Administration and should be located at the point downstream of the first downstream tributary whose drainage area equals or exceeds the contributing area to the project or stormwater management facility.

E. ESD planning techniques, treatment measures, and structural stormwater management practices, constructed in accordance with an approved plan, must not be altered after construction without approval from the Administration. Prior to considering changes to any stormwater management practice, a conservation area, or an area used as a disconnection, approval must be obtained from the Administration.

F. Compensatory Stormwater Management (Section 3.5).

4.3 Specific Design Criteria

The design criteria, methodologies, and construction specifications, subject to the approval of the Administration, are those of the Design Manual.

A. Infiltration systems must be designed in accordance with the Design Manual and must also meet the following requirements:

1. The facility design must include an overflow system with measures to provide a non-erosive discharge velocity.

2. A least one observation well must be provided for an infiltration trench. The depth to the constructed facility bottom must be marked with permanent marker on the inside of the cap.

B. Ponds, wetlands, filtering systems, and open channel systems must be designed and constructed in accordance with the Design Manual and must also include the following items:

1. Velocity dissipation devices should be placed at the outfall of all detention or retention structures and along the length of any outfall channel as necessary to provide non-erosive velocities at the point of discharge. Flow spreaders may be used to promote sheet flow.

2. If an increase in flooding or stream channel erosion could result at a downstream dam, highway, structure, or natural point of restricted stream flow, the designed release rate of the facility must be reduced.

3. Where the selected BMP is a small pond as defined in Natural Resource Conservation Service (NRCS) Code 378, an NRCS Pond Summary Sheet (see Appendix) must be submitted to and approval obtained from the Administration pursuant to the Environmental Article, Annotated Code of Maryland, Title 5, Subtitle 5.

4. Acceptable methods of modeling the stormwater discharge from a site are TR-55, TR-20 or other methods approved by the Administration.

5.0 STORMWATER MANAGEMENT PLANS

COMAR requires that the ESD process begin at project conception and proceed through final approval. Additionally, COMAR now requires that stormwater and erosion and sediment control strategies be combined. The objective is that review comments be obtained early in the approval process to promote feedback for more effective and improved final stormwater plans. Listed below is the minimum content for the three phases of plan development (concept, site development, and final). Projects with minor impacts may be able to proceed from Concept Approval directly to Final Approval.

The design review and approval process for the three different phases of project planning must ensure that all important resources have been mapped and protected, and all opportunities to enhance natural areas have been explored early in project design. Impervious cover should be minimized, nonstructural practices should be used to disconnect impervious surfaces where possible, and the use of alternative surfaces explored. When all options for the use of ESD have been exhausted, alternative management measures should be used to capture and treat runoff.

5.1 Review and Approval of Stormwater Management Plans

A. For any proposed development disturbing ≥ 5000 square feet, the Applicant must submit phased stormwater management plans to the Administration for review and approval. Plans must be submitted for the concept, site development, and final stormwater management. Each plan submittal must include the minimum content specified in Sections 4.0 and 5.3 of these Guidelines and meet the requirements of the Design Manual.

B. A completed Application for Sediment Control/Stormwater Management Plan Approval must be provided with each submittal (see Appendix).

C. The Administration will review the stormwater management and erosion and sediment control plans for each submittal and provide the applicant with comments as warranted. An approval will be issued at each phase of project design. The approval will contain appropriate comments from the Administration that must be addressed and resubmitted in the subsequent development phases. For any approval phase, the applicant may submit the required plan detail and computations to expedite the review/approval process as outlined in Section 5.3.B or 5.3.C. The Final Stormwater Management and Erosion/sediment Control Plan will be considered approved upon being stamped and signed by the Sediment and Stormwater Plan Review Division Chief and/or designee, and issuance of the written approval for the project.

D. Should the applicant desire a set of approved plans stamped by Sediment and Stormwater Plan Review Division Chief, a request must be made and the final plan submittal must include two sets of plans. Post approval requests for stamped plans cannot be honored.

E. Proposed modifications to an approved stormwater management/erosion and sediment control plan must be submitted to and approved by the Administration in writing. Requests for a modification must be accompanied by a completed application in accordance with Section 5.1.B and must include the reason for and a description of the proposed change, plan sheet(s) showing the proposed changes, and a copy of the

originally approved, affected plan sheet(s).

5.2 Preparation of the Stormwater Management Plan

A. The stormwater management plan must be prepared by any individual whose qualifications are acceptable to the Administration. For State projects, the Administration may require that the design be prepared by a professional engineer, professional land surveyor, or landscape architect licensed in the State of Maryland. For federal projects, the Administration may require that the design be prepared by a professional engineer, professional land surveyor, or landscape architect licensed in the USA.

B. If a dam safety permit or "small pond" approval is required by the Administration, the stormwater BMP design must be prepared by a professional engineer licensed in the State of Maryland for State projects and licensed in the USA for federal projects. A "Small Pond Summary Sheet" found in the Appendix must be completed and submitted to the Administration.

5.3 Contents of the Stormwater Management Plan

The plan must be accompanied by a report that includes sufficient information to evaluate the environmental characteristics of affected areas, the potential impacts of the proposed development on water resources, and the effectiveness and acceptability of measures proposed for managing stormwater runoff. The minimum information submitted to support the stormwater management plan or waiver application must be in accordance with the following:

A. **Concept Plan.** The owner/developer shall submit a concept plan that provides sufficient information for an initial assessment of the proposed project in accordance with these Guidelines and the Design Manual. Plans submitted for concept approval must include, but are not limited to:

1. A plan at a minimum scale of 1 inch = 100 feet showing site location, property boundaries, existing natural features, water and other sensitive resources, topography, and natural drainage patterns;

2. The location of all proposed impervious areas including buildings, roadways, parking, sidewalks, utilities, and other site improvements;

3. The location of the proposed limit of disturbance as well as the location of highly erodible soils, steep slopes, wetlands and other sensitive areas requiring special protection during construction;

4. Preliminary estimates of stormwater management requirements including the selection and location of ESD practices or alternative management measures to be used and the location of all points of discharge from the site;

5. A narrative that supports the concept design for both erosion and sediment control and stormwater management that describes how ESD to the MEP or alternative management measures will be implemented. Intentions to utilize waivers and/or variances must be indicated;

6. Identification of any additional protection measures for Tier II streams, Critical Areas, and impaired waters or waters with an established Total Maximum Daily Load (TMDL) above the required ESD to the MEP.

7. Any information required for the Site Development Plan or Final Stormwater Management Plan that the applicant elects to include as part of the Concept Plan; and

8. Other information as required by the Administration.

B. **Site Development Plan.** Following concept plan approval by the Administration, the owner/developer shall submit a site development plan that reflects comments received during the previous review phase. Plans and reports submitted for site development approval must be of sufficient detail to allow site development to be reviewed and include but not be limited to:

1. Plans providing the information listed in Section 5.3.E of these guidelines;

2. A report providing the information listed in Section 5.3.D of these guidelines;

3. A narrative within the stormwater report that supports the design, describes how ESD will be used to meet the minimum control requirements, and justifies any proposed structural stormwater management measures; and address the Overbank Flood Protection; and, Extreme Flood Volume, if deemed appropriate;

4. Where deemed necessary by the Administration, an analysis of the impacts of stormwater flows downstream in the watershed. The analysis must include hydrologic and hydraulic calculations necessary to determine the impact of hydrograph timing modifications resulting from the proposed development upon a dam, highway, structure, or natural point of restricted stream flow, established with the concurrence of the Administration, and must extend downstream:

   a. to the first downstream tributary whose drainage area equals or exceeds the contributing area to the BMP; or

   b. to the downstream point where the flow rate is a minimum of twice the discharge rate from the BMP;

5. Where deemed necessary, due to increased volume or rate of discharge from the project site, the Administration may require easements or other necessary property interests concerning stormwater discharge onto adjacent properties. It is the responsibility of the applicant to provide said easements or other necessary property interests. Approval of a stormwater management plan does not create or affect any right to direct runoff onto adjacent property without that property owner's permission;

6. A proposed erosion and sediment control plan that contains the construction sequence, any phasing necessary to limit earth disturbances and impacts to natural

resources, and an overlay plan showing the types and locations of ESD and erosion and sediment control practices to be used;

7. Any information required for the Final Stormwater Management Plan that the applicant elects to include as part of the Site Development Plan; and

8. Other information as required by the Administration.

C. **Final Stormwater Management Plan.** Following site development approval by the Administration the owner/developer must submit final erosion and sediment control and stormwater management plans that reflect the comments received during the previous review phase. Plans submitted for final approval must be of sufficient detail to allow all approvals and permits to be issued according to the following:

1. Final stormwater management plans must be submitted for approval in the form of construction drawings and be accompanied by a report that includes sufficient information to evaluate the effectiveness of the proposed runoff control design;

2. A Stormwater Management Waiver Application, indicating the appropriate waiver category, must be submitted for each Point of Investigation for which a waiver is being requested; and

3. Final erosion and sediment control plans must be submitted in accordance with COMAR 26.17.01.05 and the Maryland Erosion and Sediment Control Guidelines for State and Federal Projects.

D. **Stormwater Management Report.** A stormwater management report must be submitted for site development plan approval. The report should be on 8 1/2" x 11" paper. The report should be typed; however certain computational sheets may be handwritten. Any maps, diagrams, or figures that are larger than 8 1/2" x 11" must be folded to a size of 8 1/2" x 11" or smaller and placed within the report. All maps, diagrams, or figures must be clearly labeled. At a minimum each report must contain the following:

1. Title sheet;

2. Table of contents;

3. List of figures or tables;

4. Body of report;
   a. Introduction;
   b. Methodologies used;
   c. A narrative that supports the stormwater management design;
   d. Analysis;
   e. Summary and conclusions.

5. Appendices must include all the background information used in the stormwater management analysis. The background information must be sufficient to

facilitate a straightforward review and should include as applicable:

a. A drawing showing a breakdown of the site's impervious area including new impervious areas, reconstructed impervious areas, impervious areas removed (i.e. demolition), and maintenance areas not exposing earth. The acreage/square footage of these areas must be quantified on the drawing.

b. Drainage area maps depicting both pre-development and post-development conditions. The drainage area maps must delineate drainage area boundaries and show acreage to all stormwater management practices and to all points of discharge from the site. Maps must include soil types, ground cover, land uses, point(s) of investigation, and time of concentration (tc) flow paths;

c. TR-55 work sheets including computations for drainage, runoff curve number and time of concentration;

d. All associated hydraulic computations including those used to develop elevation-discharge-storage tables.

e. TR-20 analysis including schematic diagrams showing reach lengths, curve numbers, drainage areas, and structure locations, and clearly labeled printouts giving input data, output data and hydrographs;

f. All spillway computations;

g. Geotechnical investigations including boring logs and locations, site specific recommendations, and any additional information necessary for the final stormwater management design;

h. All necessary information for performing a downstream analysis to determine the downstream impacts due to runoff from the site;

i. Hydrologic computations for ESD practices or alternative management measures and other BMPs in accordance with the Design Manual;

j. Unified sizing criteria computations;

k. Stormwater volume computations for ESD practices or alternative management measures and other BMPs;

l. Hydraulic computations for all ESD practices or alternative management measures and other BMPs;

m. Waiver applications as appropriate;

n. Compensatory stormwater management;

o. Small pond summary sheet(s) as applicable;

p. Any other information required by the Administration.

E. Stormwater Management Construction Drawings. At a minimum, drawings submitted for stormwater management plan approval must include:

1. A vicinity map;

2. A location map;

3. Existing site characteristics:

   a. A topographic survey showing all existing contours, watercourses, impoundments, wooded areas, and wetlands within or adjacent to the project that receive runoff from the project site.

   b. All existing features including, but not limited to, structures and utilities.

   c. All existing BMPs including buffers, disconnections, conservation areas, etc.

4. Final site layout showing all proposed improvements including the location of buildings and other structures, impervious surfaces, utilities, storm drain systems, stormwater management practices, and proposed contours;

5. All easements and rights-of-way;

6. The delineation, if applicable, of the 100-year floodplain and any on-site wetlands;

7. Structural and construction details for all components of the proposed drainage system or systems and stormwater management facilities;

8. All necessary construction specifications;

9. A sequence of construction which addresses the implementation of both erosion/sediment control and stormwater management and at a minimum includes the following steps, in correct order;

   a. Notification of MDE's Compliance Program at 410-537-3510 a minimum of seven (7) days in advance of any earth disturbance activity to schedule a pre-construction meeting;

   b. Clearing and grubbing only for installation of perimeter erosion/sediment controls.

   c. Installation of perimeter erosion/sediment controls.

   d. Clearing, grubbing, and rough grading;

e. Construction;

f. Final grading;

g. Vegetative stabilization;

h. Installation of stormwater management practices upon permanent stabilization of contributory drainage areas;

i. With MDE approval, removal of erosion/sediment controls.

j. Stabilization of areas disturbed by removal of sediment controls.

10. A planting plan and schedule for the stormwater management facilities;

11. A maintenance schedule for each type of BMP (samples provided in Appendix);

12. Certification by the owner/developer that all stormwater management construction will be done pursuant to the plan (Owner's/Developer's Certification provided in Appendix);

13. Certification by the Engineer that the plan has been designed in accordance with the Design Manual (Design Certification provided in Appendix);

14. An As-Built certification signature block (provided in Appendix) to be executed after project completion;

15. Identify and provide any additional protection measures for Tier II streams, Critical Areas, and impaired waters or waters with an established Total Maximum Daily Load (TMDL) above the required ESD to the MEP.

16. The appropriate BMP As-Built Tabulation(s) (samples provided in Appendix); and

17. Any other information as required by the Administration.

6.0 INSPECTION

6.1 Inspection Schedule and Reports

A. The Applicant shall notify the Administration (the Compliance Program) at least 7 days before commencing any work in conjunction with the erosion/sediment control and stormwater management plans and again upon completion of the project.

B. For each ESD practice and other BMPs, regular inspections should be performed at the stages of construction specified in the Design Manual and documented by the Applicant or authorized representative. At a minimum, all ESD practices and other BMPs must be inspected upon completion of final grading and upon the establishment of permanent stabilization.

C. The Applicant shall submit notice of construction completion to the Administration on the form provided in the Appendix for each structural stormwater management practice as well as the type, number, total drainage area, and total impervious area treated by all ESD techniques and practices.

6.2 Inspection Requirements During Construction for As-Built Certification

A. Regular inspections should be made and documented during and after completion of construction for the following practices:

1. ESD Practices or Alternative Surfaces;

    a. Permeable pavers;

    b. Green roofs;

    c. Disconnection of rooftop runoff; disconnection of non-rooftop runoff; and Sheetflow to conservation areas;

    d. Rainwater harvesting;

    e. Submerged gravel wetlands;

    f. Landscape infiltration; infiltration/filtration berms; dry wells;

    g. Micro-Bioretention; rain gardens; enhanced filters;

    h. Vegetated swales;

2. Ponds:

    a. During embankment construction including, but not limited to, installation of:

        i. Cutoff trench;

ii. Inlet and outlet structures, filter diaphragms, concrete cradles, and watertight connectors on pipes;

iii. Trench for spillway pipe;

iv. Impervious core;

v. Weir wall;

vi. Riser structure; and

vii. Placement of fill.

3. Wetlands – at the stages specified for pond construction in Section 6.2.A.1 as applicable as well as during and after wetland reservoir planting and during the second growing season to verify a vegetation survival rate of at least 85 percent.

4. Infiltration trenches:

   a. During excavation to subgrade;

   b. During placement of observation wells;

   c. During placement of geotextiles and trench stone;

   d. During construction of appurtenant conveyance systems such as diversion structures, forebays, inlets, outlets, and flow distribution structures; and

5. Infiltration basins – at the stages specified for pond construction in Section 6.2.A.1 as applicable.

6. Sand filters and Bioretention:

   a. During excavation to subgrade;

   b. During placement of underdrain systems and observation wells;

   c. During placement of geotextile and all filter media;

   d. During construction of appurtenant conveyance systems such as flow diversion structures, pre-treatment, inlets, outlets, orifices, and flow distribution structures; and

7. Open channel systems:

   a. During excavation to subgrade;

   b. During placement of under drain system, observation wells, and filter

media for dry swales; and

c. During installation of check dams, or weirs.

B. Once construction is complete, As-Built Plan Certification must be submitted to the Administration by either a professional engineer or a professional land surveyor to ensure that constructed stormwater management practices and conveyance systems comply with the approved plans. At a minimum, the "as-built" submittal must include a signed As-Built Certification, completed As-Built Data Table(s), and a set of "as-built" drawings which compare the approved stormwater management plan with what was constructed. The Administration may require additional information. For a project to be closed out by the Administration, As-Built Certification must be received. An As-Built Certification form can be found in the Appendix of these Guidelines.

7.0 MAINTENANCE

A. The owner of the property, or any other person or agent in control of such property, on which work has been done pursuant to these Guidelines, must maintain in good condition and promptly repair and restore all grade surfaces, walls, drains, dams and structures, vegetation, erosion and sediment control measures, and other protective devices. Such repairs or restoration and maintenance must be in accordance with approved plans.

B. A maintenance schedule must be developed for the all stormwater management and/or ESD practices and must state the maintenance to be completed, the time period for completion, and who must perform the maintenance. This maintenance schedule must be printed on the approved stormwater management plan.

Appendix

APPLICATION FOR SEDIMENT CONTROL/STORMWATER MANAGEMENT PLAN APPROVAL

A completed application must be provided with EACH submittal

__ **INITIAL SUBMITTAL** **DATE** _____

__ **RESUBMITTAL: MDE NO. __ __-SF-__ __ __ __**

__ **MODIFICATION REQUEST: MDE NO. __ __-SF-__ __ __ __**

CONTRACT NUMBER: _____
PROJECT DESCRIPTION: _____
_____
PROJECT DISTURBANCE (ACRES): _____
PROJECT LOCATION (TOWN): _____
PROJECT LOCATION (COUNTY): _____
INFORMATION ENCLOSED: _____
_____

APPLICANT NAME: _____
APPLICANT ADDRESS: _____
_____
_____
APPLICANT CONTACT NAME: _____
APPLICANT PHONE NUMBER: _____
APPLICANT FAX NUMBER: _____
APPLICANT e-mail: _____

CONSULTANT NAME: _____
PROJECT ENGINEER: _____
CONSULTANT ADDRESS: _____
_____
_____
CONSULTANT CONTACT NAME: _____
CONSULTANT PHONE NUMBER: _____
CONSULTANT FAX NUMBER: _____
CONSULTANT e-mail: _____

MARYLAND DEPARTMENT OF THE ENVIRONMENT
Water Management Administration
Sediment & Stormwater Plan Review Division
1800 Washington Boulevard, 4th Floor, Suite 440
Baltimore, MD 21230-1708
Telephone: 410-537-3563
Fax: 410-537-3553
www.mde.state.md.us

MARYLAND DEPARTMENT OF THE ENVIRONMENT
Water Management Administration • Sediment and Stormwater Plan Review Division
1800 Washington Boulevard • Baltimore, MD 21230
(410) 537-3543 • 1-800-633-6101 • http://www.mde.state.md.us

STORMWATER MANAGEMENT WAIVER APPLICATION

OWNER: _____ MDE NO.: _____

ADDRESS: _____ PROJECT NO.: _____

LOCATION/POI: _____

CONSULTANT: _____

DESCRIPTION: _____

I/We, the Owner/Owners hereby request a stormwater management waiver be granted for the above referenced project in accordance with the following Section of the Stormwater Management Guidelines for State and Federal Projects:

____ 3.3.A. Contract plans and provisions, stormwater management report.
____ 3.3.B.1.a. Contract plans and provisions, stormwater management report.
____ 3.3.B.1.b. Contract plans and provisions, stormwater management report.*
____ 3.3.B.1.c. Contract plans and provisions, stormwater management report.*
____ 3.3.B.2.a. Contract plans and provisions, stormwater management report.
____ 3.3.B.2.b. Contract plans and provisions, stormwater management report.*
____ 3.3.B.2.c. Contract plans and provisions, stormwater management report.*
____ 3.3.B.3.a. Contract plans and provisions, stormwater management report.*
____ 3.3.B.3.b. Contract plans and provisions, stormwater management report.*
____ 3.3.B.4. Contract plans and provisions, stormwater management report.*

*Evidence of stable outfall with adequate capacity (e.g., video, photos, statement): _____

Other evidence submitted: _____

_____	_____	_____
Name of Owner or authorized representative	Signature	Date

____ Approved ____ Denied/Reason _____

By _____ _____
Sediment and Stormwater Plan Review Engineer — Date

Submit to:
Maryland Department of the Environment
Water Management Administration
Sediment and Stormwater Plan Review Division
1800 Washington Boulevard
Baltimore, MD 21230

If a project involves a waiver request for more than one (1) drainage area, a Stormwater Management Waiver Application is required for each point of investigation (POI).

MDE/WMA/PER.058

OWNER'S / DEVELOPER'S CERTIFICATION

I / We hereby certify that all clearing, grading, construction, and/or development will be done pursuant to this plan and that any responsible personnel involved in the construction project will have a certificate of attendance at a Maryland Department of the Environment approved training program for the control of erosion and sediment before beginning the project. I/We hereby authorize the right of entry for periodic on-site evaluation by appropriate inspection and enforcement authority or the State of Maryland, Department of the Environment.

_____ Date

_____ Owner / Developer Signature

_____ Card No.

_____ Printed Name and Title

DESIGN CERTIFICATION

I hereby certify that this plan has been designed in accordance with the Maryland Standards and Specifications for Soil Erosion and Sediment Control, the 2000 Maryland Stormwater Design Manual, Volumes I & II including supplements, the Environment Article Sections 4-101 through 116 and Sections 4-201 and 215, and the Code of Maryland Regulations (COMAR) 26.17.01 and COMAR 26.17.02 for erosion and sediment control and stormwater management, respectfully.

_____ Date

_____ Designer's Signature

Md. Registration No._____
P.E., R.L.S., RLA, or R.A. (circle one)

_____ Printed Name

TABLE 1

For the purposes of Section 3.3 B.4 of these Guidelines, the following are minimum county flood control requirements:

COUNTY	QP_2	QP_{10}
Allegany	NO	See Note 1
Anne Arundel	NO	See Note 1
Baltimore (County & City)	NO	See Note 1
Calvert	NO	See Note 1
Caroline	YES	NO
Carroll	NO	See Note 1
Cecil	See Note 2	See Note 1
Charles	NO	See Note 1
Dorchester	YES	NO
Frederick	NO	YES
Garrett	NO	See Note 1
Harford	NO	YES
Howard	NO	See Note 1
Kent	YES	See Note 1
Montgomery	NO	See Note 1
Prince George's	NO	See Note 1
Queen Anne's	YES	NO
St. Mary's	NO	See Note 1
Somerset	YES	NO
Talbot	YES	NO
Washington	NO	YES
Wicomico	YES	NO
Worcester	YES	NO

1. **Q_{p10} is required where there are downstream flooding issues or conveyance is inadequate.**
2. **Q_{p2} is required in the Coastal Plain (south of the Chesapeake & Delaware Canal).**

TABLE 2

For the purposes Section 3.3 B.2 of these Guidelines, the following are considered MAJOR WATERWAYS:

WATERWAY	LIMITS
Susquehanna River	main stem from mouth to Pennsylvania line
Pokomoke River	main stem from mouth to MD 12
Nanicoke River	main stem from mouth to Delaware line
Choptank River	main stem from mouth to MD 404
Chester River	main stem from mouth to MD 290
Elk River	main stem from mouth to US 40
Bush River	main stem from mouth to US 40
Gunpowder River	main stem from mouth to US 40
Patapsco River	main stem from mouth to US 1
Patuxent River	main stem from mouth to MD 416
Potomac River	main stem from mouth to I 81
Youghiogheny River	main stem from Pennsylvania line to I 68
Wicomico River	main stem from mouth to US 50

Maryland Department of the Environment
POND SUMMARY SHEET

PROJECT INFORMATION

MDE File No: _____
Project Name: _____
_____

MARYLAND COORDINATES
(to nearest 1000 feet)

East _____
North _____
County _____
ADC Map/Grid /

OWNER INFORMATION

Name: _____
Address: _____
_____
City, State, Zip _____

TYPE OF POND: ☐ Excavated ☐ Embankment ☐ Both

Drainage Area: _____ acres
Surface Area: _____ acres
Normal Depth: _____ feet
Storage at Design High Water (DHW): _____ ac-ft

HAZARD CLASS: A(Low) B(Significant) C(High) Design Storm Frequency: _____ Years

PURPOSE OF POND (Check all that apply)

☐ Stormwater Management-Wet ☐ Stormwater Management-Dry ☐ Infiltration/Water Quality ☐ Water Supply/Irrigation ☐ Sand & Gravel Wash Pond
☐ Sediment Control ☐ Livestock ☐ Flood Control ☐ Recreation ☐ Borrow Material
☐ Wetland Mitigation ☐ Wildlife/Fish ☐ Fire Control ☐ Other (Specify below): _____

EMBANKMENT

Top Elevation _____ feet
Normal Pool Elevation _____ feet
DHW Water Elevation _____ feet
Maximum Fill Height _____ feet
Top Width _____ feet
Side Slopes: U.S. _____ :1
D.S. _____ :1

Will embankment serve as public roadway? ☐ Yes ☐ No

PRINCIPAL SPILLWAY

Barrel Size: _____ inches
Design Capacity at DHW: _____ cfs
☐ BCCMP ☐ Alum (CAP) ☐ RCP ☐ PVC ☐ Cast-in-Place Box Culvert
☐ Weir ☐ Channel ☐ Other: _____

EMERGENCY SPILLWAY

Velocity: _____ ft/sec
Crest Elev: _____ ft
Spillway Protection: ☐ Grass ☐ Riprap ☐ Gabions ☐ Other: _____
Design Capacity at DHW: _____ cfs
Bottom Width: _____ feet
Side Slopes: _____ :1

DISTANCES BELOW POND TO

Property Line: _____ feet
Public Road: _____ feet

MDE Plan Reviewer approving pond: _____

date: _____

Note: This pond summary sheet is to be used by MDE Sediment and Stormwater Plan Review Division to notify MDE Dam Safety Division of low hazard (class "a") ponds which have embankment heights of 20 feet or less approved for State and federal projects. Higher hazard ponds require a permit from Maryland Department of the Environment, Dam Safety Division. October 2007

Design Procedures for Stormwater Management Extended Detention Structures (1987)

Design Procedures For Stormwater Management Extended Detention Structures

July 1987

Maryland Department of the Environment

Water Management Administration

2500 Broening Highway
Baltimore, Maryland 21224

The Sediment and Stormwater Management Administration (SSA) was incorporated into the Water Management Administration (WMA) in October, 1992. For additional information concerning this publication, please contact WMA (410) 631-3543.

EXTENDED DETENTION DESIGN

The following design procedure can be used to design ponds with extended detention times to achieve water quality benefits. The procedure is based on the use of graphs that relate the detention time to known hydrologic parameters of the watershed.

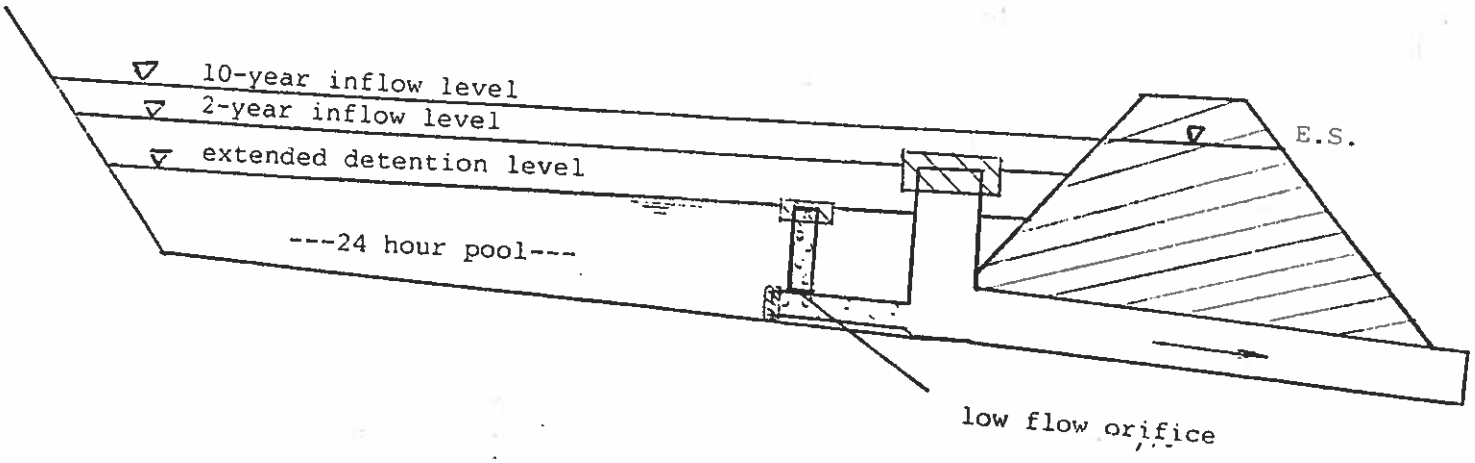
For this analysis, detention time is defined as the lag in hours between the centroids of the inflow and outflow hydrographs. For simplicity, the inflow and outflow hydrographs are assumed to have a traingular shape. Based on the definition of detention time and the geometry of a triangular hydrograph, a relationship is developed between detention time and known hydrologic parameters. This relationship has been developed in graphical form as shown in Figure 2.

The design procedure has been developed for proposed stormwater management ponds but Figure 2 may be used to determine the detention time of existing ponds. The procedure is direct and reasonably accurate with no need for iterations.

The extended detention design is based on detaining the one year frequency storm for 24 hours. This design criteria has been selected for design to achieve significant water quality benefits.

The one year frequency storm was selected for design for several reasons. First, it is more closely associated with the more frequent runoff events that carry the highest concentration of pollutants. Second, only one percent of all annual rainfall events exceed the one year frequency storm. Third, storm events smaller than the one year storm would require an excessively small outlet device that would clog very easily. And fourth, storm events larger than the one year storm would require larger detention storage volumes.

The 24 hour detention time criteria is based on the settling behavior of urban pollutants. Laboratory studies which achieve ideal settling conditions indicate that 60 to 70 percent of urban sediments and attached pollutants settle out within the first six hours and the remaining sediment requires as much as two days. The actual settling performance of wet ponds typically require a 24 hour period to remove the bulk of sediments. Since ideal settling conditions rarely occur in field conditions, a minimum detention time of 24 hours is recommended for design.



ONE-YEAR 24-HOUR EXTENDED DETENTION DESIGN

1. Compute the time of concentration (tc) and the one-year after development runoff depth (Qa) in inches.

2. Compute the initial abstraction (Ia) = (200/CN - 2) and the ratio Ia/P where P is the one-year rainfall depth.

3. Knowing t_c and Ia/P, find the unit peak factor (q_u) from Figure 1 and compute the one-year after development peak discharge (q_i) = $q_u A Q_a$ where A is the drainage area in square miles.

4. Knowing q_u and T (detention time), find q_o/q_i from Figure 2.

5. Compute the peak outflow discharge (q_o) = (q_o/q_i) x q_i.

6. Knowing q_o/q_i, compute $V_s/V_r = 0.683 - 1.43(q_o/q_i) + 1.64(q_o/q_i)^2 - 0.804(q_o/q_i)^3$.

7. Find the extended detention storage volume (V_s) = (V_s/V_r) x V_r, (Note that V_r = Qa); convert V_s to ac-ft by (V_s/12)A where A is the drainage area in acres.

8. Find the required orifice area (A) for extended detention design: $A = q_o/C\sqrt{2gh_o} = q_o/4.81h_o^{1/2}$, where h_o is the maximum storage depth associated with V_s.

9. Determine the require maximum orifice diameter (d) = $\sqrt{4A/\pi}$.

OPTIONAL DESIGN METHOD

1. Compute required volume of storage (V_s,in) = $0.60Q_a$ and convert to ac-ft where V_s(ac-ft) = (V_s(in)/12)A(ac). The required volume of storage will range from approximately 52 to 66 percent of the volume of runoff (Q_a) for curve numbers between 75 and 95 and times of concentration between 0.1 to 1 hour. Therefore, $0.60Q_a$ is a very good approximation of the extended detention volume.

2. Compute the required release discharge for a 24 hour detention time:

   $q = V_r/T = Q_a(in) \times A(ac)/T$

   where T = 24 hour;

   $q(cfs) = Q_aA/24$

3. Find the required orifice area (A) and diameter (d) to release q over 24 hours:

   $A = q/4.81h^{1/2}$ and

   $d = \sqrt{4A/\pi}$

   where h is the maximum storage depth associated with V_s.

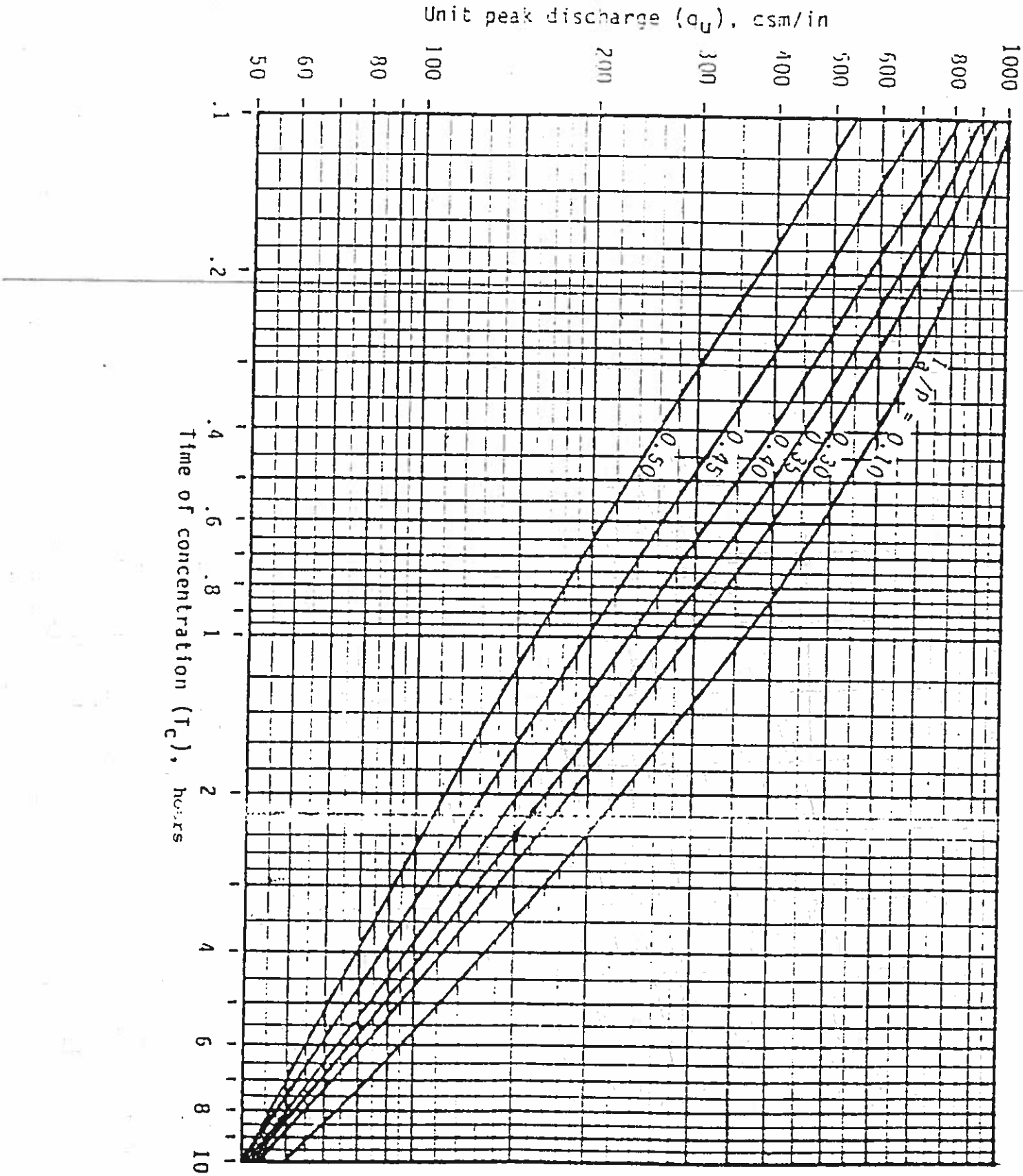


FIGURE 1. SCS GRAPHICAL METHOD OF DETERMINING PEAK DISCHARGE(q_u) IN CSM/in FOR 24-HOUR TYPE II STORM DISTRIBUTION (TR-55, Second Ed., June 1986)

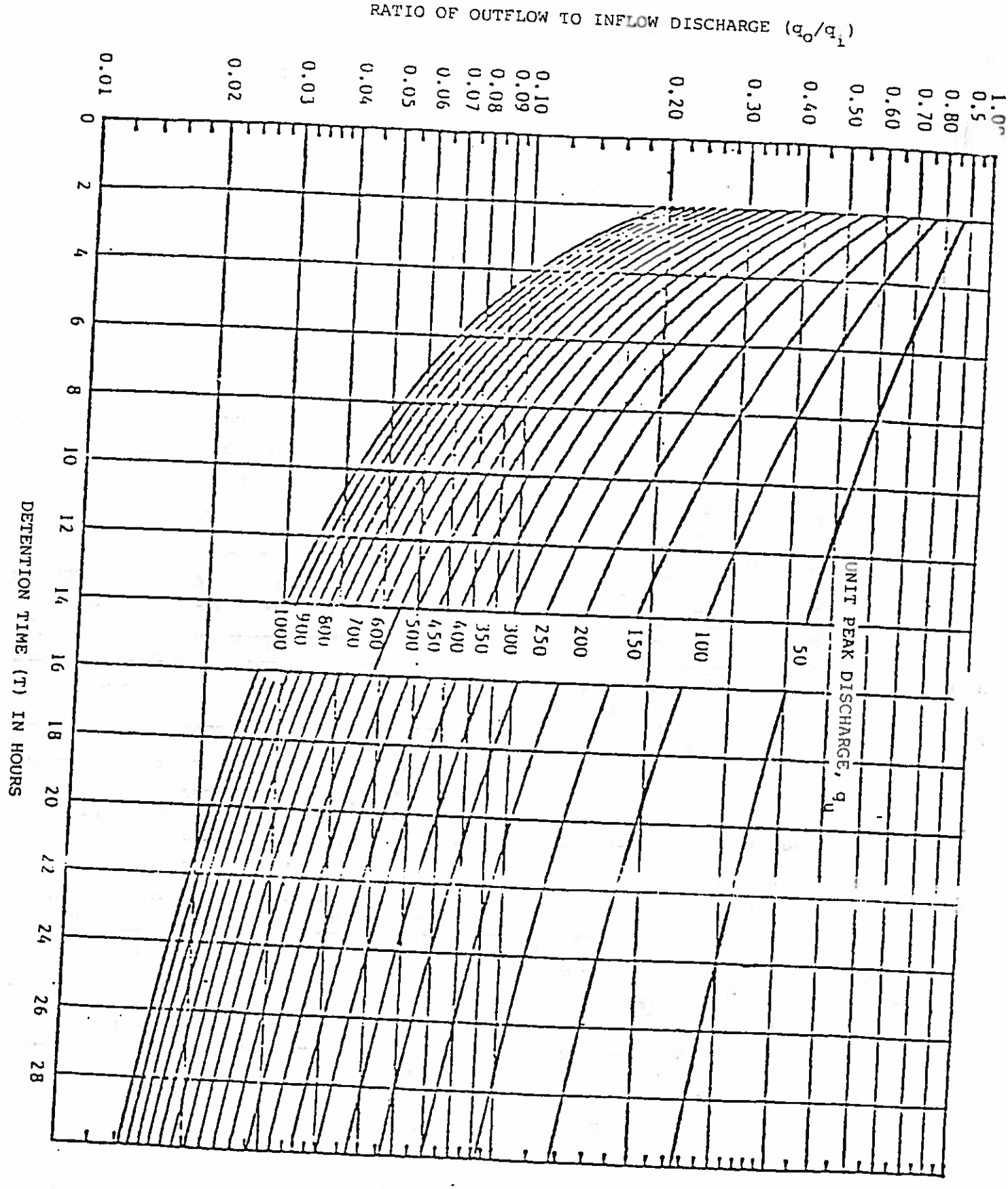


FIGURE 2. DETENTION TIME VERSUS DISCHARGE RATIOS (q_o/q_i)
(Source: Md. Soil Conservation Service)

ONE YEAR 24-HOUR EXTENDED DETENTION DESIGN EXAMPLE

An extended detention pond is to be designed for a 50 acre residential area in Anne Arundel County.

1. Compute the time of concentration (t_c, hours) and the one-year after development runoff depth (Q_a, inches).

   From Step II of the detention design example, t_c = 0.51 hours and CN_A = 75.

   The one-year 24 hour rainfall depth in Anne Arundel County is 2.7 inches. From equation 2-5 in the TR-55 Manual, the runoff depth Q_a is 0.77 inches.

2. Compute the initial abstraction (Ia) = (200/CN - 2) and the ratio Ia/P where P is the one-year rainfall depth.

   Ia = (200/75 - 2) = 0.67 in

   Ia/P = 0.67/2.7 = 0.25

3. Knowing t_c and Ia/P, find the unit peak factor (q_u) from Figure 1, and compute the one-year after development peak discharge (q_i) = $q_u A Q_a$ where A is the drainage area in square miles.

   With t_c = 0.51 hours and Ia/P = 0.25, q_u = 470 CSM/in and

   $q_i = q_u A Q_a = (470)(50/640)(0.77)$

   q_i = 28.3 CFS

4. Knowing q_u and T (extended detention time), find q_o/q_i from Figure 2.

   From Figure 2 with q_u = 470 CSM/in and T = 24 hours, q_o/q_i = 0.038 .

5. Compute the peak outflow discharge:

$q_o = q_o/q_i \times q_i$

$q_o = 0.038 \times 28.3 \text{ CFS} = 1.1 \text{ CFS}$

6. Knowing q_o/q_i, compute V_s/V_r.

$V_s/V_r = 0.683 - 1.43\ (q_o/q_i) + 1.64(q_o/q_i)^2 - 0.804(q_o/q_i)^3$

$V_s/V_r = 0.683 - 1.43(0.038) + 1.64(0.038)^2 - 0.804(0.038)^3$

$V_s/V_r = 0.63$

7. Find the extended detention storage volume (V_s) = $V_s/V_r \times V_r$

$V_s = 0.63 \times 0.77$ inches = 0.49 inches = 2.04 ac-ft.

From Step 3 of the detention example, this storage occurs at elevation 105.6 (5.6 feet headwater).

8. Find the required orifice area (A) for the extended detention design.

$A = q_o/C\sqrt{2gh_o} = q_o/4.81\ h_o^{1/2}$

$A = 1.3/4.81(5.6)^{1/2} = 0.11 \text{ ft}^2$

9. Determine the required maximum orifice diameter.

$d = \sqrt{4A/\pi}$

$d = \sqrt{4(0.12)/\pi} = 0.38$ ft. = 4.4 inches

Use a 4 inch diameter orifice.

OPTIONAL EXTENDED DETENTION DESIGN EXAMPLE

1. Compute the required volume of storage.

   V_s(ac-ft) = (Q_s/12)A where Q_s = 0.60 Q_a (in.),

   Q_a = one-year runoff depth (in.), and

   A = drainage area in acres.

   Q_s = 0.60 (0.77) = 0.46 in. V_s = (0.46/12)(50) = 1.92 ac-ft

   Based on Step III of the detention design, 1.92 ac-ft occurs at elevation 105.4 or a depth of 5.4 ft.

2. Compute the required release discharge (q_o) for a 24 hour detention time.

   $q_o = V_r/T = Q_aA/T$ = q_o = (0.77)(50)/24 = 1.60 CFS

3. Find the required orifice area (A) and diameter (d) to release the outflow discharge (q_o) over 24 hours.

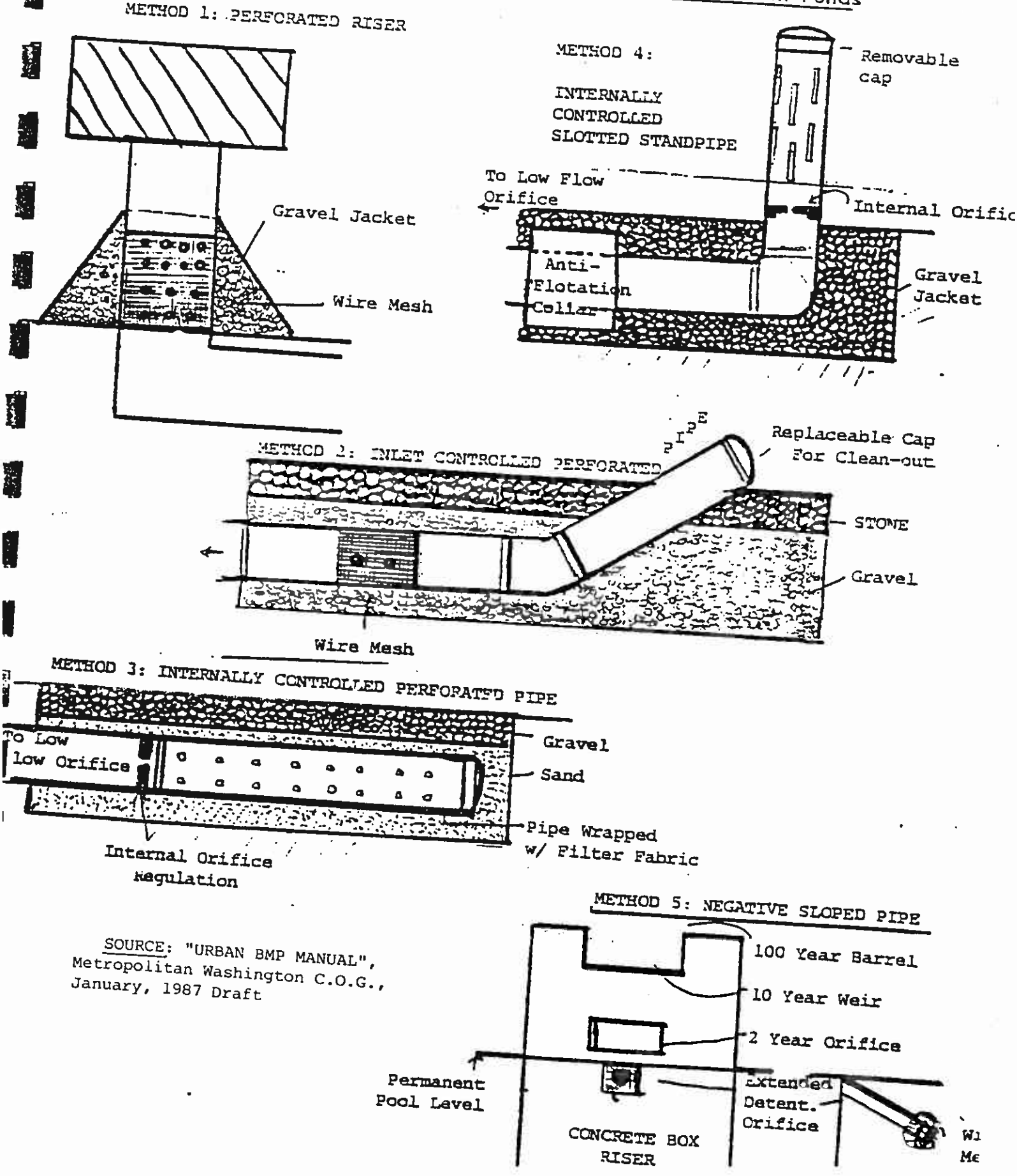
   $A = q_o/4.81h^{1/2}$ and $d = \sqrt{4A/\pi}$

   $A = 1.60/4.81(5.4)^{1/2} = 0.143\ ft^2$

   $d = \sqrt{4(0.143)/\pi} = 0.43$ ft = 5.2 inches

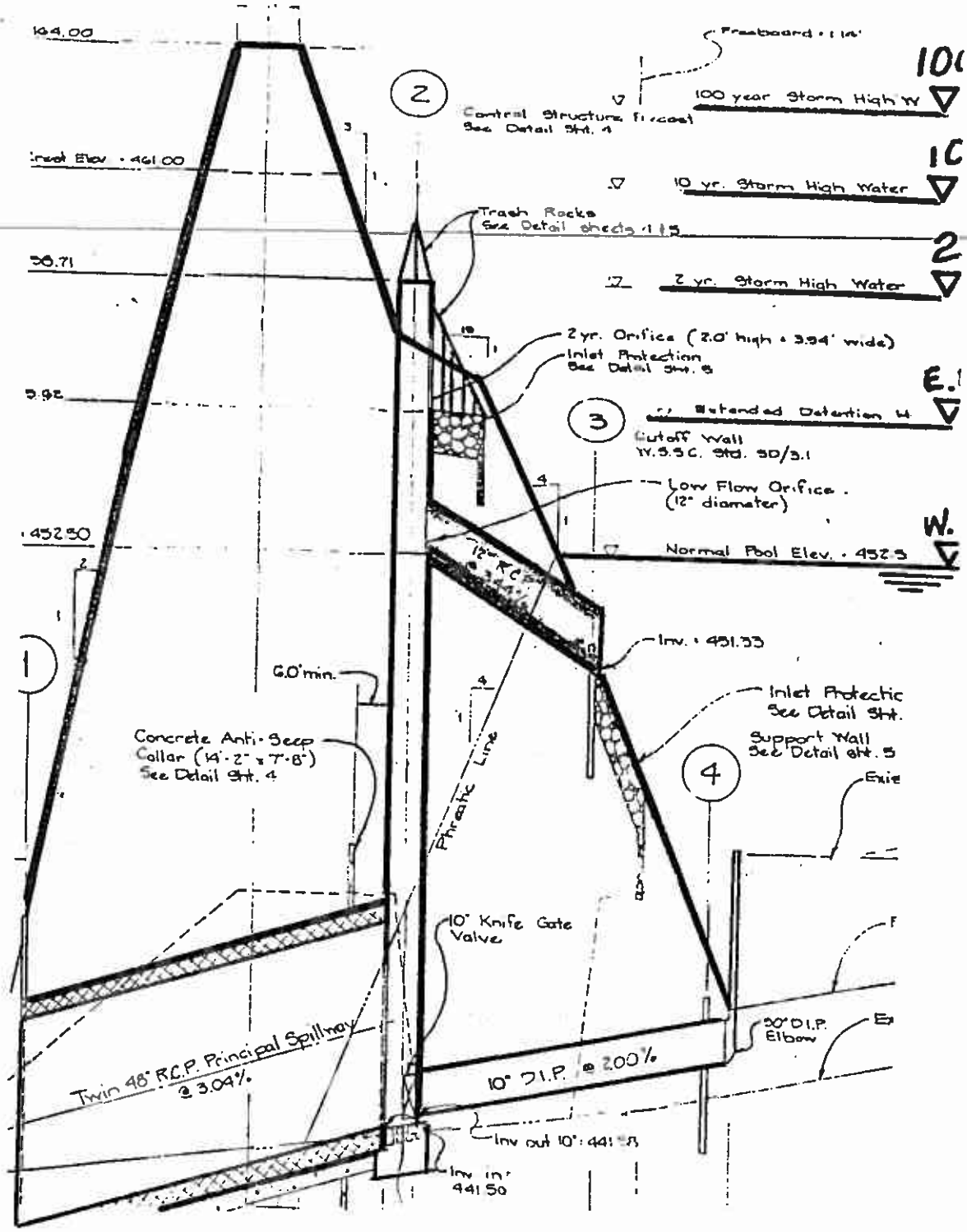
   Use a 5 inch orifice.

Figure 2.2: Common Approaches to Extend Detention Times in Ponds



SOURCE: "URBAN BMP MANUAL", Metropolitan Washington C.O.G., January, 1987 Draft

EXTENDED DETENTION METHOD 5



EXTENDED DETENTION DESIGN

by

Bruce W. Harrington

12/87

The following design is based on a 50 acre residential (1/4 acre lots) watershed which has a curve number of 75 and a time of concentration of 0.51 hours. The design detention time was determined from the difference in centroids of triangular shaped inflow and outflow hydrographs. The extended detention design was based on releasing the 1 - year frequency storm event over a 24 hour detention time. The inflow and outflow discharges were calculated by the TR-55 Method.

The TR-20 Program was used to determine the inflow and outflow hydrographs for the 1, 3, and 6 month storm events, and the 1, 2, 5, and 10 year storm events based on a 24 hour rainfall duration. These storms correspond to rainfall depths of 0.6, 1.2, 1.8, 2.7, 3.3, 4.3, and 5.2 inches respectively. Storm events larger and smaller than the design storm were selected to examine the effect on there detention times. A detention time of 6 hours or greater is considered significant since settling column test indicate a particulate pollutant removal rate of approximately 67 percent or greater.

Three different methods were used to compute the detention time of runoff. Method 1 is based on the difference in time between the center of mass of the inflow and outflow hydrographs from the TR-20 Program. The center of mass corresponds to the time on the hydrograph where one half of the runoff volume occurs. Method 1 is assumed to be the most accurate estimate of detention time since it is based on the TR-20 curvelinear hydrographs. Method 2 is computed from the difference in time from the centriods of triangular shaped inflow and outflow hydrographs. The detention time from Method 2 was determined from a figure developed by the MD. Soil Conservation Service. Method 2 is assumed to be less accurate than Method 1 since it is based on synthetic triangular hydrographs. Method 3 assumes the detention time is the difference in the time base between the inflow and outflow hydrograps from the TR-20 Program. This method was selected just to see if detention times could be approximated simply by the hydrograph time bases.

The results of the TR-20 Program and the computed detention times are shown in the following tables. Since the TR-20 Program computed slightly different discharge values than the TR-55 Method, the 1 year storm resulted in a detention time of 21 hours instead of 24 hours. The 1 month frequency storm resulted in no runoff and therefore was not included in the following tables.

As shown in Table 1, detention times determined from Methods 1 and 2 are very similar with a difference ranging from 0.2 to 3.6 hours. Method 3 resulted in irrational detention times for the 1,2, and 5 year storms and therefore is not a reliable estimate of detention time.

TABLE 1

Storm Event (frequency)	Discharge (cfs)		Detention Time (hrs)		
	Inflow	Outflow	Method 1	Method 2	Method 3
3 month	0.93	0.45	1.2	1.0	0.8
6 month	8.40	0.75	8.4	10.0	9.4
1 year	28.7	1.30	18.4	21.0	32.4
2 year	45.2	6.60	9.4	5.8	32.8
5 year	76.0	27.9	3.8	2.0	33.2
10 year	105.7	52.0	2.0	1.0	33.2

Table 2 is based on the same design as above except the outlet device has been changed. A perforated riser has been used in place of the single 4 inch orifice. Sixteen one inch holes have been placed over a 3 foot interval in the riser. Method 1 has been selected to determined the detention time since it is the most accurate method. The results indicate that the perforated riser provides longer detention times for storm events less than the 1 year storm. Although, the detention times are only 1 to 2 hours longer and the hydraulic design of the 16 orifices is more complex.

TABLE 2

Storm Event (frequency)	Discharge (cfs) Inflow	Outflow	Detention Time (hrs) Method 1
3 month	0.93	0.45	2.8
6 month	8.40	0.75	11.6
1 year	28.7	1.30	18.4
2 year	45.2	6.6	9.4
5 year	76.0	27.9	3.8
10 year	105.7	52.0	2.0

In an attempt to achieve longer detention times for storm events smaller than the 1 year storm, a perforated riser with 64 one-half inch holes was selected. The holes are spaced every 6 inches at 8 different levels with 8 holes at each level. This design results in a detention time of 6.0 hours for the 3 month storm (1.2 inches of rainfall) which is a substantial increase compared to the design of the 16 hole riser shown in Figure 2.

TABLE 3

Storm Event (frequency)	Discharge (cfs) Inflow	Outflow	Detention Time (hrs) Method 1
3 month	0.93	0.22	6.0
6 month	8.40	0.54	12.4
1 year	28.7	1.30	18.4
2 year	45.2	6.6	9.4
5 year	76.0	27.9	3.8
10 year	105.7	52.0	2.0

The results of the extended detention designs has shown that smaller frequency storms which are associated with the first flush of runoff can be controlled to achieve particulate pollutant removal. The control of storm events less than the one year storm requires several small orifice holes spaced along the riser length. This technique is effective since a multiple orifice riser will detain small storms events much longer than a single orifice riser. This is true because the total opening area in a multiple hole riser is not in use until a storm event rises near the top of the riser. In contrast, the total equivalent flow area in a single orifice is flowing full during very small headwater depths that are associated with small storm events. Consequently, a larger discharge occurs over a smaller detention time and the removal of particulate pollutants is reduced.

Research is needed to simplify the design of a multiple hole riser without creating any significant errors in predicting discharges. It is also important to determine if this type of outlet device will avoid or minimize clogging which if occured would change the design detention time and discharge release rates.

Guidelines for Constructing Wetland Stormwater Basins (1987)

Guidelines For Constructing Wetland Stormwater Basins

March, 1987

Maryland Department of the Environment

Water Management Administration

2500 Broening Highway
Baltimore, Maryland 21224

The Sediment and Stormwater Management Administration (SSA) was incorporated into the Water Management Administration (WMA) in October, 1992. For additional information concerning this publication, please contact WMA (410) 631-3543.

GUIDELINES FOR CONSTRUCTING WETLAND STORMWATER BASINS

TABLE OF CONTENTS

		Page
A.	Introduction	1
B.	The Physical Aspects of the Wetland Basin	1
1.	The Water Balance of the Wetland	1
2.	The Size of the Wetland	2
3.	The Permanent Pond	2
a.	Frequently Flooded Areas	2
b.	The Shape and Depth of the Permanent Pond	3
4.	Modifications to the Incoming Flow of Water	4
5.	The Outlet Structure and Extended Detention	4
C.	The Biological Aspects of the Basin	10
1.	The Wetland Substrate	10
a.	Preferred Soils	10
b.	Other Soils	10
2.	The Wetland Vegetation	11
a.	Planting Wetland Vegetation	11
b.	Desirable Species Characteristics	11
c.	Selection of the Wetland Species	11
d.	The Number of Species to Plant	12
e.	Depth Requirements of Selected Species	16
f.	The Plant Propagule and Dates For Planting	16

Page

3. Submerged Aquatic Vegetation (SAV) 17

4. Preparing the Site For Planting 17

5. The Planting Procedure 18

6. Manpower Requirements 19

7. Potential Nuisance Species 19

8. Wetland Maintenance 19

D. Summary of Shallow Wetland Criteria 20

1. Site Selection 20

2. Maximizing the Wetland Surface Area 20

3. Extended Detention 21

4. Water Depth Requirements 21

5. Frequently Flooded Zones 21

6. Extended Detention Outlet Structure 21

7. Protecting the Orifice From Blockage 21

8. Grading or Disking the Basin Before Planting 21

9. Area of the Basin to Vegetate 22

10. Number of Wetland Species to Plant 22

11. Proper Treatment of Plant Material 22

12. Planting Procedure 22

13. Wetland Maintenance 23

LIST OF TABLES

Page

Table 1. Initial Considerations When Selecting A Wetland Site 5

Table 2. General Features of the Wetland Design 6

Table 3. Emergent Species For Wetland Establishment 13

Table 4. Species and Numbers of Individual Plants For Establishing on Artificial Wetlands 15

LIST OF FIGURES

Figure 1. Potential Wetland Design 7

Figure 2. Potential Wetland Design 8

Figure 3. Potential Wetland Design 9

GUIDELINES FOR CONSTRUCTING WETLAND STORMWATER BASINS

INTRODUCTION

The purpose of this report is to present guidelines for the construction of shallow wetlands in stormwater basins. However, before construction begins it is important to understand the nature and purpose of this type of basin. First, a shallow wetland will be heavily vegetated, with only about 25% of the total area in relatively open water. The basin will not look like a lake with an abundance of open water and a small amount of fringing wetland vegetation. The heavily vegetated wetland basin is a relatively wild area which can provide food and shelter to resident and migratory birds. Some species of birds will eat the seeds produced by the vegetation, while others will feed on the roots, rhizomes, and tubers produced below-ground by the plants.

The shallow water will support a diverse array of animals and insects. The food chain will reach from phytoplankton and bacteria through water beetles and small fish to flying predators such as dragonflies and swallows. A wetland basin surrounded by a residential community can function as an ecological laboratory to the school children in the neighborhood.

Shallow wetland basins do not have the long turnover times of the deep ponds described by Driscoll (1983). However, they do provide an intense pool of biological activity that, coupled with extended detention, should function to remove and/or transform solids and nutrients contained in stormwater runoff.

The shallow water in these basins may result in little or no initial excavation requirements, which can reduce the construction costs. This factor makes wetland basins relatively easy to install in existing dry stormwater basins. Due to the shallow nature of the ponds, they should not be utilized during the sediment control phase of a project. To function as a sediment basin, the invert of the sediment basin shall be one foot above the invert of the shallow marsh basin. Upon final stabilization of the site, the marsh invert shall be established and the vegetation planted.

PHYSICAL ASPECTS OF THE WETLAND BASIN

Water Balance of the Wetland

In order to maintain a shallow pool of water for a wetland the inflow of water must be greater than that leaving the basin by infiltration Water inputs can include stormwater runoff, base flow, and groundwater. If the basin intersects groundwater there should be little trouble in maintaining a permanent pond. However, stormwater runoff and base flow maintenance of a permanent pond will require the infiltration rate to be less than those

inputs. Basin infiltration rates can be estimated by the infiltration rates of the different soil types in the basin or, more accurately, by running infiltration tests in the basin. If the infiltration rate of the basin exceeds the estimated input of water, other means can be used to decrease the infiltration rate. These methods include lining the basin with clay or installing a plastic liner beneath a protective layer of soil or sand.

Harrington (1986) has suggested a method for calculating the watershed area required to maintain a wet pond when there is no base flow. The water in the pond is maintained by runoff from storm events. This method takes into consideration the imperviousness of the watershed and the infiltration rate of the soils on the stormwater basin, and is primarily intended for the construction of deeper ponds. It may also be applicable to wetland ponds. However, due to the very shallow water in wetland ponds (e.g., 6 inches) it is not clear if this method is sufficiently accurate to maintain permanent, shallow water levels. Further study should answer this question. If shallow wetlands can be constructed in areas without base flow their use could be expanded significantly.

Wetland Size

Shallow wetland basins will provide the greatest benefits to wildlife and pollution control when the wetland surface area is maximized. Thus it is recommended that when creating a wetland in an existing stormwater basin most of the surface area of the basin be utilized for the wetland (see below). The contribution of the wetland to water quality will vary with the surface area available for the wetland. For those basins that utilize large increases in depth instead of surface area to control peak flows the wetland will contribute less to water quality. However, in those basins where the surface area component of volume storage is large a shallow wetland constructed on this surface should make a substantially greater contribution to water quality. In addition, wetlands constructed on both types of basin will contribute to wildlife habitat. Due to the lower amount of permanent storage on shallow wetlands (as compared to deep ponds), however, it is recommended that an extended detention time of 24 hours for the 1-year storm be utilized.

Although it is strongly recommended that wetland basins utilize extended detention, that may not always be possible. If not, it is recommended that the surface area of the wetland should account for a minimum of 3 percent of the area of the subwatershed draining into it. If this ratio cannot be met another form of control, such as a deep pond, should be used (Driscoll 1983; Harrington 1986).

When a new stormwater basin is planned which will include a shallow wetland the dimensions for peak runoff control should be set to maximize the surface area available for the wetland.

Wetland Permanent Pond

1. Frequently Flooded Areas

As mentioned above, the surface area of the wetland should be maximized in relation to the surface area of the entire stormwater basin. However, there is a somewhat gray area that is not entirely wetland and not entirely upland that should be incorporated into the wetland structure. This is a bordering area that will be flooded whenever stormwater runoff enters

the basin, but that will not have standing water in it after the period of extended detention is over. This area will support a diverse group of plants that will thrive on the damp soil and which can tolerate the brief periods of flooding associated with extended detention. However, most of these species would not be able to tolerate constant inundation. The plant community in this area is likely to provide cover for some nesting birds as well as a source of food, primarily as seeds. It is recommended that this frequently flooded zone include the area within approximately 10 to 20 feet from the edge of the permanent pond.

2. Shape and Depth of the Permanent Pond

Shallow water (i.e. < 12 inches) promotes the growth of most species of emergent vegetation. Since emergent vegetation is likely to contribute to the pollution removal capability of the wetland, and certainly contributes to its value to wildlife, the water of the wetland should be at depths conducive to the growth of emergent vegetation.

In general, approximately 75% of the wetland should have water depths less than 12 inches, and 25% of the wetland should have depths ranging from 2 to 3 feet. The deeper depths will, for the most part, result in open water, which will make the entire wetland more attractive to waterfowl. Waterfowl seem to prefer a habitat with both cover and open water (Weller 1978). In addition, the deeper water will favor the growth of submerged aquatic vegetation, another food source for waterfowl.

The deeper area of the wetland should include the outlet structure so that outflow from the basin is not interfered with by sediment buildup. Having the outlet at the surface of a 2 or 3 feet pond means that a considerable amount of sediment build-up can occur before outflow is blocked. Regardless, it is recommended that a forebay be established at the pond inflow points to capture larger sediments. The depth of the forebay should be in excess of 3 feet and contain approximately 10% of the total volume of the normal pool.

After passing through the forebay, the incoming runoff should pass through shallow areas of emergent vegetation in order to maximize sedimentation and the mixing of runoff with the shallow pond water. As much vegetation as possible, and as much distance as possible should separate the basin inlet from the outlet. The length to width ratio should be at least 2 to 1. This is to avoid the so-called "short-circuiting" effect whereby stormwater runoff can flow out of the wetland with only minimal treatment by the wetland. Although using extended detention will certainly minimize short-circuiting, stormwater runoff in excess of the extended detention capacity will be susceptible to short-circuiting.

Of the 75% of the wetland that should be 12 inches deep or less, it is recommended that approximately 25% range from 6 inches deep to 12 inches deep, and that the remaining 50% be 6 inches or less in depth. An arrangement that should work well would be to have the water depth slope gradually but regularly from the 12 inches depth at the edge of the deep area to the 6 inches depth, and then fix the basin depth at approximately 6 inches throughout most of the remaining 50% of the shallows. The water should gradually get shallower about 10 feet from the edge of the pond.

It is not altogether necessary to have precise depths and a smoothly graded substrate. When grading, however, it would be preferable to err on the side of shallow water rather than deeper water. In addition, the irregularity of the substrate that may result from machinery tracks or other incidental factors will add some diversity to the wetland by promoting the establishment of species with various depth requirements. However, the basin should be graded as carefully as possible to the depth specifications set out above. Grading will also

"soften up" the basin soil enough that no supplemental disking or plowing will be required. However, if the basin does not need grading or excavating the soil should be broken up with a disk or chisel. Tables 1 and 2 list the initial and general design considerations for artificial wetlands discussed above.

Several possible wetland layouts are shown in Figures 1 to 3. These basins have the inlet and the outlet at opposite ends of the basin. If this is not possible the incoming stormwater runoff should be channeled away from the outlet structure into the stand of emergent vegetation.

Modifications to the Incoming Flow of Water

As discussed above, if the outlet and the inlet structures must be located close together it is recommended that the incoming stormwater runoff be channeled away from the outlet structure. If runoff enters the wetland with high velocity, bottom scour and damage to the emergent vegetation could result. If high water velocity is a potential problem some type of energy dissipation device should be installed. For channel flow rip-rap placed along the channel should be installed as needed. For basins in which runoff enters directly through a pipe the runoff should be directed at an energy dissipating structure. This would be a particular requirement for inflow pipes which discharge from above the surface of the wetland.

Outlet Structure and Extended Detention

The requirements of an outlet structure for a wetland basin include damming up the volume of water needed for wetland creation, detaining a certain volume of water for extended periods of time, and permitting water to flow from the wetland without blockage. Outlet structures include the common barrel and riser type and a simple damming device for retrofitting existing peak flow attenuation devices. The structures operate by damming up the base flow that previously left the basin at ground level. The structures have an orifice (or orifices) that permits the runoff to leave the basin. Above the orifice is a section of the outlet structure that detains a certain volume of runoff during storm events as runoff enters the basin faster than it can leave the basin through the orifice. Once the storm event is over the water level in the basin drops as the detained runoff flows out of the basin through the orifice.

The Washington, D.C. area portion of the U.S. Environmental Protection Agency's National Urban Runoff Program (MWCOG 1983) demonstrated the value of extended detention for dry stormwater basins. The relatively low volume of permanent water storage in shallow wetlands in comparison to deep ponds and lakes makes it important to incorporate extended detention into the wetland basin design. Based on studies reported in the MWCOG (1983) report, it is recommended that the runoff from a one year storm be detained for at least 24 hours.

The orifices used for extended detention will be vulnerable to blockage from plant material or other debris that will enter the basin with stormwater runoff. Some form of protection against blockage will almost certainly be necessary. The device used to protect the orifice must allow water to pass freely through the orifice, therefore some type of non-corrodible wire mesh is recommended. In general, wire mesh laid directly across the orifice will not suffice since the mesh can become blocked almost as easily as the orifice itself. Instead, the mesh should have some depth to it, so that the area that must be blocked

Table 1. Initial Considerations When Selecting a Wetland Site.

A. The rate of water flow into the pond must be greater than the infiltration rate of the basin. If not, a liner should be installed.

B. For basins that are to be retrofitted, all of the surface area should be used for the wetland.

C. When sizing new stormwater basins, maximize the surface area component and utilize it for wetland creation.

D. When extended detention is to be used there is no minimum size for the wetland basin in relation to the subwatershed area: Without extended detention the wetland area should be at least 3% of the subwatershed area.

Table 2. General Features of the Wetland Design.

A. 25% of the total wetland area should be 2 - 3 ft deep.

B. 75% of the total wetland area should be less than 12 inches deep.

C. The outlet structure should be included in the deeper area of the wetland.

D. There should be a 3 foot deep forebay having at least 10% of the total basin volume.

E. The wetland perimeter should be bordered by a 10-20 ft wide zone that is temporarily flooded at most storm events.

F. Incoming runoff should flow into the shallow, vegetated area of the wetland.

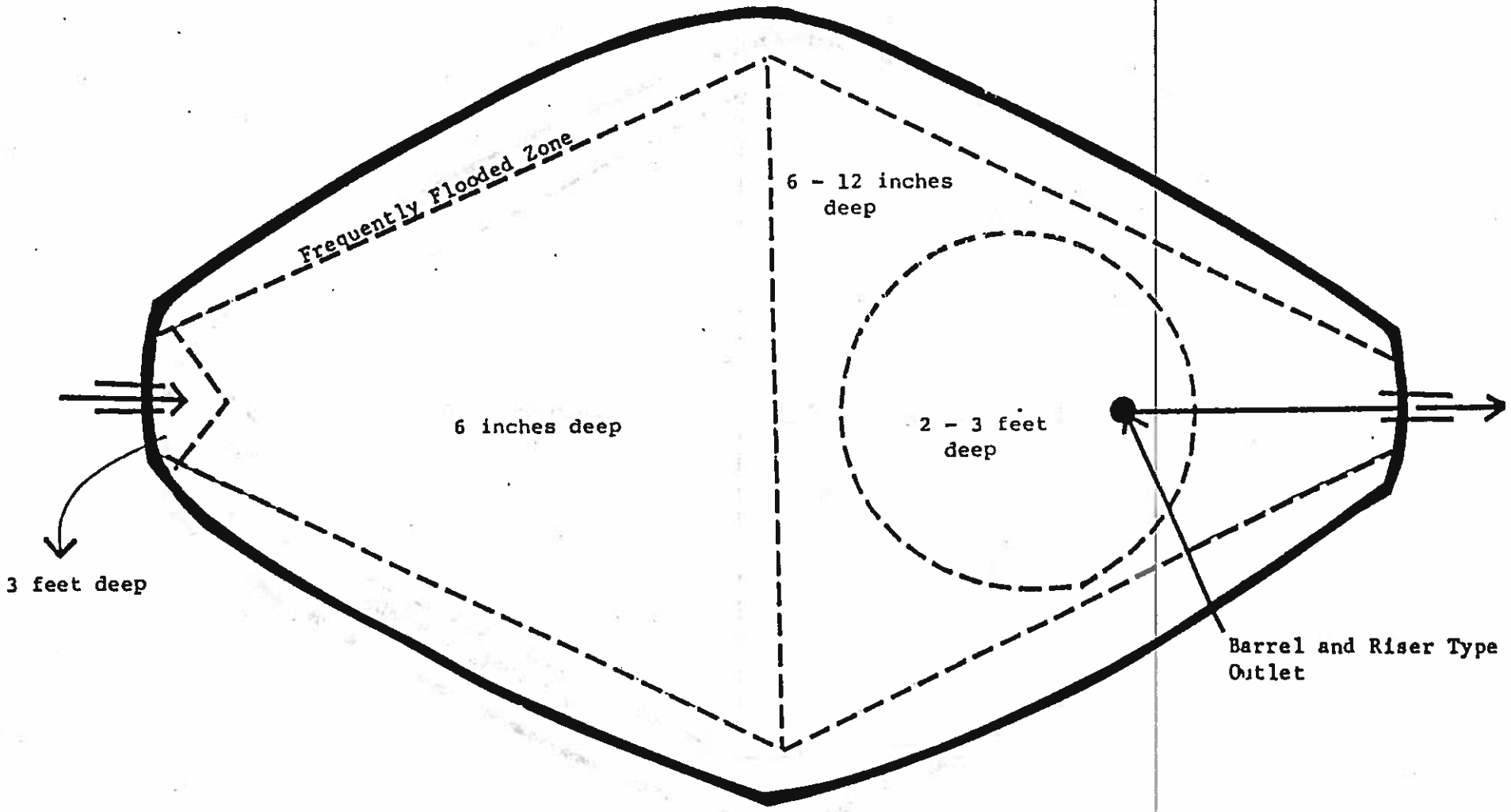


Figure 1. Potential Wetland Design

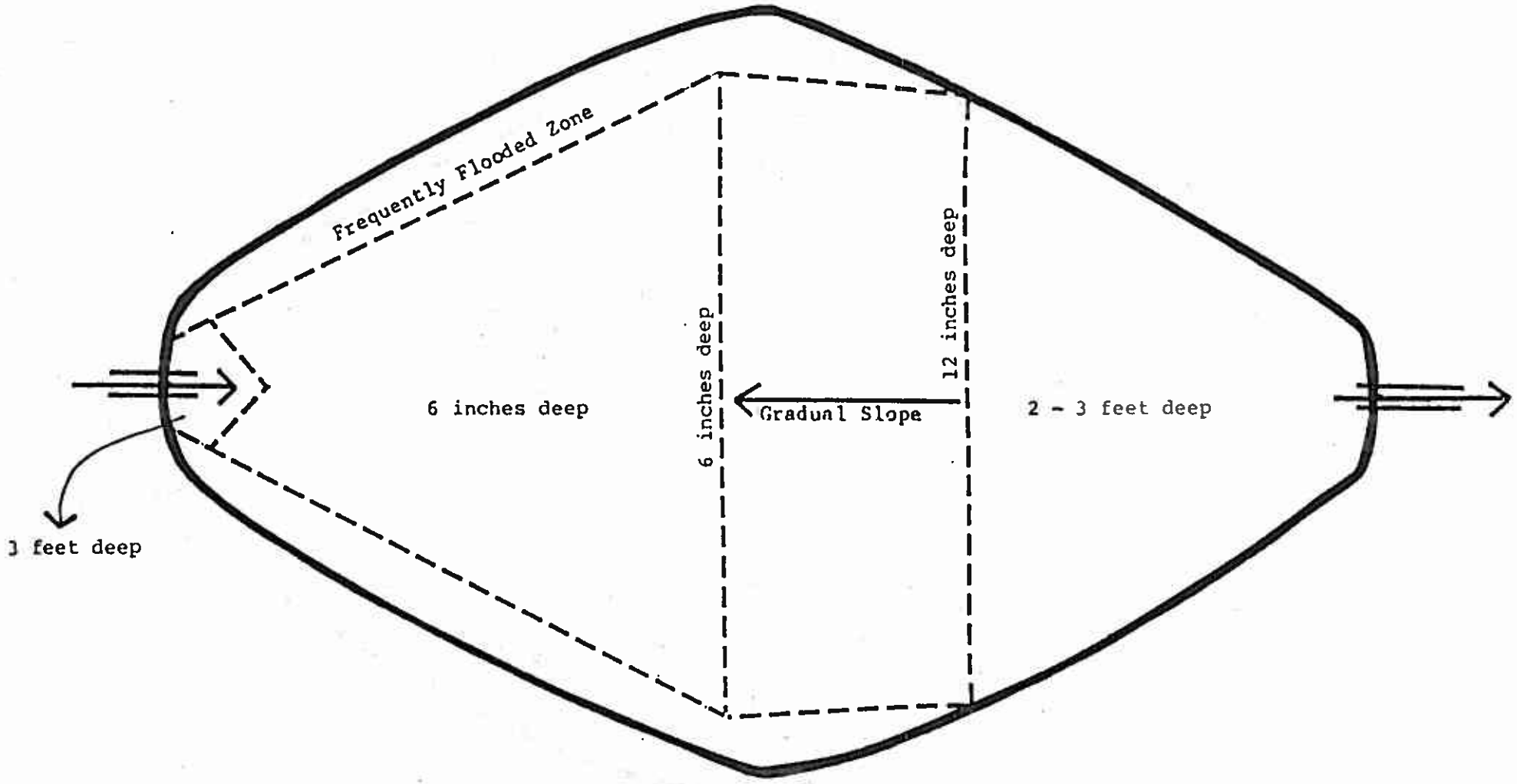


Figure 2. Potential Wetland Design

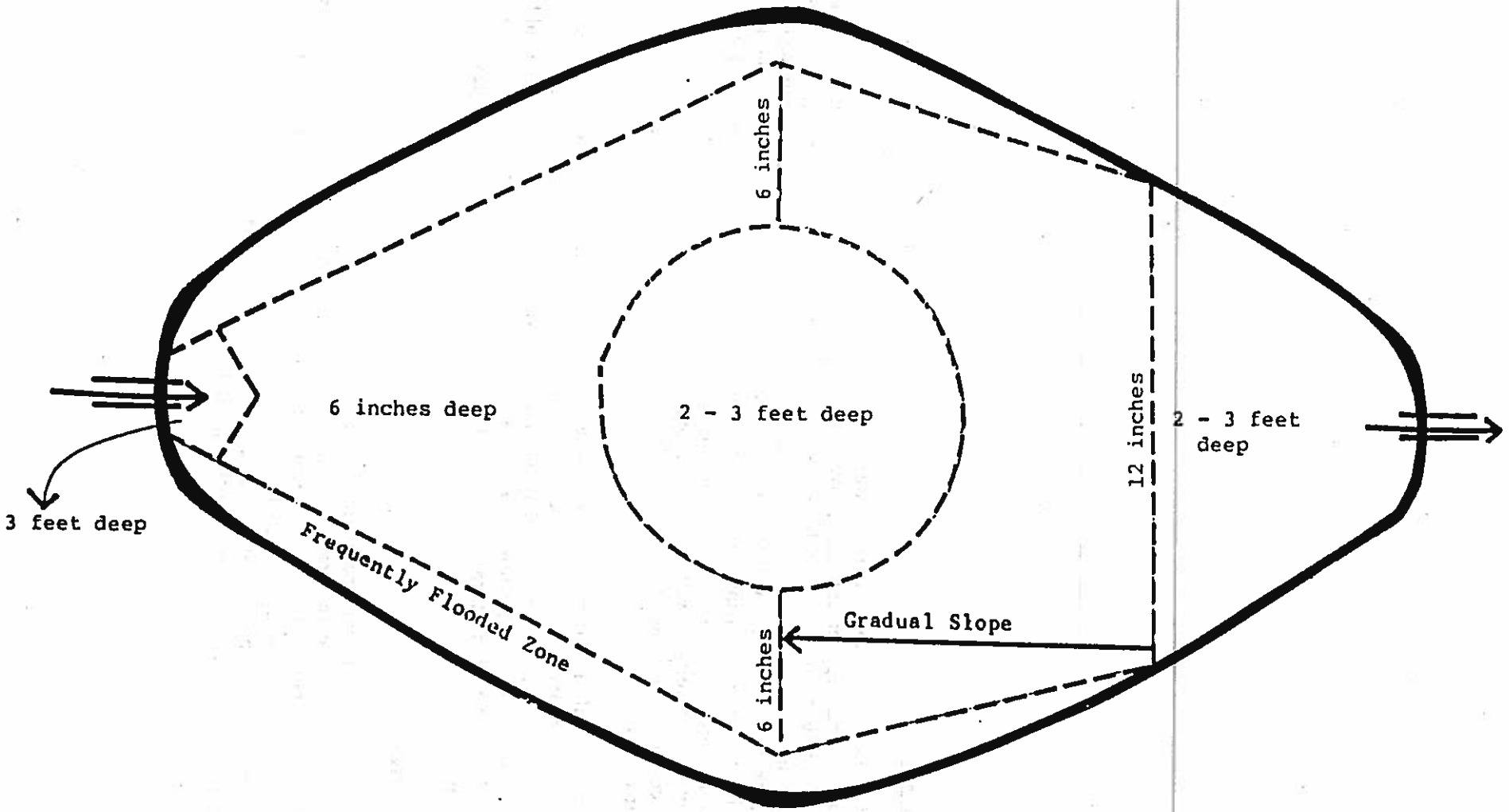


Figure 3. Potential Wetland Design

in order to interfere with water flow is relatively large. Given enough time, most of the organic materials (e.g. wood, vegetation, paper) floating by the outlet will lose buoyancy and sink.

The design of the protective device should result in a structure that has some depth to it. Hemispheric, pyramid, and box-like structures are possible, among others. The devices should be made of mesh and be reinforced so that they do not collapse and lose their functional surface area. They should also be attached very securely to the outlet structure. Since only periodically will the water level in the basin be above the orifice most of the protective structure should be below the permanent pond elevation.

BIOLOGICAL ASPECTS OF THE BASIN

Wetland Substrate

1. Preferred Soils

Wetland soils that have supported wetland vegetation will generally contain a pool of plant propagules. This type of soil can prove valuable when constructing an artificial wetland, since many of these propagules can be expected to generate vegetation in the new wetland. However, it is unlikely that a site for an artificial wetland will contain a preponderance of wetland soil, or that such soil will be available for application to the basin. On the other hand, it is likely that dry basins scheduled for conversion to wetland basins will contain at least isolated pockets of such soils. These basins will have base flow, and the presence of base flow generally results in wetland vegetation. The vegetation may be located along the channel that contains the flow, or there may be pockets of wetland vegetation in low areas of the basin that do not drain completely.

This type of soil should be preserved when the wetland basin is created. If excavating is necessary the wetland soil should be saved and then spread over the excavated and/or graded soil in the areas planned for shallow water. However, the best choice would be to maintain the wetland soil in its present position with no disturbance, although this will only be effective if the elevation of the wetland soil is compatible with the final elevation of the permanent pond.

2. Other Soils

Most of the soils that will be available for constructing artificial wetlands in stormwater basins will be acceptable for the establishment of wetland vegetation. Soil depth may be more important than soil type in establishing vegetation, since the plants must be anchored securely to the substrate to avoid being uprooted. A soil depth of at least 4 inches is recommended for the shallow wetland basin. If there is insufficient substrate depth on the basin the remainder can be made up using sand or other available soil material.

Wetland Vegetation

1. Planting Wetland Vegetation

The long term effects of artificially established wetland vegetation on the long-term vegetative development of the wetland is not yet clear. However, data show that artificial establishment does influence the short-term development of the wetland. In addition, volunteer species are not likely to occur in large numbers for at least several years after establishment of the wetland. For this reason it is recommended that wetland vegetation be artificially introduced on newly constructed wetland basins.

2. Desirable Species Characteristics

Shallow wetlands will not be completely homogeneous even if the construction plans call for homogeneity. Differences in soil types, depth, water circulation, and other factors will result in habitat variations on the wetland. To take advantage of this heterogeneity, more than one species of wetland vegetation should be established on the wetland. A greater number of sites on the wetland can thus be utilized, which will increase the probability that more of the wetland will be vegetated. There are other benefits also, including an increase in the diversity of food for wildlife, which will likely result in utilization by more wildlife species. In addition, the growth cycles of wetland species differ, with some species reaching peak biomass in the late spring while others will not reach peak biomass until later in the summer. A mix of such species will result in maximizing the presence of vegetation on the wetland throughout the growing season.

The most important species to be established on the wetland are those that spread aggressively. Aggressive species will spread to other sections of the wetland and by their increase in numbers make it more likely that the establishment will be successful. In addition rapidly spreading species will make it unnecessary to plant vegetation in all parts of the wetland, thereby resulting in a savings of money and manpower.

It is recommended that at a minimum 2 aggressive wetland species (which will be termed "primary" species here) be established in quantity on the wetland. This should ensure that the artificially established vegetation will spread and influence the species composition of the wetland for several years, at least.

In addition to the 2 primary species, it is recommended that 3 additional species (termed "secondary" species) be planted on the wetland, although in far lesser numbers than the two primary species. These species should have wildlife, aesthetic and other values but need not be as aggressive as the primary species. This small pool of secondary species may provide the wetland with larger populations of these important species in later years.

3. Selection of the Wetland Species

The primary qualities that are needed in a species for establishment on an artificial wetland are aggressiveness in spreading and value to wildlife. Although the productivity, and thus the nutrient uptake of species may be important to water quality improvements, there is not yet enough information available to select species by nutrient uptake rates.

Not all species have both aggressiveness and value to wildlife. Two species, Typha spp. (cattail) and Phragmites australus (common reed) are aggressive wetland species but do not appear to have good wildlife value. This is particularly true of Phragmites. Other species, such as Peltandra virginica (arrow arum), have good wildlife value but are reported to spread relatively slowly on the wetland. In Peltandra this is probably a result of very little vegetative propagation with the preponderance of spreading the result of seed germination.

There are a number of wetland species that are available commercially, and several others of less obvious value that could be scavenged from other wetlands. Table 3 lists the wetland species that are available, commercially and in local wetlands, for planting. The species are listed in terms of their suitability for establishing on artificial wetlands.

As can be seen in Table 3 under "primary species" there are several species that meet the requirements for aggressiveness. These species include Sagittaria latifolia (arrowhead), Scirpus americanus (common three-square), and Scirpus validus (soft-stem bulrush). All of these species are common in Maryland freshwater wetlands and are available commercially. Two of these three species should be chosen from this list.

This does not mean that other species of wetland plants that are not rapid spreaders are unsuitable for artificial wetlands. Such species may be quite valuable to the longer-term vegetation of the wetland and may even come to dominate it. However, they may not be suitable for establishing vegetation on the wetland relatively quickly. The three secondary species discussed above that are to be planted in lesser numbers on the new wetland should come from that section of Table 3 labeled "secondary species". However, no more than 1 of those species should have a maximum depth of 3 inches. Thus at least two of the species selected should have a maximum depth of 6 inches or more. Table 4 summarizes the plant selection procedures discussed above.

The last two species in Table 3, Typha spp. (cattail) and Phragmites australus (common reed) are special cases. These species are very aggressive and may completely dominate a wetland. Their relatively low wildlife food value and the density of the plant communities they form can result in a wetland with a low value to wildlife in terms of both food and habitat. It is recommended that cattail and common reed not be planted on artificial wetlands.

4. Number of Individuals of Each Species to Plant

There is limited information on which to base recommendations for the number of individual plants to establish on a wetland. This includes both influencing the long-term species composition as well as the immediate success of the artificial establishment. However, it can probably be safely assumed that if the habitat conditions on the wetland are not conducive to the growth of a certain species, that species will not do well even if planted at high population densities. Therefore, the first consideration is to have the proper water depths for the species that are going to be planted.

If habitat conditions are suitable the entire area planned for vegetation need not be planted. Aggressive species will colonize the areas not planted. It is recommended that 30 percent of the shallow (12 inches or less) area of the basin be planted with wetland vegetation. This vegetated area should be divided into four sites whose surface areas are approximately equal. Mixing species should be avoided in order to reduce competition within the planted areas. Each area should be located in that part of the wetland most conducive to the growth of the species it will contain, but in addition, the four areas should be placed as

Table 3. Emergent Species For Wetland Establishment

Species	Maximum Depth	Available Commercially
A. Primary species		
Sagittaria latifolia (duck potato)	12 inches	yes
Scirpus americanus (common three square)	6 inches	yes
Scirpus validus (softstem bulrush)	12 inches	yes
B. Secondary species		
Acorus calamus (sweet flag)	3 inches	yes
Cephalanthus occidentalis (button bush)	2 feet	yes
Hibiscus Moscheutos (rose mallow)	3 inches	yes
Hibiscus laevis (halbered-leaved r. mallow)	3 inches	no
Leersia oryzoides (rice cutgrass)	3 inches	yes
Nuphar luteum (spatterdock)	5 feet (2 ft min)	no
Peltandra virginica (arrow-arum)	12 inches	yes
Pontederia cordata (pickerel weed)	12 inches	yes
Saururus cernuus (lizards tail)	6 inches	yes

Table 3. (Continued)

Species	Maximum Depth	Available Commercially
C. Unacceptable species		
Phragmites australus (common reed)	3 inches	no
Typha latifolia (common cattail)	12 inches	yes
Typha angustifolia (narrow-leaved cattail)	12 inches	yes

Table 4. Species and Numbers of Individual Plants For Establishing Artificial Wetlands.

A. Select 2 Primary species

1. These species should cover 30% of the shallow zone of the wetland using a 3 ft spacing.

2. These species should be planted in 4 monospecific areas.

3. An additional 40 clumps/acre of each species should be distributed over the wetland.

B. Select 3 Secondary species

1. For each of the 3 species, plant 10 clumps of 5 individuals each as close to the edge of the pond as possible, per acre of wetland.

far apart as possible while still fulfilling the habitat requirements of the individual species. Within each area the individual plants should be spaced 3 feet apart.

In addition to these 4 sites small clumps of the primary species should be planted throughout the rest of the wetland to increase the probability and rate of colonization of unplanted areas. It is recommended that 40 clumps per acre per species be set out in this fashion. Each clump should contain one or more individuals of a single species. The clumps should be equally divided among the 2 primary species. Of course, species should not be planted where water depths are not conducive to the growth of that particular species. Place the clumps throughout suitable areas of the wetland.

Based on the above discussion, the number of individuals of each species to be planted is a function of the total area and shape of the site to be planted. In general, the planted areas should be made as square as possible within the overall design of the wetland, rather than long and narrow. The greater area to perimeter ratio of the square design may help to preserve relatively homogeneous populations of the planted species by reducing colonization.

In addition to the 2 primary species to be planted in abundance, 3 secondary species should also be planted on the wetland. It is recommended that approximately 50 individuals of each of these additional species be planted per acre on the new wetland. These plants should be set out in 10 clumps of approximately 5 individuals each. The clumps should be planted within 6 feet of the edge of the pond in the shallow area leading up to the ponds edge. In addition, the clumps should be spaced as far apart as possible, but there is no need to segregate species to different areas of the wetland.

5. Depth Requirements of the Selected Species

Emergent vegetation appears to grow best in water less than 12 inches deep, with depths of approximately 6 inches or less showing high growth rates. The three species mentioned above as primary species (Scirpus americanus, S. validus, and Sagittaria latifolia) will all do well in water approximately 6 inches or less deep. This is not to say that these species will have low survival rates in somewhat deeper water, however. They are often found in deeper water in natural wetlands, although the requirements for successful growth in deeper water may be more stringent than in shallower water. Thus the probability of successful establishment is greater in shallower water. In general the plants recommended for wetland establishment are suited for the recommended wetland depths, and this is noted in Table 3. The depth requirements of other species are also noted in Table 3.

6. Plant Propagule and Dates for Planting

Wetland plant establishment using seeds has been shown to have a low success rate due to the relatively exacting germination requirements of seeds. By contrast, growing plants and dormant underground plant parts are much more amenable to transplanting. The latter two categories of plant propagules are the primary means of plant establishment recommended here.

The growth cycle of perennial plants determines what form of propagule will be suitable for planting at particular periods during the year. At the end of the growing season, generally sometime in October or November, the above ground portion of the plant dies, while the below ground portion of the plant becomes dormant. The following spring the underground portion of the plant breaks dormancy and, using food reserves built up during the previous growing season, sends up new shoots. This growth generally begins in April.

From the above brief discussion it can be seen that the natural period of dormancy of wetland plants is also the correct time for planting dormant underground parts. Likewise, growing plants should be set out on the wetland during the growing season. In general, plants can be established on the wetland at all times of the year except late summer and fall. There are two reasons for this. First, plants must have sufficient growing time to store up food reserves in the below ground parts. Plants grown in bulk in the nursery have a difficult time doing this; consequently, they must be set out in the wetland sufficiently early to store up below ground reserves. It is recommended that July be the latest month for setting out actively growing nursery plants.

Dormant, below-ground plant parts are usually available in late November or December, although some dormant material may be available even earlier in the year. The principle time of the year for planting dormant material is from approximately November through April, although actively growing material may be available in April.

Not all species are desirable to plant in the dormant state. This may be due to the high probability of wintering waterfowl to detect and eat the planted material, or the low percent germination of dormant material. Since these factors may vary it is recommended that the probability of successful establishment be discussed with the seller of the plant material. In general, however, it is recommended that plant material be set out in the spring and summer, using actively growing material.

Submerged Aquatic Vegetation (SAV)

Submerged aquatic vegetation is an important food for waterfowl and may aid in improving the quality of stormwater runoff passing through the wetland. However, there appear to be few if any commercial SAV sources for fresh water sites at the present time. Therefore, the artificial introduction of submerged aquatic vegetation is not being recommended at this time. However, the recommendation for a deep pond in the artificial wetland (see above) was made, in part, to provide suitable habitat for SAV. It is quite likely that SAV will be brought to the wetland by migrating waterfowl or other means.

Although the introduction of SAV is not being recommended at this time, it is also not being discouraged. If a source of SAV is known a small amount can be introduced into the deeper part of the wetland. SAV that are an excellent waterfowl food and suitable for introduction include Potamogeton spp., Vallisneria spp., and Ceratophyllum demersum. Although these and most other SAV species can tolerate water deeper than the 2 to 3 feet discussed earlier, that depth range should be maintained due to the turbidity that seems to occur frequently in stormwater basins. Deeper, turbid water might eliminate SAV habitat in stormwater basins.

Preparing the Site for Planting

The only site preparation that is necessary for the actual planting (besides flooding the basin) is to ensure that the substrate is soft enough to permit relatively easy insertion of the plants. If the basin has been graded or excavated there will be no problem. However, there could be difficulty if the wetland is to be created by simply flooding a previously dry basin. Such basins may have a compacted substrate or the overlying vegetation may have formed a dense root mat or a sod that could make planting difficult. It is recommended that this type

of basin be "softened up" by disking or some other type of physical disturbance before the basin is flooded. Disturbance to the upper 6 inches of substrate should be sufficient.

Planting Procedures

The planting procedure begins when the final site preparations have been completed. These site preparations will include the flooding of the wetland to the proper depths, or if planting is to be done on the unflooded wetland, final plans to flood the wetland as soon as planting is complete.

Dormant below-ground plant parts are relatively easier to handle. They are stored dry, usually in mulch, at temperatures slightly above freezing to maintain the dormant state. These propagules should be kept dry until the time of planting, and freezing should be avoided. Planting consists of burying the dormant material to the proper depth in the substrate.

When growing plants are to be established on the wetland one of the primary concerns is to keep the roots moist. If the roots dry out they will be damaged and decrease the probability of a successful planting. Plants will be received from the nursery either growing in small peat pots or bare rooted. Bare rooted plants will very likely have some form of root protection when received, including moisture retaining plastic bags or water filled tubs. These plants can be kept for a number of days in this condition, although they should be kept out of direct sunlight. However, this type of environment is not a good one for maintaining healthy plants. They should be planted as soon as possible.

The potted plants will be received in very small peat pots that can dry out quickly if left in direct sunlight. Keep them in a shaded location. If planting is delayed there should be a source of water to moisten the peat pots if they do begin to dry out.

To ensure that the plants are spaced correctly it is strongly recommended that guides be placed in the proper locations in the wetland. These will not only help to maximize the coverage of the plants, but will also aid in avoiding damage to those already planted (when planting is being done on a flooded basin). This is particularly important with small plants that may not be sufficiently tall to reach the surface of the water. These plants will not be visible when the water is muddied by people walking in it. The planting guides can be stakes connected by string, with 3 feet intervals marked on the string. When a row is completed the stakes and string can be moved. Guides in one direction should be sufficient; a grid pattern is probably unnecessary.

The mechanism of setting out the plants in the wetland is relatively simple. For peat potted plants a hole is made in the substrate wide enough to take the peat pot, and deep enough that the wetland substrate is at the same level as the soil level in the peat pot. The hole can be made with a sharp wooden stake or a trowel or any other suitable tool. The personnel doing the planting, however, will find that tools that float will make the procedure much easier. The peat pot should be torn in several places right before planting to facilitate root spreading. When the peat pot is in the hole the surrounding substrate is pressed down firmly around it.

Bare rooted plants are treated similarly to peat potted plants, although the holes should be made large enough accommodate the roots. The roots should be spread out as much as possible when the plants are set into the hole, as opposed to being bunched together. The

plants should be placed deep enough that the wetland substrate is level with the point on the plant where stem becomes root. This point is usually easily identified. Thus the final arrangement of the roots in these plants will be shallow but spread out, with an overall depth of approximately 4 to 6 inches.

If the planting is to be done before the wetland is flooded no more than 24 hours should elapse before flooding occurs if bare root plants are involved. If flooding cannot occur within that time other arrangements, such as diverting the base flow through the planted area or utilizing water from a fire hydrant, should be employed. If only peat potted plants are involved no more than 72 hours should elapse between planting and flooding without using other means of wetting the plants.

Manpower Requirements

Setting out plants in a wetland is a relatively simple operation. The primary requirement for the job is a back strong enough to take a great deal of stooping. Planting a flooded wetland will take a little longer than a non-flooded one. Based on field operations, it is estimated that one person can plant 60 plants or more an hour in a flooded basin. Three people should have little difficulty planting 3,000 plants in less than two days.

Several factors may facilitate planting. These include floating tools for easy retrieval when the tools are dropped into the water, and floating tubs to hold the plants. Floating tubs will result in much higher planting efficiencies than other methods of carrying the plants, such as newspaper bags.

Potential Nuisance Species

There are two types of organisms that could affect the acceptance of the wetland basin by the people in the surrounding community. These include thick surface algal growths and mosquitos. Neither of these factors are likely to be a problem in the first years of the wetlands existence. However, they could arise if sedimentation changes the flow characteristics in the basin. The primary cause of either algal mats or mosquitos would probably be standing water in portions of the wetland that were prevented from draining properly. These areas could accumulate nutrients which would favor algal growth, while at the same time the fluctuating water level or other extreme habitat conditions could decrease or eliminate natural predators of mosquito larvae. Without these abnormal conditions algae and mosquitos will probably not be a problem around artificial wetlands. The correct maintenance procedures will restore the planned drainage characteristics and very likely eliminate any algal or mosquito problems.

Wetland Maintenance

Solids will accumulate on the wetland by two means. These include sedimentation of suspended solids carried to the basin in stormwater runoff and base flow, and the accumulation of plant material. Accumulation of this material could result in a loss of the area of ponded water available for emergent vegetation. Two remedies are available. The first is to raise the elevation of the water level in the permanent pond by raising the height of the orifice in the outlet structure. This can be accomplished by blocking off the old extended detention orifice and cutting a new one. Since the amount of runoff subjected to

extended detention is a function of the height of the outlet structure above the orifice, cutting a new orifice higher in the structure will decrease the volume of runoff that can be held for extended periods. This height should be restored to the outlet structure by welding on the necessary amount of material. The loss of peak storage volume by increasing the water level will be minimal considering the shallowness of the wetland.

The second remedy is to remove the accumulated solids by excavation. This will require draining some of the water from the wetland and could involve considerable disruption to the vegetative community, which could require replanting. However, much of the accumulated solids will probably be in the deeper forebay of the basin inlet (see Figures 1 - 3) where the runoff first loses velocity upon entering the wetland. This area should be relatively easy to excavate. In addition, not all of the water will have to be removed from the wetland since the overall ponded area (approximately 25% of the total wetland area) should not accumulate solids as rapidly as the forebay. Thus the deeper pond may not require excavating and can remain flooded when the shallower areas are drained.

At this time it is not clear how long shallow wetland basins will function without maintenance. To avoid maintenance as much as possible it is recommended that wetland basins be installed on stabilized watersheds and not be used for sediment control. In addition, the maintenance procedure recommended here is that the outlet structure be modified to raise the elevation of the permanent pond when solids accumulate. This procedure can be repeated until the peak storage volume requirements of the basin are in danger of being compromised, at which time excavation will be required.

SUMMARY OF SHALLOW WETLAND CRITERIA

1. Site Selection

In order to maintain a shallow pool of water for a wetland the inflow of water must be greater than that leaving the basin by infiltration. Water inputs can include stormwater runoff, base flow, and groundwater. If the basin intersects groundwater there should be little trouble in maintaining a permanent pond. However, stormwater runoff and base flow maintenance of a permanent pond will require the infiltration rate to be less than those inputs. Basin infiltration rates can be estimated by the infiltration rates of the different soil types in the basin or, more accurately, by running infiltration tests in the basin. If the infiltration rate of the basin exceeds the estimated input of water other means can be used to decrease the infiltration rate of the basin. These methods include lining the basin with clay or installing a plastic liner beneath a protective layer of soil or sand.

2. Maximizing the Wetland Surface Area

When creating a wetland in an existing dry stormwater basin as much of the surface area of the basin as possible should be utilized for the permanent pond and frequently flooded zone (see below for a discussion of the frequently flooded zone). When a new stormwater basin is planned the dimensions required for controlling peak runoff volume should be set to maximize the surface area component as compared to the depth component.

3. Extended Detention

It is recommended that wetland basins utilize an extended detention program of 24 hours of detention for a 1 year storm. If extended detention is not possible, the surface area of the wetland should account for a minimum of 3 percent of the area of the subwatershed draining into it.

4. Water Depth Requirements

Approximately 75% of the wetland pond should have water depths less than 12 inches, while 25% of the wetland pond should have depths ranging from 2 to 3 feet. Of the 75% of the wetland that is less than 12 inches deep, 25% should range from 6 inches to 12 inches deep, while the remaining 50% should be 6 inches or less in depth.

The deeper areas of the wetland pond should include the outlet structure so that outflow from the basin is not interfered with by sediment buildup. In addition, a great deal of sediment deposition will occur near the inflow pipe as the incoming runoff loses velocity upon entering the basin. To prevent this area from becoming blocked with sediment it is recommended that an area of approximately 10% of the total basin volume inflow point have a depth of at least 3 feet. Several possible wetland layouts are shown in Figures 1 through 3.

5. Frequently Flooded Zones

There should be an area of very little slope around the periphery of the permanent wetland pond that is temporarily flooded during most runoff events but which drains as the detained runoff leaves the basin. It is recommended that this frequently flooded zone include the area within approximately 10 to 20 feet from the edge of the permanent pond.

6. Extended Detention Outlet Structure

The requirements of an extended detention outlet structure for a wetland basin include damming up the volume of water needed for the wetland, detaining a certain volume of water for the period of extended detention, and permitting water to flow from the wetland without blockage. The outlet structure is a dam with an orifice at the level of the surface of the permanent pond. The limited diameter of the orifice prevents runoff from leaving the basin as quickly as it enters, resulting in an increase in the volume of water in the basin. The section of the structure which continues above the orifice detains the runoff as the water depth increases. Once the storm event is over the water level drops as the detained runoff flows out of the basin through the orifice.

7. Protecting the Orifice From Blockage

The relatively small orifices used for extended detention will be vulnerable to blockage. Some form of protection will be necessary. It is recommended that wire mesh be used to fashion a cube, sphere, or other three-dimensional structure possessing considerable surface area.

8. Grading or Disking the Basin Before Planting

The basin substrate should be soft enough to permit relatively easy insertion of the plants into the soil. If the basin has been recently graded or excavated the soil should be

sufficiently soft. However, if the basin soil is compacted or the existing (dry basin) vegetation has formed a sod or root mat planting will be difficult. In these cases it is recommended that the basin soil be disked or otherwise physically disturbed before the basin is planted (and before flooding).

9. Area of the Basin to Vegetate

It is recommended that 30% of the shallow (12 inches or less) area of the basin be planted with wetland vegetation. This vegetated area should be divided into four sites whose surface areas are approximately equal. The four sites should be located as far apart as possible.

10. Number of Wetland Species to Plant

It is recommended that a total of 5 wetland species be established on the wetland. Two of these species should be selected from the list in Table 1 under the heading "primary species". These two species should be established throughout the entire 30% area selected for planting. As this area was divided into four sections (see above), each section should have only 1 species planted on it. This vegetation should be planted at a spacing of 3 feet between individual plants.

In addition to the above procedure, it is recommended that 40 clumps per acre of each primary species be distributed throughout the rest of the shallow portion of the wetland. Each clump should contain one or more individuals of a single species.

The remaining 3 species of wetland plants should be selected from that portion of the list in Table 1 under the heading "secondary species". It is recommended that 50 individuals of each secondary species be planted per acre of wetland. The species should be set out in 10 clumps of 5 individuals each. These clumps should be located within 6 feet of the edge of the pond, and be distributed throughout the wetland.

11. Proper Treatment of Plant Material

For successful establishment of wetland vegetation the nursery stock must be correctly handled prior to planting. For growing plants, this consists of keeping the roots moist at all times, and in keeping the plants out of direct sunlight as much as possible. Vegetation should be planted as quickly as possible to avoid the adverse effects of on-site storage. Dormant plant material should be stored under conditions as similar as possible to those under which the material was stored at the nursery.

12. Planting Procedure

For planting peat-potted plants, make a hole in the substrate wide enough to take the peat pot, and deep enough that the wetland substrate is at the same depth (or a little deeper) than the soil level in the peat pot. The peat pot should be torn in several places right before planting to facilitate root spreading. Press the substrate firmly around the peat pot.

For bare-rooted plants make the hole large enough to spread out the roots horizontally. The plants should be placed deep enough that the wetland substrate is level with the point on the plant where the stem becomes root.

13. Wetland Maintenance

Sediment accumulation will be the primary maintenance problem in shallow wetlands. Sediment accumulation could result in a loss of ponded portions of the wetland, or the formation of shallow channels that could reduce the mixing of stormwater with pondwater. Two maintenance remedies are available for sediment effects. The first is to raise the elevation of the water level in the permanent pond by raising the height of the orifice in the outlet structure. This can be accomplished by blocking off the old orifice and cutting a new one higher up on the structure. To continue detaining the same volume of runoff for extended periods the portion of the outlet structure above the orifice will have to be lengthened to make up for the portion lost by raising the orifice. This procedure can be repeated until the peak storage volume requirements of the basin are in danger of being compromised, at which time excavation will be required.

The second remedy is removal of the sediment by excavation. This will require drainage of some of the wetland water and could result in considerable damage to the wetland vegetation. Replanting could be required.

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Feasibility & Design of Wet Ponds to Achieve Water Quality Control (1986)

Feasibility And Design Of Wet Ponds To Achieve Water Quality Control

July, 1986

Maryland Department of the Environment

Water Management Administration

2500 Broening Highway
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INTRODUCTION

The State of Maryland is committed in an all out effort to reduce the pollutants associated with urban runoff. Urban runoff carries pollutants such as nitrogen, phosphorus, heavy metals, sediment, and many other toxic materials that are significantly reducing the water quality in the Chesapeake Bay. As a result of this degradation in water quality, life in the Bay is slowly declining. Without effective urban runoff control, life in the Bay and its tributaries will continue to decline.

Due largely to increased awareness in the declining health of the Chesapeake, Maryland's Stormwater Management Program addresses the management of urban runoff water quality as well as quantity. This is achieved through the selection of stormwater management practices in accordance with a preferential list. Infiltration is the first practice which must be considered. When infiltration practices are not feasible, wet "retention" ponds are the preferred stormwater management method. Dry "detention" ponds are considered only as a last alternative, because they provide very little pollutant removal. The feasibility of infiltration practices is clearly determined by the criteria in the "Standards and Specifications for Infiltration Practices" (DNR, 1984). However, there are no written criteria to determine when wet ponds are feasible and how to design them for water quality benefits. It is the purpose of this paper to establish water quality criteria for the feasibility and design of wet ponds.

Wet ponds have been proven to be very effective in removing pollutants from urban runoff. Several studies have been done through the Nationwide Urban Runoff Program (NURP) conducted by EPA (1983) that provide evidence of the

effectiveness of wet ponds in removing urban runoff pollutants. The high pollutant removal rate of wet ponds is primarily attributed to the permanent pool of water which provides for gravity settling, chemical flocculation and biological uptake of pollutants.

Gravity settling is the removal of particles through sedimentation in the wet pool area. The removal rate of these particles is directly related to the pond's geometry, volume, residence (detention) time, and the size of the particles. Removal by settling occurs when the average velocity in the pond is less than the critical settling velocity of the particles (Barfield, 1981).

Chemical flocculation occurs when the heavier sediment particles overtake and coalesce with smaller, lighter particles to form still larger particles. The opportunity for particle contact increases as the depth of the permanent pool increases. As a result, the removal of the smaller suspended matter depends not only on the pond surface area, but the depth of the pond as well.

The last process of water pollutant removal is biological uptake. Biological uptake occurs primarily in the bottom of the pond as a result of the metabolism of microorganisms. These microorganisms, primarily in the form of bacteria, digest organic matter. The biological component, which is not well understood, is a complex system of transformation, storage, and cycling of nutrients, metals, and other materials found in urban runoff.

POLLUTANT REMOVAL PARAMETERS

There are several parameters that will determine the pollutant removal efficiency of a wet pond. These parameters include the pond geometry, wet pond depth, the area ratio, and the volume ratio. These parameters are discussed in detail in the following sections.

Pond Geometry

The pond geometry has a strong influence on how effectively the permanent pool volume is utilized to remove pollutants. In some cases, there are areas

of the pond that are ineffective in providing any pollutant control. This occurs in dead storage areas where inflow is bypassed without mixing. Figure 1 shows several examples of reservoir shapes which have large dead storage volumes and are to be avoided.

To avoid dead storage areas where mixing and settling of inflow pollutants do not occur, the length to width ratio should be no less than 2:1. In addition, a wedge shaped reservoir with the inlet located at the narrow end will maximize inflow mixing. If dead storage areas of flow are unavoidable based on topographic conditions, the effective length of flow can be increased by adding diversion barriers in the pond. These barriers may be created by a small island, a peninsula, or some sort of baffle.

Wet Pond Depth

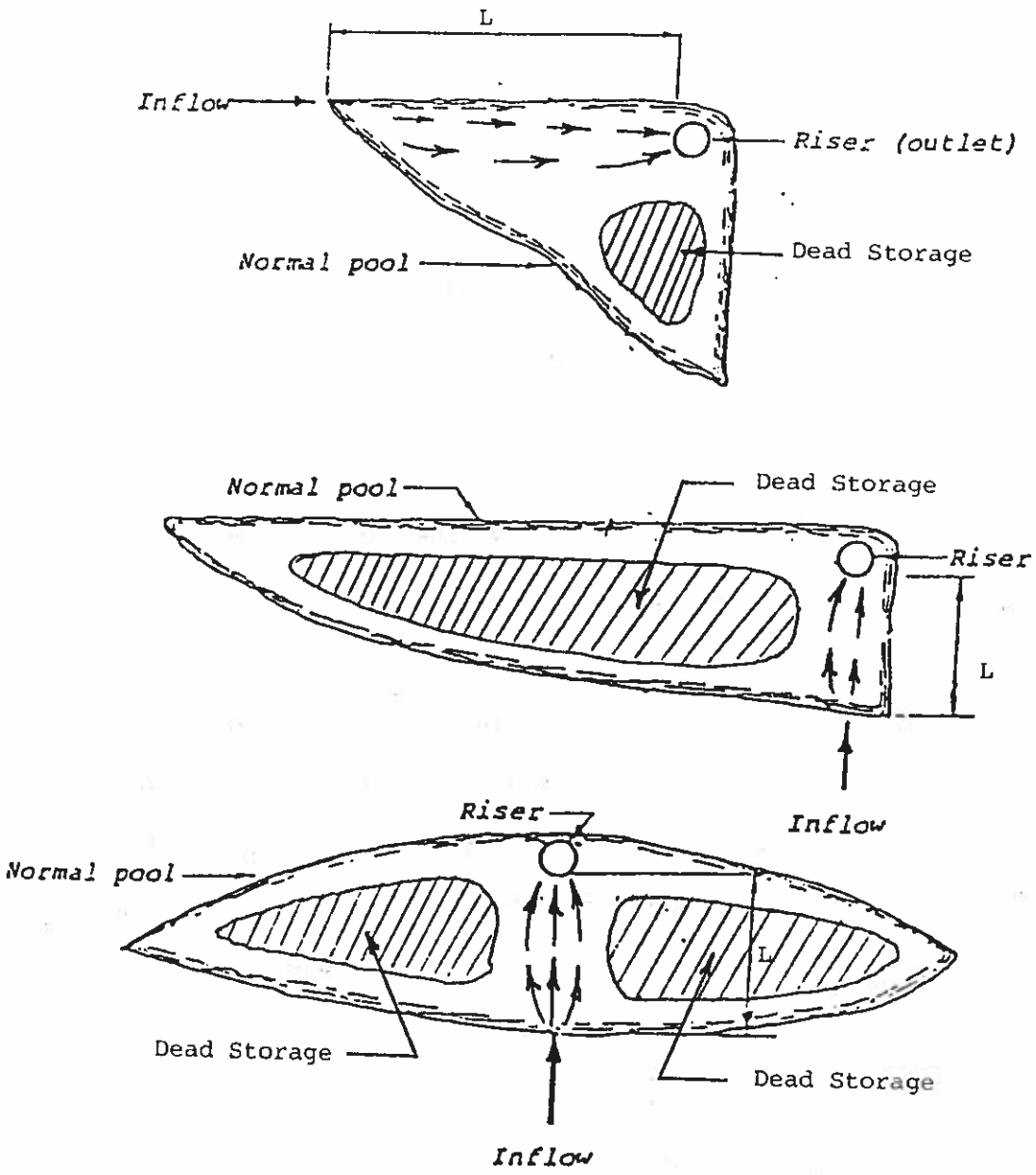
Selecting the wet pond depth is dependent on the intended use of the pond. If the pond is to be a multiple purpose facility, the depth of the permanent pool will vary to provide water quality enhancement, wildlife benefits, and recreational uses.

A shallow marsh habitat or wetlands environment can be created by a wet pool depth ranging from 1/2 to 2 feet. The shallow depth will allow emergent aquatic vegetation to be established which is very beneficial in removing nutrients and other attached pollutants from the water column. A shallow marsh area also provides an excellent environment for wildlife (Godfrey, 1985).

The Maryland Soil Conservation Service pond guidelines specify that a fish pond will require a 6 to 8 feet deep pool over at least 1/3 of the surface area. The shoreline should be sloped to be at least 3 feet deep within 6 feet of the water's edge and have a minimum surface area of 1/4 acre (SCS, 1981).

With respect to water quality enhancement, a pond containing areas of both shallow depths (less than 2 feet) and deep depths (greater than 3 feet) may be the most beneficial. The emergent aquatic vegetation in the shallow areas will

Figure 1. EXAMPLES OF DEAD STORAGE AREAS IN WET PONDS



reduce nutrient loads into the pond which will prevent excessive algae growth. The deeper areas of the pond will provide pollutant removal by gravity settling during and after storm events. Figure 2 illustrates a typical pond profile with multiple depths.

Wet ponds should generally be limited to a maximum depth of 15 feet. Ponds that are deeper than 15 feet are classified as a dam and will require special design and approval by the Maryland Water Resources Administration.

Area and Volume Parameters of Wet Ponds

There are two important area and volume parameters that effect the pollutant removal efficiency of wet ponds. These parameters are the area ratio (A/A_s), and the volume ratio (VB/VR).

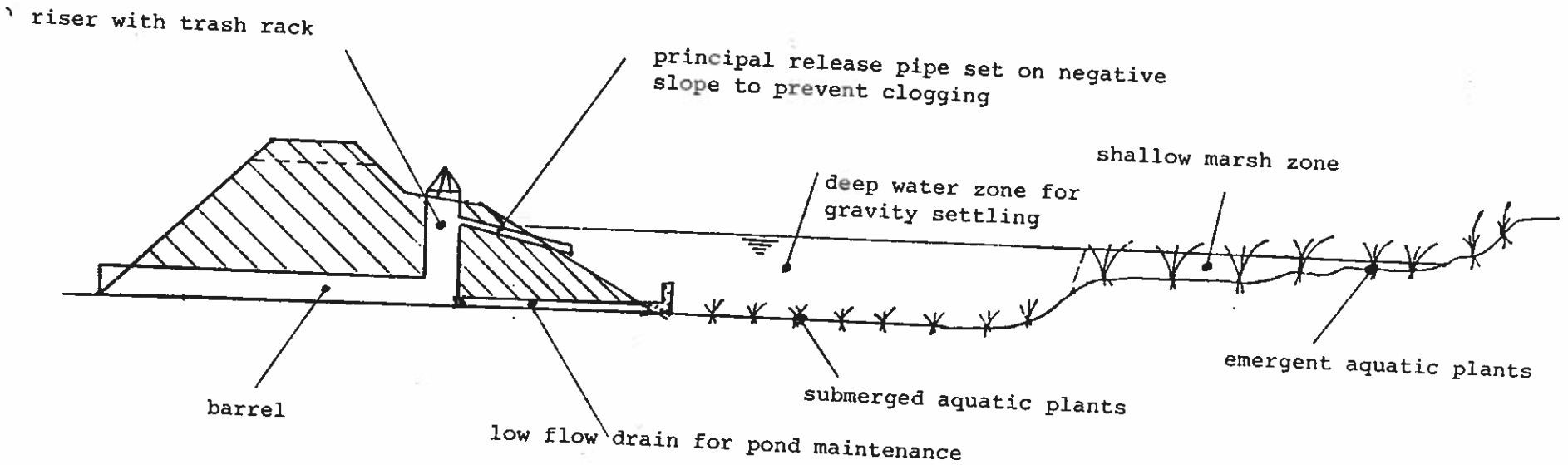
The area ratio (A/A_s) is determined by dividing the drainage area (A) by the wet pool surface area (A_s). For an example, an area ratio of 40 represents a 2 acre basin surface area serving an 80 acre drainage area.

The Soil Conservation Service uses the area ratio to provide guidance for design of farm ponds. They have used the rule of thumb of the drainage area to pond surface area ranging from 10 to 50.

The volume ratio (VB/VR) is equal to the wet pool volume (VB) divided by the mean runoff volume (VR). The mean runoff volume can be estimated by multiplying the mean rainfall depth times the rational runoff coefficient (C). Based on 25 years of gage records, the mean rainfall depth (per event) for Washington, D.C. and Baltimore is approximately 0.4 inches. Therefore, the mean runoff volume (per event) for Maryland in units of inches can be approximated by 0.4C.

The Rational Method was selected for water quality analysis because studies have shown that it results in a more accurate runoff prediction than the TR-55 Method for small rainfall events (Morris, 1983). The apparent error involved

FIGURE 2. Wet Pond Profile With Shallow Marsh Habitat



with the TR-55 Method is the large initial abstraction assumed during small rainfall events which results in very small runoff depths. In addition, the Nationwide Urban Runoff Program water quality data is based on the Rational Method.

In 1978, the United States Environmental Protection Agency initiated a multi-year study to examine the significance of urban runoff as a component of the nation's water pollution problems, along with the need and potential for its control. The study, termed the Nationwide Urban Runoff Program or NURP, was designed to build on the limited body of knowledge then available on the impacts of urban runoff on receiving waters, and to develop practical engineering data on the relative cost and effectiveness of control measures.

Table 1, which was developed from the NURP data, tabulates the performance of retention basins in removing pollutant mass loads over all monitored storm events (EPA, 1983). Removal efficiency is determined from the sum of pollutant masses entering the basin and leaving the outflow device. This NURP data suggests that pollutant removal performance will improve when the volume ratio increases and the area ratio decreases. However, the variability in the actual monitored results tends to confuse the pollutant removal effects of the area and volume ratios.

As an example, retention basins 4 and 5 have the same relative volume ratios (approximately 1.0) but the area ratios are quite different. Basin 5 (area ratio of 87) has removed 85 percent of the total suspended solids (TSS) while basin 4 (area ratio of 329) has removed only 5 percent. From this example, it is apparent that a smaller area ratio which results in a larger surface area significantly increases the pollutant removal efficiency.

The effects of the volume ratio can be seen between basins 6 and 8 where the area ratios are relatively constant. Basin 8, which has a volume ratio of

TABLE 1. OBSERVED PERFORMANCE OF RETENTION BASINS (NURP)

Basin No.	Average Basin Depth (ft)	Size Ratios		Average Mass Removals From All Monitored Storms (%)						
		A/A_s	VB/VR	TSS	BOD	TP	TN	T.Cu	T.Pb	T.Zn
1	2.6	10526.34	0.045	(-)	14	(-)	(-)	(-)	9	(-)
2	2.6	2857.14	0.17	32	3	12	7	(-)	26	(-)
3	5.0	1111.11	0.52	32	21	18	14	.	62	13
4	4.1	328.58	1,16	5	(-)	34	20	.	.	5
5	1.5	86.96	1.02	85	4	3	19	.	82	(-)
6	3.3	54.35	3.07	60	TOC=7	45	(-)	.	80	.
7	2.0	35.09	5.31	81	.	54	27	.	.	26
8	4.6	58.48	7.57	91	69	79	60	57	95	71
9	5.2	57.14	10.70	84	.	.	34	71	78	71

7.6, removed 91 percent of the sediment load while basin 6, having a volume ratio of 3.1, removed only 60 percent of the sediment load. Therefore, based on actual field data, a larger wet pool volume will provide an increase in pollutant removal.

DYNAMIC AND QUIESCENT POLLUTANT REMOVAL MODEL

Another method of examining the pollutant removal efficiency of wet ponds is to use a probabilistic analysis of storm runoff and settling theory. This model is based on techniques developed by DiToro and Small (1979) which describes removal efficiency as a function of storage volume. The model considers the pollutant removal by settling properties during dynamic conditions in which flows move through the basin, and under quiescent conditions during the time between rainfall events.

Driscoll (1983) has developed a microcomputer version of the model for computing percent removal rates of the total sediment loads. Input data used in the computer program includes rainfall statistics, settling velocities of urban runoff particles, rational runoff coefficients, wet pool depths, and area ratios. The program outputs the standard input data as well as the volume ratios and the percent sediment load removal.

Figures 3, 4, and 5 have been developed based on the output data from the computer program using Maryland rainfall data. These figures can be used to predict the percent reduction of sediment load and attached pollutants retained by wet ponds. The figures are valid for 10 different watershed landuse conditions and average wet pool depths of 3, 6, and 9 feet. Percent reduction of sediment and attached pollutants loads for conditions different than those provided in the figures may be determined by interpolation.

For an example, a wet pond with an average wet pool depth of 3 feet, serving a 50 percent impervious watershed, designed with an area ratio of 200

FIGURE 3.

Percent Reduction of Sediment Load and Attached Pollutants

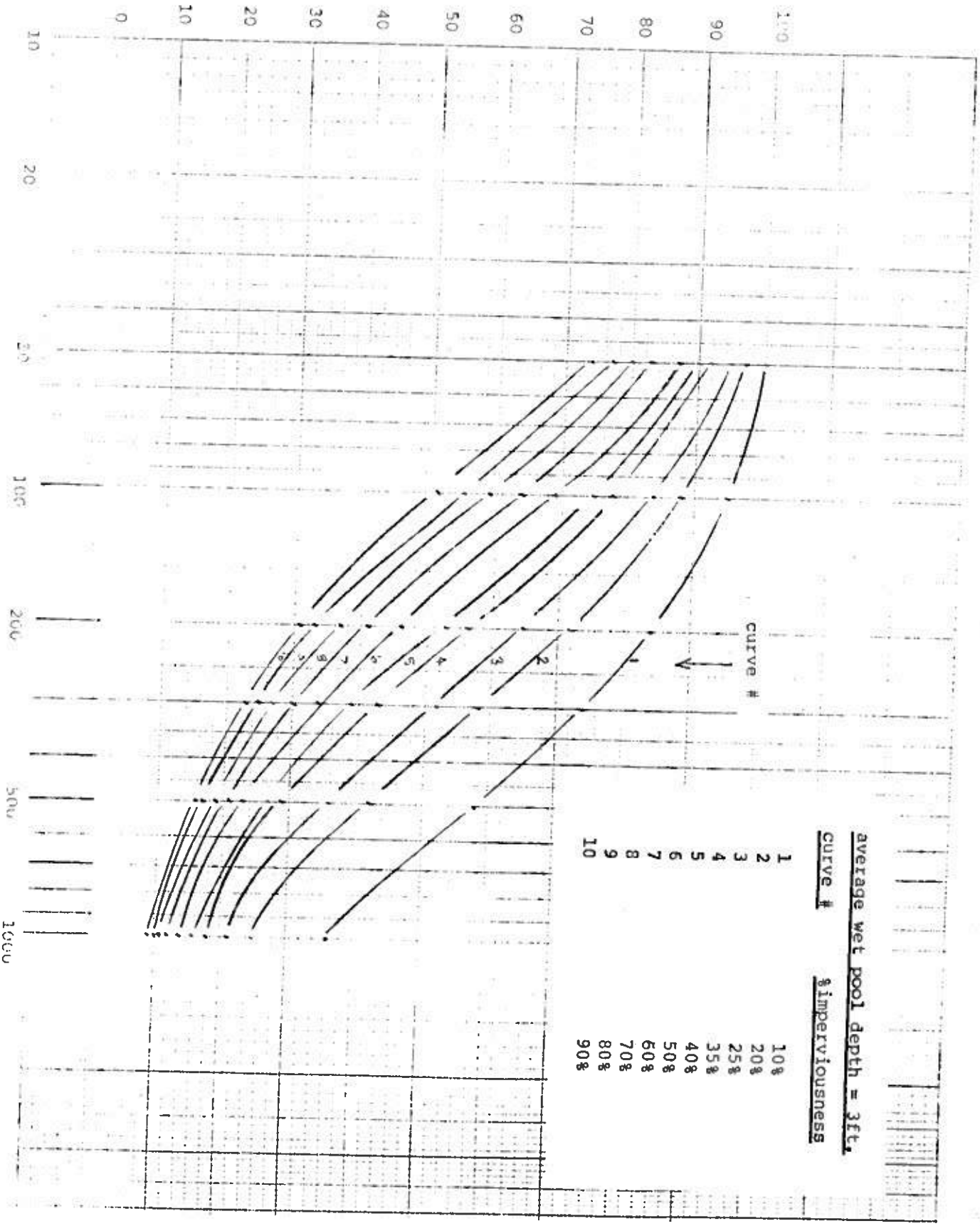


FIGURE 4.

Percent Reduction of Sediment Load and Attached Pollutants

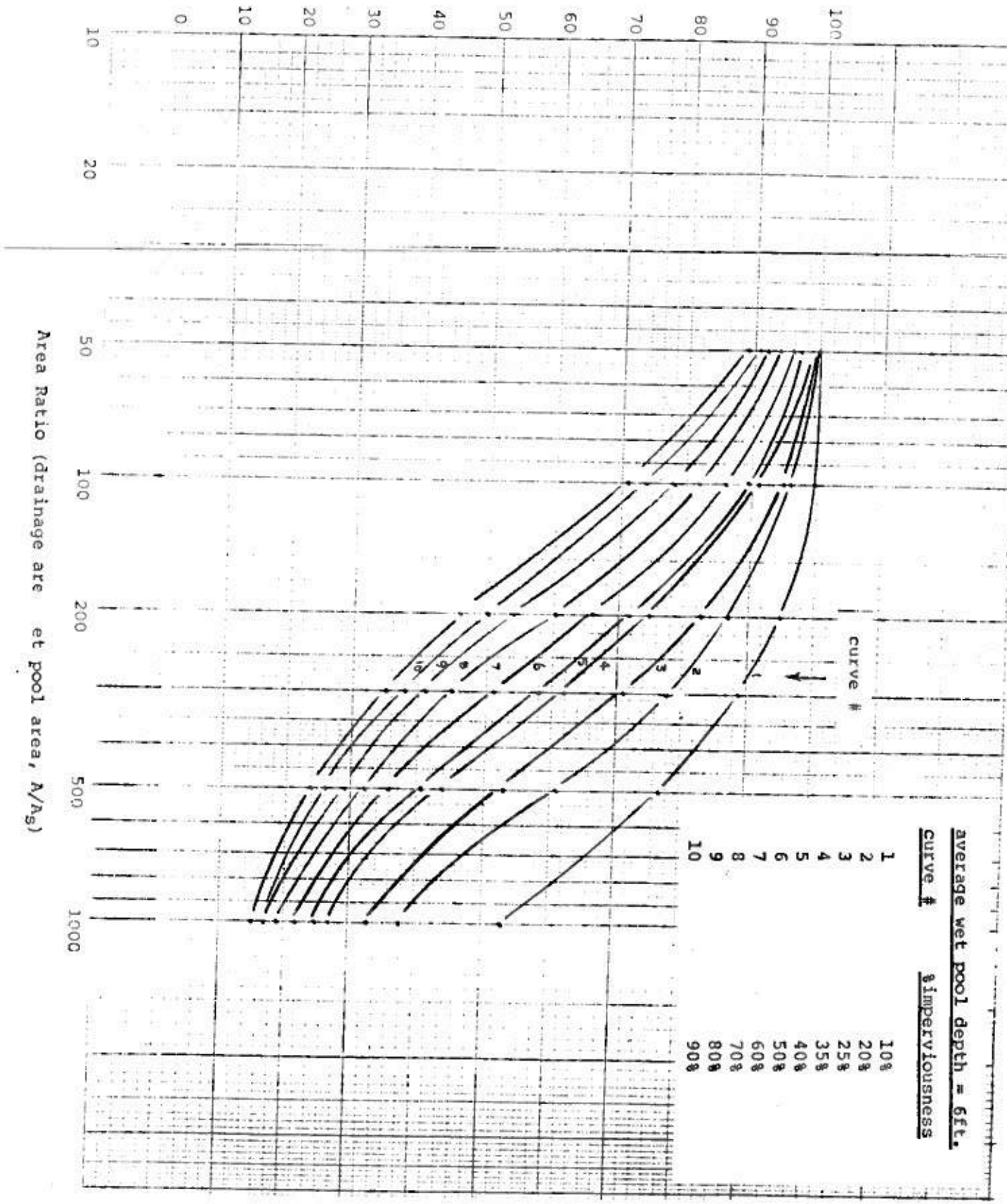
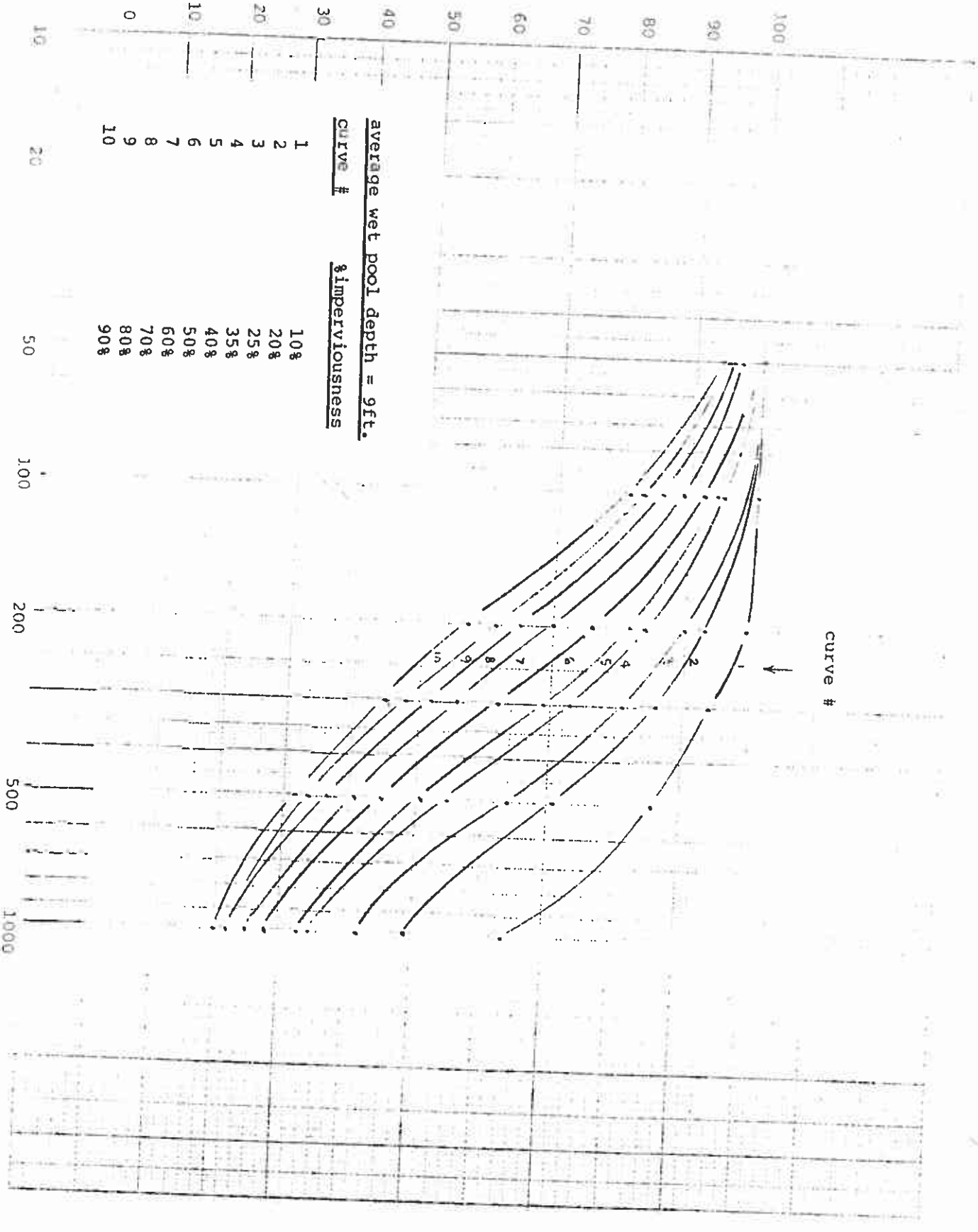


FIGURE 5.

Percent Reduction of Sediment Load and Attached Pollutants



will remove approximately 46 percent of the total sediment load (see Figure 3). If the pond was designed with an area ratio of 50, the predicted percent sediment removal would increase to 87 percent. It is very evident from this example that a smaller area ratio (larger pond surface area) will improve the pollutant removal efficiency. This conclusion agrees with the actual monitored pollutant data of the wet ponds collected in the NURP Study.

The landuse also effects the pollutant removal efficiency of wet ponds. A wet pond located in an urban area will receive more surface runoff than in a rural area. Because of the increase in runoff and the additional pollutant washoff, an urban pond will require a larger wet pool volume to provide an equivalent removal efficiency. An increase in volume can be accomplished by increasing the pond surface area (reducing the area ratio) or the wet pool depth. To achieve a 70 percent reduction in sediment load, a 3 feet deep wet pond in a 90 percent impervious watershed (area ratio = 350) would require over 6 times the surface area as a pond in a 10 percent impervious watershed (area ratio = 56).

The wet pool depth can be increased to achieve equivalent water quality benefits, but it is not as effective as changing the surface area. A 3 feet deep pond in a 35 percent impervious watershed would be equivalent in removal efficiency to a 9 feet deep wet pond in a 90 percent impervious watershed (both ponds would require an approximate 130 area ratio and would be expected to remove 70 percent of the sediment load).

It is interesting to note that over 90 percent removal occurs under quiescent conditions. The dynamic removal rates during the time of flow through the pond only accounts for 2 and 6 percent removal of the total sediment load. This is a result of the short residence or detention time that occurs during the storm event as compared to the quiescent time in between rainfall events.

Since several other pollutants are attached to sediment, an approximate estimate of removal rates for other particulate pollutants can be made. Based on NURP data, the particulate fraction of lead and total phosphorus is approximately 90 and 65 percent, respectively. An empirical estimate of particulate fractions for TKN, Ca, Zn, and BOD is approximately 50 percent. In the absence of any local data, the estimated removal rates of these pollutants can be determined by multiplying the particulate fraction by the sediment removal rate.

MINIMUM DRAINAGE AREA

The feasibility of creating a wet pool is highly dependent on the amount of runoff entering the pond as well as the seepage losses out of the pond bottom. The amount of surface runoff is determined primarily by the pond's drainage area and landuse conditions. It is very possible for a small developed watershed to produce more runoff than a larger wooded watershed. Therefore, it would be very difficult and perhaps erroneous to select a single minimum drainage area that would apply to all landuse conditions.

The Soil Conservation Service (SCS) has a history of designing wet farm ponds. According to some SCS personnel, there are farm ponds on the Eastern Shore that remain wet with drainage areas less than 10 acres. SCS personnel on the Western Shore of Maryland have recommended a minimum drainage area from 10 to 50 acres.

The City of Rockville requires a minimum drainage area of 10 acres and a minimum surface area of 1/4 acre for wet ponds. It appears that each individual or organization with some background in pond design has a different opinion on the minimum drainage area criteria.

The minimum drainage area criteria is variable because of the large diversity in soil and landuse conditions. The soil and landuse conditions

effect the runoff into a pond and the seepage rate through the bottom of the pond. For an example, a 10 acre drainage area may provide an adequate supply of water due to a highly impervious ground cover and a clay pond bottom. On the other hand, a 50 acre site may not supply enough water if there are high seepage losses through the pond's floor area.

Wet ponds may be established for any drainage area if it can be demonstrated that an adequate source of groundwater is available. But for the purpose of developing design criteria, it is assumed that the only source of water is from surface runoff.

POND SEEPAGE

Excessive seepage in ponds may occur when the underlying soils are too permeable to hold water. Permeable soils which include sand, loamy sand, sandy loam, and loam textural classes should only be used with infiltration practices. Soils that are classified in the silt loam through clay textural classes may be used for wet ponds because of their relatively low permeability rates. Although, a wet pond can be constructed on any soils if there is a high groundwater table that would prevent the use of infiltration practices.

In areas where the seepage losses are moderately high (silt loams and clay loams), the permeability of the soils may be reduced to a point where losses are insignificant or at least minimized. The method to prevent or minimize seepage losses depends primarily on the proportions of clay, silt, and sand in the soil.

With respect to water quality, a wet pond can be constructed in areas of permeable soils. The pond may remain dry during periods of low rainfall and become wet after larger rainfall events. This type of system can be classified as an infiltration-wet pond. The pond may naturally seal over time as sediment builds up on the pond floor. This type of pond is very good for water quality

because it will capture polluted runoff, although, it may not be aesthetically pleasing.

Compaction

Some pond areas can be made relatively impervious by compaction alone if the underlying soil material contains sand, silt, and at least 10 percent of clay. However, the reduction of seepage losses may be difficult to determine without taking an infiltration test of the soil. This method is the least expensive method to reduce the soil permeability.

Clay Blankets

Pond areas containing high percentages of coarse grained soils can be sealed by blanketing them with clay layers. The best clay blanket would consist of a material containing 40 percent or more of clay, but no less than 20 percent. Good blanket material can usually be found at a borrow area close enough to the pond to permit hauling at a reasonable cost.

The thickness of the blanket is a function of the depth of water to be impounded. Use a minimum depth of 12 inches for all depths of water up to 10 feet. Increase this thickness by 2 inches for each foot of water over 10 feet.

Waterproof Linings

Waterproof linings are another way of reducing excessive seepage. Polyethylene, vinyl, butyl-rubber membranes, and asphalt-sealed fabric liners are being used because they virtually eliminate seepage if properly installed.

Thin films of these materials are structurally weak, but if not broken or punctured, they are almost completely watertight. Black polyethylene films are less expensive and have better aging properties than vinyl. Vinyl, on the other hand, is more resistant to impact damage and is readily seamed and patched with a solvent cement.

All plastic membranes should have a cover of earth or earth and gravel not less than 6 inches thick to protect against punctures. The bottom 3 inches of cover should be no coarser than silty sand (SCS Handbook No. 590, 1982).

Based on the factors presented in the previous sections which relate to the feasibility of a wet pond, the wet pond design criteria can now be established.

WET POND DESIGN CRITERIA

Wet pond design will be based on the volume and area ratios, the wet pool depth and an inflow - outflow analysis.

Volume Ratio and Residence Time

The volume ratio is directly related to the runoff residence time in wet basins. If the volume of the permanent pool (VB) is much larger than the volume of runoff (VR), only a small amount of water will be displaced during an average rainfall event. As a result, pollutants in the water will have a longer residence time to settle out. The question is, what is the critical residence time necessary for significant pollutant removal.

NURP studies have shown that a residence or detention time of 24 hours can remove more than two-thirds of the sediment, nutrients and trace metal loads (2). Water quality studies done by Rast, Jones and Lee (1983) have suggested that a residence time of 2 weeks is necessary for significant phosphorus removal. The volume of storage required for a 2 week residence time is very large and may exceed the storage volume for peak discharge control. In addition, the wet pool depth may exceed 15 feet for some landuse categories. In contrast, a 24 hour residence time will result in a very small volume of storage and would create very shallow wet pool depths.

The dynamic and quiescent model used by Driscoll (1983) was used to examine pollutant removal rates for different volume ratios and the corresponding residence times. The results of the model indicated that a volume ratio of 2.5

is required to achieve 70 percent removal of sediment loads. This corresponds to a residence time of approximately 9 days. The volume of storage required for the 9 day residence time appears to provide very reasonable wet pond volumes which lie in between the volumes required for the 1 day and the 2 week residence time criteria. As a result, the 9 day residence time criteria has been selected for design because it will provide a sufficient wet pool volume for water quality control without creating an enormous surface area requirement for wet ponds.

The volumes of storage required for the 9 day residence time are shown in Figure 6. These volumes increase as the percent imperviousness of the contributing area increases. Therefore, as the runoff and attached pollutants increase, the size of the permanent pool will increase. These volumes range from 0.14 to 0.86 inches of runoff which corresponds to a 10 to 90 percent impervious landuse condition. A graphical form of wet pool volumes versus percent imperviousness has also been provided in Figure 6 to provide volumes of storage for any landuse condition and to avoid interpolation.

The volumes of storage were determined by multiplying the volume of runoff by 2.5 (VB/VR = 2.5). The average volume of runoff is equal to the average rainfall depth times the Rational Runoff Coefficient (C). The average rainfall depth for Maryland is 0.4 inches. Rational C values were determined by assuming a pervious C value of 0.05 and an impervious C value equal to 0.95 and weighting the C values for different landuse conditions. The approximation of Rational C values compares very closely to the values in current literature.

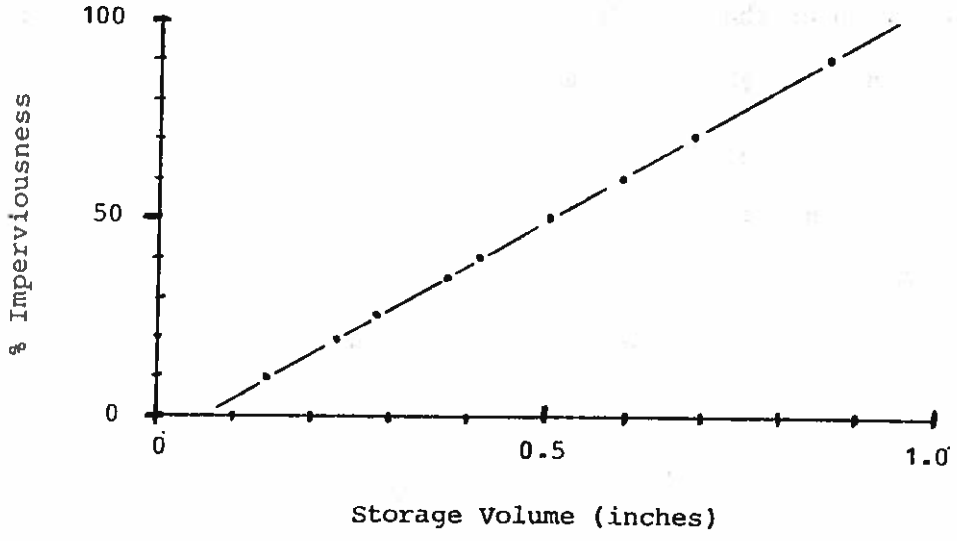
Area Ratio

The logical approach to establishing the minimum area ratio criteria is to examine the inflow and outflow volumes for various landuses and soil conditions. If outflow is less than inflow, the pond will remain wet. The average inflow volume can be determined from rainfall records and the Rational

FIGURE 6.

MINIMUM WATER QUALITY STORAGE CRITERIA FOR WET PONDS

	Percent Impervious (I)	Wet Pond Storage Volume Q_s, (inches)
Low Density Single Family	10%	0.14
Low Density Single Family	20%	0.23
Medium Density Single Family	25%	0.28
Medium Density Single Family	35%	0.37
Multi Family Residence	40%	0.41
Multi Family Residence	50%	0.50
Industrial or Office	60%	0.59
Industrial or Office	70%	0.68
Commercial	90%	0.86



Method to compute runoff rates. The underlying soil infiltration rate will determine the outflow volume from the pond bottom. Evaporation losses are considered to be insignificant since the average rainfall rate will exceed the evaporation rate by approximately 0.4 inches (Clark, 1977). Evaporation losses may be larger than the rainfall on the pond's surface during the summer season but for design purposes, the rainfall is assumed to offset the evaporation losses.

Table 2 has been developed based on an inflow-outflow analysis. The values in Table 2 represent the minimum drainage area to pond surface area ratio (area ratio) necessary to support a wet pool of water. For an example, a pond constructed on a clay soil will require only 5 acres of drainage area to support a one acre wet pool, whereas a pond built on a sandy loam soil will require 250 acres of drainage area to provide one acre of wet pool area. This example applies to a commercial land use category.

As can be seen from Table 2, the minimum area ratio decreases for less permeable soil and higher percent imperviousness. This means areas of higher runoff will require a smaller drainage area to support a permanent pool of water.

In general, soil textures that are feasible for infiltration practices are not feasible for wet ponds due to the excessive seepage losses between rainfall events. Soils used for infiltration include the sand through silt loam textural classes and exclude all clay soils (DNR, 1984). Wet ponds should only be considered in areas where the underlying soil has an infiltration rate less than 0.52 inches/hour or the groundwater table is encountered above the pond bottom. The portion of Table 2 that is shaded represents areas in which infiltration practices must be utilized based on high soil infiltration rates.

TABLE 2. REQUIRED MINIMUM AREA RATIOS (A/A_S) FOR WET PONDS

		(Infiltration Zone)				Soil Texture Classes (Wet Pond Zone)						
		Sand	Loamy Sand	Sandy Loam	Loam	Silt Loam	Sandy Clay Loam	Clay Loam	Silty Clay Loam	Sandy Clay	Silty Clay	Clay
		Saturated Infiltration Rate, (f, in./hr.)										
Land Use Category	Percent Impervious	8.27	2.41	1.02	0.52	0.27	0.17	0.09	0.06	0.05	0.04	0.02
Low Density Single Family	10%	12436	3624	1534	782	406	256	135	90	75	60	30
Low Density Single Family	20%	7570	2206	934	476	247	156	82	55	46	37	18
Medium Density Single Family	25%	6218	1812	767	391	203	128	68	45	38	30	15
Medium Density Single Family	35%	4706	1371	580	296	154	97	51	34	28	23	11
Multifamily Residential	40%	4247	1238	524	267	139	87	46	31	26	21	10
Multifamily Residential	50%	3482	1015	429	219	114	72	38	25	21	17	8
Industrial	60%	2951	860	364	186	96	61	32	21	18	14	7
Industrial	70%	2560	746	316	161	84	53	28	19	15	12	6
Commercial	90%	2024	590	250	127	66	42	22	15	12	10	5

This area represents soil textural classes that require the use of infiltration practices.

The following wet pond design procedure is based on the existing soil texture in the bottom of the pond. It does not account for sediment clogging that may occur during or after construction. The pond bottom may seal over time, which will be a function of the erodible upland soils. However, for design purposes, the sediment clogging factor cannot be predicted and is not included in design.

For the purpose of maintenance, wet ponds should include a low flow pipe to drain the pond for sediment removal. Otherwise, the pond will have to be dredged out, or pumped down and excavated to remove sediment buildup. This type of operation may be very expensive.

WET POND DESIGN PROCEDURE

1. Compute the minimum required wet pool volume (V_s) based on Q_s from Figure 6 where $Vs = Q_s A/12$ (ac-ft)
2. Select an average wet pool depth (d) and compute the required wet pool surface area (As) by:
   a. excavated basin formula (trapezoidal shape)

      $As_{avg} = V_s/d$;

      $W_{avg} = \sqrt{As_{avg}/2}$ where $L_{avg} = 2W_{avg}$;

      $W_{top} = W_{avg} + Zd$ and $L_{top} = L_{avg} + Zd$

      where z is the horizontal to vertical side slope ratio; and

      $A_s = W_{top} \times L_{top}$;

   b. natural embankment pond formula

      $A_s = V_s/0.4d$ or use contour data if available.
3. Compute the area ratio (A/As) by dividing the drainage area (A) by the wet pool surface area (As) obtained from step 2.
4. Find the minimum allowable area ratio (A/As*) from Table 2 based on landuse and pond soil texture. If the computed area ratio is less than the minimum allowable area ratio, the pond will not support a permanent

pool of water. In this case, set As = $A/(A/A_s*)$ and solve for the revised pond depth (d) by:

a. natural embankment pond

$d = 2.5\ V_s/A_s$ or from contour data if available;

b. excavated basin

$d = V_s/A_s$ for $d \leq 3$ ft & $Z \leq 5$; or

$d = 1.3\ V_s/A_s$ for 3 ft $< d <$ 12 ft & $Z \leq 3$; for

$d \geq 3$ ft & $Z \geq 3$, solve for d by trial and error from the excavated basin formula in Step 2 by assuming a depth and computing A_s. When the computed A_s is approximately equal to the actual surface area, the depth is correct.

5. Enter Figures 3, 4, or 5 knowing the wet pool depth (d), area ratio (A/A_s), and percent imperviousness to determine the percent reduction of the sediment load and attached pollutants. If the percent reduction is less than 70%, select the area ratio associated with a 70% removal rate and repeat Step 4.

The 70% removal rate is a recommended criteria for wet ponds. In some cases, a 70% removal criteria may not be feasible based on landuse, soil and geometric conditions. If a 70% removal rate is not obtainable, justification to use other management practices must be evaluated.

SUMMARY

The Chesapeake Bay is a very treasured resource that has been used for generations by local people and others throughout the world for recreation and seafood production. Hopefully, the Bay will continue to provide its great natural resources for future generations. However, without effective urban runoff control, this may not occur.

Wet ponds can be designed to be very effective in capturing urban runoff pollutants and thus will help prevent urban runoff from contaminating the Bay and its tributaries. This paper has presented guidelines for the feasibility and design of wet ponds to achieve water quality enhancement. The important parameters that have been identified and selected for design are pond geometry, storage volume and surface area. Estimates of pollutant removal have been developed based on different wet pool depths, surface areas and landuse conditions. The estimates of pollutant removal are based on gravity settling theory and do not account for additional pollutant removal that will occur from biological activity.

Research is now underway to develop guidelines for creating artificial shallow marsh habitats so that the pollutant removal efficiency achieved by the biological activity in these shallow marsh environments can be examined.

CASE STUDIES

Case Study No. 1

A wet pond is to be constructed for a proposed residential development which has a 100 acre drainage area and a 35% impervious landuse cover. Based on soil borings taken at the pond site, the underlying soil has been classified as a silty clay loam.

Wet Pond Design Procedure

1. Compute the minimum wet pool volume (V_s) = $Q_s A/12$, Determine Q_s from Figure 6 based on a 35% impervious cover: Q_s = 0.37 inches, V_s = (0.37 inches)(100 acres)(1 ft/12 inches) = 3.08 ac-ft.
2. Select an average wet pool depth (d) = 5 feet and solve for surface area (A_s) based on a natural embankment pond: $A_s = V_s/0.4d$ = 3.08 ac-ft/0.4(5 ft) = 1.54 acres.
3. Compute the area ratio (A/A_s) = 100 acres/1.54 acres = 64.9.
4. Find the minimum allowable area ratio (A/A_s*) from Table 2 based on 35% impervious cover and a silty clay loam pond soil: A/A_s* = 34. Since the area ratio (A/A_s = 64.9) is greater than the minimum allowable area ratio the pond should maintain a permanent pool of water.
5. Enter Figures 3, 4, or 5 knowing the wet pool depth (d = 5 ft), area ratio (A/A_s = 64.9) and percent imprviousness (35%), and determine the percent reduction in sediment load and attached pollutants. Since the wet pool depth is 5 feet, the percent removal is interpolated between Figures 3 and 4: d = 3 ft, percent removal = 87%, for d = 6 ft, percent removal = 97%. By interpolation, percent removal = 93.7% for d = 5 ft.

Case Study No. 2

Use the same wet pond criteria as stated in Case Study No. 1, but design an excavated basin with 3:1 side slopes (Z = 3).

Wet Pond Design Procedure

1. V_s = 3.08 ac-ft (See Case Study No. 1).

2. Select an average wet pool depth (d) = 5 feet and solve for surface area (A_s) based on an excavated basin and a side slope ratio (Z) = 3:

   $As_{avg} = V_s/d$ = 3.08 ac-ft/5.0 ft = 0.62 ac = 27,007.2 ft^2.

   $W_{avg} = \sqrt{As_{avg}/2} = \sqrt{27,007.2/2}$ = 116.2 ft.

   $L_{avg} = 2\ W_{avg}$ = 232.4 ft.

   $W_{top} = W_{avg} + Zd = 116.2 + 3(5)$ = 131.2 ft.

   $L_{top} = L_{avg} + Zd = 232.4 + 3(5)$ = 247.4 ft.

   $A_s = W_{top} \times L_{top}$ = 131.2 ft x 247.4 ft.

   = 32,458.9 ft^2 = 0.75 ac.

3. Compute the area ratio (A/A_s) = 100ac/0.75ac = 133.3

4. Find the minimum allowable area ratio (A/A_s*) from Table 2, A/A_s* = 34 (See Case Study No. 1).

   Since A/A_s = 133.3 is greater than A/A_s* = 34, the pond should maintain a permanent pool of water.

5. Enter Figures 3, 4, or 5 knowing d = 5 ft, A/A_s = 133.3 and percent imperviousness = 35% and determine the percent reduction in sediment load and attached pollutants. For d = 3 ft (Figure 3), percent removal = 70%, for d = 6 ft (Figure 4), percent removal = 84%. By linear interpolation, percent removal = 79.3% for d = 5 ft.

Case Study No. 3

A wet pond is proposed for a 10 acre commercial site since the underlying soil has been classified as sandy clay loam and is unfeasible for infiltration practices. The drainage area consist of 90% impervious cover.

Wet Pond Design Procedure

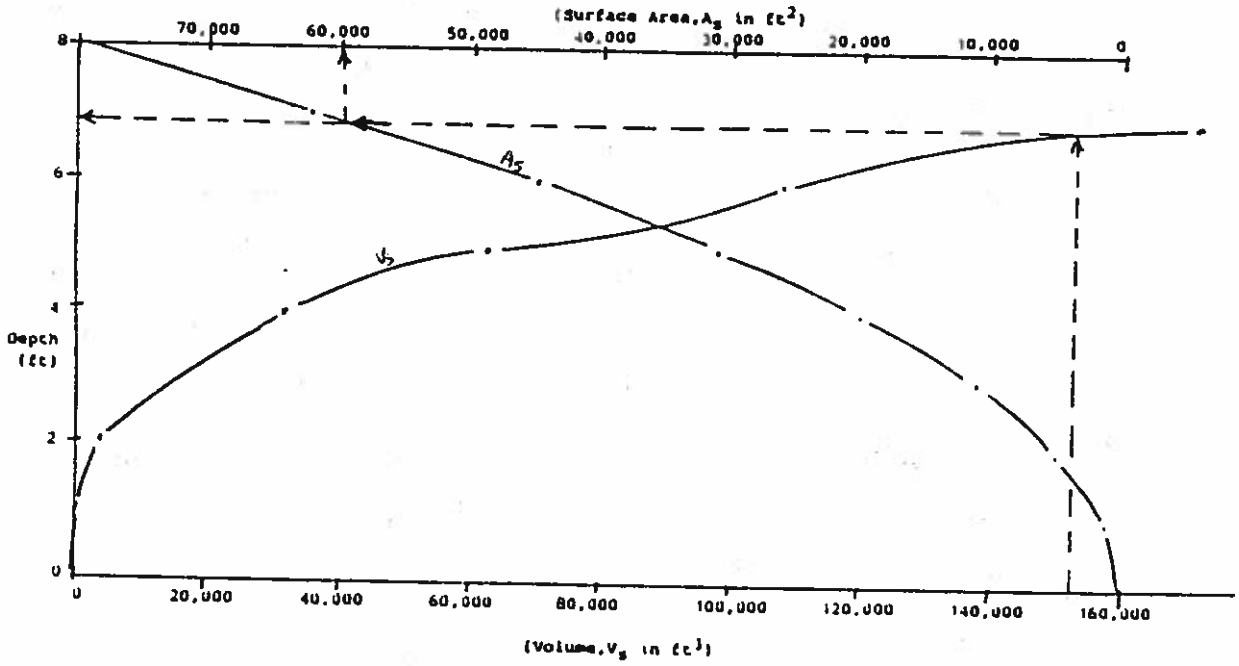
1. Compute the minimum wet pool volume (V_s) = $Q_s A/12$. Determine Q_s from Figure 6 based on a 90% impervious cover: Q_s = 0.86 inches, V_s = (0.86 inches)(10 acres)(1 ft/12 inches) = 0.72 ac-ft.
2. Select an average wet pool depth (d) = 6 feet and solve for surface area (A_s) for a natural embankment pond:
   $A_s = V_s/0.4d$ = 0.72 ac-ft/0.4(6ft).
   A_s = 0.30 acres.
3. Compute the area ratio (A/A_s) = 10 acres/0.30 acres = 33.3
4. Find the minimum allowable area ratio (A/A_s*) from Table 2 based on 90% impervious cover and a sandy clay loam soil: A/A_s* = 42. Since the area ratio (33.3) is less than the minimum allowable are ratio (42), the pond will not support a permanent pool of water. Set A_s = $A/(A/A_s$*) and solve for the revised pond depth (d) = 2.5 V_s/A_s (embankment pond): A_s = (10 acres)/42 = 0.24 acres and d = 2.5 (0.72 ac-ft)/0.24 ac = 7.5 ft.
5. Enter Figures 4 and 5 and find the percent removal for d = 6 and 9 feet. For A/A_s = 42 and a 90% impervious cover, percent removal = 90% for d = 6 ft, and percent removal = 95% for d = 9 ft (note that values are slightly off graph). Interpolate the percent removal for d = 7.5 ft; percent removal = 92.5%.

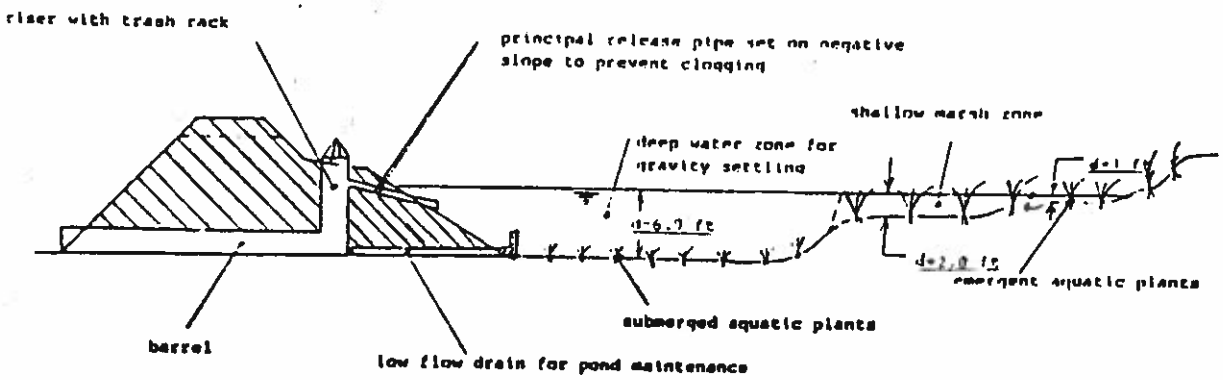
Two options are available if the average pool depth is too deep. One, the average depth may be reduced which will result in an infiltration-

wet basin that will exhibit periods of wet and dry conditions. Two, the pond bottom may be lined with clay or a waterproof liner to create a smaller average depth. In both cases, the surface area of the pond will increase since the depth is reduced and volume remains unchanged.

Case Study No. 4

A soil analysis has been done for a proposed stormwater management site. The soil has been classified as a silt loam which is on the borderline for use with an infiltration basin or a wet pond. The developer proposes to install a wet pond to prevent a constant maintenance routine and to increase the value of land adjacent to the pond. A multiple depth wet pond is selected for the low density single family development. The pond will provide management for a 300 acre watershed which contains a 10% impervious landuse cover. A depth versus area and volume curve has been developed from planimetering an existing contour map. A profile of the proposed pond has also been plotted as shown below.





Wet Pond Design Procedure

1. Compute the minimum wet pool volume (V_s) = $Q_s A/12$ where Q_s = 0.14 inches from Figure 6 based on a 10% impervious cover: V_s = (0.14 inches)(300 ac)/1 ft/12 in = 3.5 ac-ft = 152,460 ft^3.
2. Since a depth vs area and volume curve is available, determine the depth and corresponding surface area associated with V_s: d = 6.9 ft and A_s = 60,000 ft^3 = 1.38 ac.
3. Compute the area ratio (A/A_s) = 300 acres/1.38 acres = 217.4.
4. Find the minimum allowable area ratio (A/A_s*) from Table 2 based on a 10% impervious cover and a silt loam soil: A/A_s* = 406. Since the area ratio (217.4) is less than the minimum allowable ratio (406), the pond will not support a permanent pool of water. The developer has decided to line the bottom of the pond with a clay loam material that is available near the site. As a result, the revised minimum area ratio (A/A_s*) = 135. Therefore, the pond should support a permanent pool of water with an area ratio of 217.4.
5. Determine the average depth of the pond and compute the percent removal of the sediment load and attached pollutants. The depth of the pond varies from 6.9 ft, 2.0 ft, and 1.0 ft as shown on the pond profile. The average depth can be approximated by summing the volume in each different depth zone and dividing by the pond surface area. For this example, 60% of the surface area is 6.9 ft deep, 20% is 2.0 ft deep and 20% is 1.0 ft deep. The average depth (d_{avg}) = 0.6(6.9) + 0.2(2.0) + 0.2(1.0) = 4.7 ft. Determine the percent removal for 3 ft and 9 ft and interpolate the removal rate for 4.7 ft. For A/A_s = 217.4 and a 10% impervious cover; percent removal for 3 ft = 83%, percent removal for 6 ft = 94%. By interpolation, percent removal for 4.7 ft = 89.2%.

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Surface storage Volume Tables for Bioretenion and Bioswales (2012)

Surface Storage Volume Tables for Bioretention, Bioswales, Rain Gardens, and Landscape Infiltration

Tables to be used with State Highway Administration (SHA) Bioretention Soil Mix (BSM)

Limitations and Guidance:

1) These tables are used for determining the amount of surface storage required above the media. The tables can only be used with State Highway Administration (SHA) Bioretention Soil Mix (BSM) with an infiltration rate of 1 inch/hour. The tables are not valid for media with an infiltration rate different than 1 inch/hour. If SHA BSM is not used, then 75% of the ESD volume (minimum) must be stored above the surface of the media. If SHA BSM is used but the designer elects to not use the tables, then 60% of the ESD volume (minimum) must be stored above the surface of the media.
2) The Pe correlates to the drainage area of the ESD facility.
3) The vertical column is selected based on the ratio of the surface area of the ESD facility (Af) to the impervious surface in the drainage area (Ai).
4) The horizontal row is selected based on the percentage of impervious area (% Imp) in the contributing drainage area to the ESD facility.
5) The resulting percentage is the required percentage of 100% of the ESDv that must be stored as temporary ponding above the surface of the ESD facility.
6) If the design satisfies these tables, and the minimum media depths are used from the Chapter 5 guidance, then the requirement to store 75% of the ESDv will be met.

Storage Volume (% of ESDv) required above surface for Pe =								0.1 inch			
	Af/Ai										
% Imp	2%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
5%	21%	10%	3%	0%	0%	0%	0%	0%	0%	0%	0%
10%	23%	12%	3%	0%	0%	0%	0%	0%	0%	0%	0%
15%	26%	14%	5%	0%	0%	0%	0%	0%	0%	0%	0%
20%	29%	17%	6%	0%	0%	0%	0%	0%	0%	0%	0%
25%	30%	17%	6%	0%	0%	0%	0%	0%	0%	0%	0%
30%	31%	17%	6%	0%	0%	0%	0%	0%	0%	0%	0%
35%	31%	18%	6%	0%	0%	0%	0%	0%	0%	0%	0%
40%	32%	18%	6%	0%	0%	0%	0%	0%	0%	0%	0%
45%	33%	18%	6%	0%	0%	0%	0%	0%	0%	0%	0%
50%	34%	19%	6%	0%	0%	0%	0%	0%	0%	0%	0%
55%	34%	19%	6%	0%	0%	0%	0%	0%	0%	0%	0%
60%	35%	19%	6%	0%	0%	0%	0%	0%	0%	0%	0%
65%	35%	19%	6%	0%	0%	0%	0%	0%	0%	0%	0%
70%	35%	19%	6%	0%	0%	0%	0%	0%	0%	0%	0%
75%	35%	19%	6%	0%	0%	0%	0%	0%	0%	0%	0%
80%	35%	19%	6%	0%	0%	0%	0%	0%	0%	0%	0%
85%	35%	19%	6%	0%	0%	0%	0%	0%	0%	0%	0%
90%	35%	19%	6%	0%	0%	0%	0%	0%	0%	0%	0%
95%	35%	19%	6%	0%	0%	0%	0%	0%	0%	0%	0%

Storage Volume (% of ESDv) required above surface for Pe =								0.2 inch			
	Af/Ai										
% Imp	2%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
5%	32%	18%	10%	6%	3%	1%	0%	0%	0%	0%	0%
10%	32%	20%	12%	7%	3%	1%	0%	0%	0%	0%	0%
15%	35%	24%	14%	9%	5%	1%	0%	0%	0%	0%	0%
20%	38%	26%	17%	10%	6%	1%	0%	0%	0%	0%	0%
25%	39%	27%	17%	10%	6%	1%	0%	0%	0%	0%	0%
30%	39%	28%	17%	10%	6%	1%	0%	0%	0%	0%	0%
35%	40%	28%	18%	10%	6%	1%	0%	0%	0%	0%	0%
40%	41%	29%	18%	10%	6%	1%	0%	0%	0%	0%	0%
45%	42%	30%	18%	10%	6%	1%	0%	0%	0%	0%	0%
50%	42%	30%	19%	10%	6%	1%	0%	0%	0%	0%	0%
55%	43%	31%	19%	10%	6%	1%	0%	0%	0%	0%	0%
60%	44%	31%	19%	10%	6%	1%	0%	0%	0%	0%	0%
65%	44%	31%	19%	10%	6%	1%	0%	0%	0%	0%	0%
70%	44%	31%	19%	10%	6%	1%	0%	0%	0%	0%	0%
75%	44%	31%	19%	10%	6%	1%	0%	0%	0%	0%	0%
80%	44%	31%	19%	10%	6%	1%	0%	0%	0%	0%	0%
85%	44%	31%	19%	10%	6%	1%	0%	0%	0%	0%	0%
90%	44%	31%	19%	10%	6%	1%	0%	0%	0%	0%	0%
95%	44%	31%	19%	10%	6%	1%	0%	0%	0%	0%	0%

DRAFT

Storage Volume (% of ESDv) required above surface for Pe =								0.3	inch		
	Af/Ai										
% Imp	2%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
5%	37%	24%	14%	10%	7%	5%	3%	1%	1%	0%	0%
10%	38%	25%	16%	12%	8%	6%	3%	1%	1%	0%	0%
15%	40%	29%	20%	14%	10%	7%	5%	2%	1%	0%	0%
20%	43%	32%	23%	17%	11%	9%	6%	3%	1%	0%	0%
25%	43%	32%	23%	17%	11%	8%	6%	3%	1%	0%	0%
30%	44%	33%	24%	17%	12%	8%	6%	3%	1%	0%	0%
35%	44%	34%	24%	18%	12%	8%	6%	3%	1%	0%	0%
40%	45%	35%	25%	18%	12%	8%	6%	3%	1%	0%	0%
45%	46%	36%	25%	18%	12%	8%	6%	3%	1%	0%	0%
50%	46%	36%	26%	19%	12%	8%	6%	3%	1%	0%	0%
55%	47%	37%	26%	19%	13%	9%	6%	3%	1%	0%	0%
60%	47%	37%	27%	19%	13%	9%	6%	3%	1%	0%	0%
65%	47%	37%	27%	19%	13%	9%	6%	3%	1%	0%	0%
70%	47%	37%	27%	19%	13%	9%	6%	3%	1%	0%	0%
75%	47%	37%	27%	19%	13%	9%	6%	3%	1%	0%	0%
80%	47%	37%	27%	19%	13%	9%	6%	3%	1%	0%	0%
85%	47%	37%	27%	19%	13%	9%	6%	3%	1%	0%	0%
90%	47%	37%	27%	19%	13%	9%	6%	3%	1%	0%	0%
95%	47%	37%	27%	19%	13%	9%	6%	3%	1%	0%	0%

Storage Volume (% of ESDv) required above surface for Pe =								0.4	inch		
	Af/Ai										
% Imp	2%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
5%	39%	28%	18%	13%	10%	8%	6%	4%	3%	2%	1%
10%	41%	29%	20%	15%	12%	9%	7%	5%	3%	1%	1%
15%	43%	32%	24%	18%	14%	11%	9%	7%	5%	3%	1%
20%	45%	35%	26%	21%	17%	13%	10%	8%	6%	3%	1%
25%	46%	36%	27%	22%	17%	13%	10%	8%	6%	3%	1%
30%	46%	37%	28%	22%	17%	13%	10%	8%	6%	3%	1%
35%	47%	38%	28%	22%	18%	13%	10%	8%	6%	3%	1%
40%	48%	38%	29%	23%	18%	13%	10%	8%	6%	3%	1%
45%	48%	39%	30%	23%	18%	13%	10%	8%	6%	3%	1%
50%	49%	40%	30%	24%	19%	14%	10%	8%	6%	3%	1%
55%	50%	41%	31%	24%	19%	14%	10%	8%	6%	3%	1%
60%	50%	41%	31%	25%	19%	14%	10%	8%	6%	3%	1%
65%	50%	41%	31%	25%	19%	14%	10%	8%	6%	3%	1%
70%	50%	41%	31%	25%	19%	14%	10%	8%	6%	3%	1%
75%	50%	41%	31%	25%	19%	14%	10%	8%	6%	3%	1%
80%	50%	41%	31%	25%	19%	14%	10%	8%	6%	3%	1%
85%	50%	41%	31%	25%	19%	14%	10%	8%	6%	3%	1%
90%	50%	41%	31%	25%	19%	14%	10%	8%	6%	3%	1%
95%	50%	41%	31%	25%	19%	14%	10%	8%	6%	3%	1%

Storage Volume (% of ESDv) required above surface for Pe =								0.5	inch		
	Af/Ai										
% Imp	2%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
5%	41%	32%	21%	16%	12%	10%	8%	7%	5%	4%	3%
10%	43%	32%	23%	18%	14%	12%	10%	8%	6%	5%	3%
15%	45%	35%	26%	21%	18%	14%	12%	9%	8%	6%	5%
20%	47%	38%	29%	24%	20%	17%	13%	11%	9%	7%	6%
25%	48%	39%	30%	24%	21%	17%	14%	11%	9%	7%	6%
30%	48%	39%	31%	25%	21%	17%	14%	11%	9%	7%	6%
35%	49%	40%	31%	26%	22%	18%	14%	11%	9%	7%	6%
40%	50%	41%	32%	26%	22%	18%	14%	11%	9%	7%	6%
45%	50%	42%	33%	27%	22%	18%	14%	11%	9%	7%	6%
50%	51%	42%	34%	28%	23%	19%	15%	11%	9%	7%	6%
55%	52%	43%	34%	28%	23%	19%	15%	12%	9%	7%	6%
60%	52%	44%	35%	28%	23%	19%	15%	12%	9%	7%	6%
65%	52%	44%	35%	28%	23%	19%	15%	12%	9%	7%	6%
70%	52%	44%	35%	28%	23%	19%	15%	12%	9%	7%	6%
75%	52%	44%	35%	28%	23%	19%	15%	12%	9%	7%	6%
80%	52%	44%	35%	28%	23%	19%	15%	12%	9%	7%	6%
85%	52%	44%	35%	28%	23%	19%	15%	12%	9%	7%	6%
90%	52%	44%	35%	28%	23%	19%	15%	12%	9%	7%	6%
95%	52%	44%	35%	28%	23%	19%	15%	12%	9%	7%	6%

DRAFT

Storage Volume (% of ESDv) required above surface for Pe =								0.6	inch		
	Af/Ai										
% Imp	2%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
5%	42%	34%	24%	18%	14%	12%	10%	9%	7%	6%	5%
10%	45%	35%	25%	20%	16%	14%	12%	10%	8%	7%	6%
15%	47%	37%	29%	24%	20%	17%	14%	12%	10%	9%	7%
20%	49%	40%	32%	26%	23%	20%	17%	14%	11%	10%	9%
25%	49%	41%	32%	27%	23%	20%	17%	14%	11%	10%	8%
30%	50%	41%	33%	28%	24%	20%	17%	14%	12%	10%	8%
35%	50%	42%	34%	28%	24%	21%	18%	15%	12%	10%	8%
40%	51%	43%	35%	29%	25%	21%	18%	15%	12%	10%	8%
45%	52%	44%	36%	30%	25%	22%	18%	15%	12%	10%	8%
50%	52%	44%	36%	30%	26%	22%	19%	15%	12%	10%	8%
55%	53%	45%	37%	31%	26%	22%	19%	16%	13%	10%	9%
60%	53%	45%	37%	31%	27%	23%	19%	16%	13%	10%	9%
65%	53%	45%	37%	31%	27%	23%	19%	16%	13%	10%	9%
70%	53%	45%	37%	31%	27%	23%	19%	16%	13%	10%	9%
75%	53%	45%	37%	31%	27%	23%	19%	16%	13%	10%	9%
80%	53%	45%	37%	31%	27%	23%	19%	16%	13%	10%	9%
85%	53%	45%	37%	31%	27%	23%	19%	16%	13%	10%	9%
90%	53%	45%	37%	31%	27%	23%	19%	16%	13%	10%	9%
95%	53%	45%	37%	31%	27%	23%	19%	16%	13%	10%	9%

Storage Volume (% of ESDv) required above surface for Pe =								0.7	inch		
	Af/Ai										
% Imp	2%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
5%	43%	36%	26%	20%	16%	14%	12%	10%	9%	8%	6%
10%	46%	37%	27%	22%	18%	16%	13%	12%	10%	9%	7%
15%	48%	39%	30%	25%	22%	19%	17%	14%	12%	10%	9%
20%	50%	42%	33%	28%	25%	22%	19%	17%	14%	12%	11%
25%	50%	42%	34%	29%	25%	22%	20%	17%	15%	12%	11%
30%	51%	43%	35%	30%	26%	23%	20%	17%	15%	12%	11%
35%	51%	44%	36%	30%	26%	23%	20%	18%	15%	12%	11%
40%	52%	44%	37%	31%	27%	24%	21%	18%	15%	13%	11%
45%	53%	45%	38%	32%	28%	24%	21%	18%	16%	13%	11%
50%	53%	46%	38%	33%	28%	25%	21%	19%	16%	13%	11%
55%	54%	46%	39%	33%	29%	25%	22%	19%	16%	13%	11%
60%	55%	47%	39%	34%	29%	26%	22%	19%	16%	13%	11%
65%	55%	47%	39%	34%	29%	26%	22%	19%	16%	13%	11%
70%	55%	47%	39%	34%	29%	26%	22%	19%	16%	13%	11%
75%	55%	47%	39%	34%	29%	26%	22%	19%	16%	13%	11%
80%	55%	47%	39%	34%	29%	26%	22%	19%	16%	13%	11%
85%	55%	47%	39%	34%	29%	26%	22%	19%	16%	13%	11%
90%	55%	47%	39%	34%	29%	26%	22%	19%	16%	13%	11%
95%	55%	47%	39%	34%	29%	26%	22%	19%	16%	13%	11%

Storage Volume (% of ESDv) required above surface for Pe =								0.8	inch		
	Af/Ai										
% Imp	2%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
5%	43%	38%	28%	22%	18%	15%	13%	11%	10%	9%	8%
10%	46%	38%	29%	24%	20%	17%	15%	13%	12%	10%	9%
15%	49%	41%	32%	27%	24%	21%	18%	16%	14%	12%	11%
20%	51%	43%	35%	30%	26%	23%	21%	19%	17%	15%	13%
25%	51%	44%	36%	31%	27%	24%	22%	19%	17%	15%	13%
30%	52%	44%	37%	32%	28%	24%	22%	20%	17%	15%	13%
35%	52%	45%	38%	32%	28%	25%	22%	20%	18%	15%	13%
40%	53%	46%	38%	33%	29%	26%	23%	20%	18%	16%	13%
45%	54%	46%	39%	34%	30%	26%	23%	21%	18%	16%	13%
50%	54%	47%	40%	35%	30%	27%	24%	21%	19%	16%	14%
55%	55%	48%	41%	35%	31%	28%	24%	21%	19%	16%	14%
60%	55%	48%	41%	36%	31%	28%	25%	22%	19%	17%	14%
65%	55%	48%	41%	36%	31%	28%	25%	22%	19%	17%	14%
70%	55%	48%	41%	36%	31%	28%	25%	22%	19%	17%	14%
75%	55%	48%	41%	36%	31%	28%	25%	22%	19%	17%	14%
80%	55%	48%	41%	36%	31%	28%	25%	22%	19%	17%	14%
85%	55%	48%	41%	36%	31%	28%	25%	22%	19%	17%	14%
90%	55%	48%	41%	36%	31%	28%	25%	22%	19%	17%	14%
95%	55%	48%	41%	36%	31%	28%	25%	22%	19%	17%	14%

DRAFT

Storage Volume (% of ESDv) required above surface for Pe =								0.9	inch		
	Af/Ai										
% Imp	2%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
5%	44%	39%	30%	24%	20%	17%	14%	13%	11%	10%	9%
10%	47%	40%	31%	25%	22%	19%	16%	15%	13%	12%	11%
15%	50%	42%	34%	29%	25%	22%	20%	18%	16%	14%	13%
20%	52%	44%	37%	32%	28%	25%	23%	21%	19%	17%	15%
25%	52%	45%	37%	32%	28%	25%	23%	21%	19%	17%	15%
30%	52%	45%	38%	33%	29%	26%	24%	22%	19%	17%	15%
35%	53%	46%	39%	34%	30%	27%	24%	22%	20%	18%	16%
40%	54%	47%	40%	35%	31%	27%	25%	22%	20%	18%	16%
45%	54%	47%	41%	36%	32%	28%	25%	23%	21%	18%	16%
50%	55%	48%	41%	36%	32%	29%	26%	23%	21%	19%	16%
55%	56%	49%	42%	37%	33%	29%	26%	24%	21%	19%	17%
60%	56%	49%	42%	37%	33%	30%	27%	24%	21%	19%	17%
65%	56%	49%	42%	37%	33%	30%	27%	24%	21%	19%	17%
70%	56%	49%	42%	37%	33%	30%	27%	24%	21%	19%	17%
75%	56%	49%	42%	37%	33%	30%	27%	24%	21%	19%	17%
80%	56%	49%	42%	37%	33%	30%	27%	24%	21%	19%	17%
85%	56%	49%	42%	37%	33%	30%	27%	24%	21%	19%	17%
90%	56%	49%	42%	37%	33%	30%	27%	24%	21%	19%	17%
95%	56%	49%	42%	37%	33%	30%	27%	24%	21%	19%	17%

Storage Volume (% of ESDv) required above surface for Pe =								1	inch		
	Af/Ai										
% Imp	2%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
5%	44%	39%	32%	26%	21%	18%	16%	14%	12%	11%	10%
10%	47%	41%	32%	27%	23%	20%	18%	16%	14%	13%	12%
15%	50%	43%	35%	30%	26%	24%	21%	19%	18%	16%	14%
20%	52%	45%	38%	33%	29%	26%	24%	22%	20%	19%	17%
25%	52%	46%	39%	34%	30%	27%	24%	23%	21%	19%	17%
30%	53%	46%	39%	35%	31%	28%	25%	23%	21%	19%	17%
35%	53%	47%	40%	35%	31%	28%	26%	23%	22%	20%	18%
40%	54%	48%	41%	36%	32%	29%	26%	24%	22%	20%	18%
45%	55%	48%	42%	37%	33%	30%	27%	25%	22%	20%	18%
50%	56%	49%	42%	38%	34%	30%	28%	25%	23%	21%	19%
55%	56%	50%	43%	38%	34%	31%	28%	26%	23%	21%	19%
60%	57%	50%	44%	39%	35%	31%	28%	26%	23%	21%	19%
65%	57%	50%	44%	39%	35%	31%	28%	26%	23%	21%	19%
70%	57%	50%	44%	39%	35%	31%	28%	26%	23%	21%	19%
75%	57%	50%	44%	39%	35%	31%	28%	26%	23%	21%	19%
80%	57%	50%	44%	39%	35%	31%	28%	26%	23%	21%	19%
85%	57%	50%	44%	39%	35%	31%	28%	26%	23%	21%	19%
90%	57%	50%	44%	39%	35%	31%	28%	26%	23%	21%	19%
95%	57%	50%	44%	39%	35%	31%	28%	26%	23%	21%	19%

Storage Volume (% of ESDv) required above surface for Pe =								1.1	inch		
	Af/Ai										
% Imp	2%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
5%	44%	40%	33%	27%	23%	19%	17%	15%	13%	12%	11%
10%	48%	42%	33%	28%	24%	21%	19%	17%	15%	14%	13%
15%	51%	44%	36%	31%	27%	25%	22%	21%	19%	17%	16%
20%	53%	46%	39%	34%	30%	27%	25%	23%	22%	20%	18%
25%	53%	47%	40%	35%	31%	28%	26%	24%	22%	20%	19%
30%	53%	47%	40%	36%	32%	29%	26%	24%	22%	21%	19%
35%	54%	48%	41%	37%	33%	30%	27%	25%	23%	21%	19%
40%	55%	48%	42%	37%	34%	30%	28%	26%	23%	22%	20%
45%	55%	49%	43%	38%	34%	31%	28%	26%	24%	22%	20%
50%	56%	50%	43%	39%	35%	32%	29%	27%	24%	22%	20%
55%	57%	50%	44%	39%	36%	33%	30%	27%	25%	23%	21%
60%	57%	51%	45%	40%	36%	33%	30%	28%	25%	23%	21%
65%	57%	51%	45%	40%	36%	33%	30%	28%	25%	23%	21%
70%	57%	51%	45%	40%	36%	33%	30%	28%	25%	23%	21%
75%	57%	51%	45%	40%	36%	33%	30%	28%	25%	23%	21%
80%	57%	51%	45%	40%	36%	33%	30%	28%	25%	23%	21%
85%	57%	51%	45%	40%	36%	33%	30%	28%	25%	23%	21%
90%	57%	51%	45%	40%	36%	33%	30%	28%	25%	23%	21%
95%	57%	51%	45%	40%	36%	33%	30%	28%	25%	23%	21%

DRAFT

Storage Volume (% of ESDv) required above surface for Pe =								1.2	inch		
	Af/Ai										
% Imp	2%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
5%	45%	41%	34%	28%	24%	21%	18%	16%	14%	13%	12%
10%	48%	43%	35%	29%	25%	22%	20%	18%	16%	15%	14%
15%	51%	45%	37%	32%	29%	26%	24%	22%	20%	18%	17%
20%	53%	47%	40%	35%	32%	29%	26%	24%	23%	21%	20%
25%	53%	47%	41%	36%	32%	29%	27%	25%	23%	22%	20%
30%	54%	48%	41%	37%	33%	30%	28%	25%	24%	22%	20%
35%	54%	49%	42%	38%	34%	31%	28%	26%	24%	22%	21%
40%	55%	49%	43%	38%	35%	32%	29%	27%	25%	23%	21%
45%	56%	50%	44%	39%	36%	33%	30%	27%	25%	23%	22%
50%	56%	51%	44%	40%	36%	33%	30%	28%	26%	24%	22%
55%	57%	51%	45%	41%	37%	34%	31%	29%	26%	24%	22%
60%	57%	52%	45%	41%	37%	34%	31%	29%	27%	25%	23%
65%	57%	52%	45%	41%	37%	34%	31%	29%	27%	25%	23%
70%	57%	52%	45%	41%	37%	34%	31%	29%	27%	25%	23%
75%	57%	52%	45%	41%	37%	34%	31%	29%	27%	25%	23%
80%	57%	52%	45%	41%	37%	34%	31%	29%	27%	25%	23%
85%	57%	52%	45%	41%	37%	34%	31%	29%	27%	25%	23%
90%	57%	52%	45%	41%	37%	34%	31%	29%	27%	25%	23%
95%	57%	52%	45%	41%	37%	34%	31%	29%	27%	25%	23%

Storage Volume (% of ESDv) required above surface for Pe =								1.3	inch		
	Af/Ai										
% Imp	2%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
5%	45%	41%	35%	30%	25%	22%	19%	17%	15%	14%	13%
10%	48%	43%	36%	30%	26%	23%	21%	19%	18%	16%	15%
15%	51%	46%	38%	33%	30%	27%	24%	23%	21%	19%	18%
20%	53%	48%	41%	36%	32%	30%	27%	25%	24%	22%	21%
25%	54%	48%	41%	37%	33%	30%	28%	26%	24%	23%	21%
30%	54%	49%	42%	38%	34%	31%	29%	27%	25%	23%	22%
35%	55%	49%	43%	38%	35%	32%	29%	27%	25%	24%	22%
40%	55%	50%	44%	39%	36%	33%	30%	28%	26%	24%	22%
45%	56%	50%	44%	40%	37%	34%	31%	29%	27%	25%	23%
50%	57%	51%	45%	41%	37%	34%	32%	29%	27%	25%	23%
55%	57%	52%	46%	41%	38%	35%	32%	30%	28%	26%	24%
60%	58%	52%	46%	42%	38%	35%	33%	30%	28%	26%	24%
65%	58%	52%	46%	42%	38%	35%	33%	30%	28%	26%	24%
70%	58%	52%	46%	42%	38%	35%	33%	30%	28%	26%	24%
75%	58%	52%	46%	42%	38%	35%	33%	30%	28%	26%	24%
80%	58%	52%	46%	42%	38%	35%	33%	30%	28%	26%	24%
85%	58%	52%	46%	42%	38%	35%	33%	30%	28%	26%	24%
90%	58%	52%	46%	42%	38%	35%	33%	30%	28%	26%	24%
95%	58%	52%	46%	42%	38%	35%	33%	30%	28%	26%	24%

Storage Volume (% of ESDv) required above surface for Pe =								1.4	inch		
	Af/Ai										
% Imp	2%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
5%	45%	42%	36%	31%	26%	23%	20%	18%	16%	15%	14%
10%	49%	44%	37%	31%	27%	24%	22%	20%	18%	17%	16%
15%	52%	46%	39%	34%	30%	28%	25%	24%	22%	20%	19%
20%	54%	48%	42%	37%	33%	31%	28%	26%	25%	23%	22%
25%	54%	49%	42%	38%	34%	31%	29%	27%	25%	24%	22%
30%	55%	49%	43%	39%	35%	32%	30%	28%	26%	24%	23%
35%	55%	50%	44%	39%	36%	33%	30%	28%	26%	25%	23%
40%	56%	50%	44%	40%	37%	34%	31%	29%	27%	25%	24%
45%	56%	51%	45%	41%	38%	35%	32%	30%	28%	26%	24%
50%	57%	52%	46%	42%	38%	35%	33%	30%	28%	27%	25%
55%	58%	52%	46%	42%	39%	36%	33%	31%	29%	27%	25%
60%	58%	53%	47%	43%	39%	36%	34%	31%	29%	27%	26%
65%	58%	53%	47%	43%	39%	36%	34%	31%	29%	27%	26%
70%	58%	53%	47%	43%	39%	36%	34%	31%	29%	27%	26%
75%	58%	53%	47%	43%	39%	36%	34%	31%	29%	27%	26%
80%	58%	53%	47%	43%	39%	36%	34%	31%	29%	27%	26%
85%	58%	53%	47%	43%	39%	36%	34%	31%	29%	27%	26%
90%	58%	53%	47%	43%	39%	36%	34%	31%	29%	27%	26%
95%	58%	53%	47%	43%	39%	36%	34%	31%	29%	27%	26%

DRAFT

Storage Volume (% of ESDv) required above surface for Pe =								1.5	inch		
	Af/Ai										
% Imp	2%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
5%	45%	42%	37%	32%	27%	24%	21%	19%	17%	16%	14%
10%	49%	45%	38%	32%	28%	25%	23%	21%	19%	18%	16%
15%	52%	47%	40%	35%	31%	29%	26%	24%	23%	21%	20%
20%	54%	49%	43%	38%	34%	32%	29%	27%	25%	24%	23%
25%	54%	49%	43%	39%	35%	32%	30%	28%	26%	24%	23%
30%	55%	50%	44%	39%	36%	33%	31%	29%	27%	25%	24%
35%	55%	50%	44%	40%	37%	34%	31%	29%	27%	26%	24%
40%	56%	51%	45%	41%	38%	35%	32%	30%	28%	26%	25%
45%	57%	52%	46%	42%	38%	36%	33%	31%	29%	27%	25%
50%	57%	52%	46%	42%	39%	36%	34%	32%	29%	28%	26%
55%	58%	53%	47%	43%	40%	37%	34%	32%	30%	28%	26%
60%	58%	53%	47%	44%	40%	37%	35%	33%	30%	28%	27%
65%	58%	53%	47%	44%	40%	37%	35%	32%	30%	28%	27%
70%	58%	53%	47%	44%	40%	37%	35%	32%	30%	28%	27%
75%	58%	53%	47%	44%	40%	37%	35%	32%	30%	28%	27%
80%	58%	53%	47%	44%	40%	37%	35%	32%	30%	28%	27%
85%	58%	53%	47%	44%	40%	37%	35%	32%	30%	28%	27%
90%	58%	53%	47%	44%	40%	37%	35%	32%	30%	28%	27%
95%	58%	53%	47%	44%	40%	37%	35%	32%	30%	28%	27%

Storage Volume (% of ESDv) required above surface for Pe =								1.6	inch		
	Af/Ai										
% Imp	2%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
5%	45%	42%	38%	33%	28%	25%	22%	20%	18%	16%	15%
10%	49%	45%	38%	33%	29%	26%	24%	22%	20%	19%	17%
15%	52%	47%	41%	36%	32%	29%	27%	25%	24%	22%	21%
20%	54%	49%	43%	39%	35%	32%	30%	28%	26%	25%	23%
25%	55%	50%	44%	39%	36%	33%	31%	29%	27%	25%	24%
30%	55%	50%	44%	40%	37%	34%	32%	29%	28%	26%	24%
35%	56%	51%	45%	41%	38%	35%	32%	30%	28%	27%	25%
40%	56%	51%	46%	42%	38%	36%	33%	31%	29%	27%	26%
45%	57%	52%	46%	42%	39%	36%	34%	32%	30%	28%	26%
50%	58%	53%	47%	43%	40%	37%	35%	33%	30%	29%	27%
55%	58%	53%	48%	44%	41%	38%	35%	33%	31%	29%	28%
60%	59%	54%	48%	44%	41%	38%	36%	34%	31%	30%	28%
65%	59%	54%	48%	44%	41%	38%	36%	34%	31%	30%	28%
70%	58%	54%	48%	44%	41%	38%	36%	34%	31%	30%	28%
75%	58%	54%	48%	44%	41%	38%	36%	34%	31%	30%	28%
80%	58%	54%	48%	44%	41%	38%	36%	34%	31%	30%	28%
85%	58%	54%	48%	44%	41%	38%	36%	34%	31%	30%	28%
90%	58%	54%	48%	44%	41%	38%	36%	34%	31%	30%	28%
95%	58%	54%	48%	44%	41%	38%	36%	34%	31%	30%	28%

Storage Volume (% of ESDv) required above surface for Pe =								1.7	inch		
	Af/Ai										
% Imp	2%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
5%	45%	43%	38%	34%	29%	26%	23%	21%	19%	17%	16%
10%	49%	45%	39%	34%	30%	27%	24%	23%	21%	19%	18%
15%	52%	48%	41%	37%	33%	30%	28%	26%	24%	23%	21%
20%	54%	50%	44%	39%	36%	33%	31%	29%	27%	25%	24%
25%	55%	50%	44%	40%	37%	34%	31%	29%	28%	26%	25%
30%	55%	50%	45%	41%	37%	35%	32%	30%	28%	27%	25%
35%	56%	51%	46%	41%	38%	36%	33%	31%	29%	28%	26%
40%	57%	52%	46%	42%	39%	36%	34%	32%	30%	28%	27%
45%	57%	53%	47%	43%	40%	37%	35%	33%	31%	29%	27%
50%	58%	53%	48%	44%	41%	38%	35%	33%	31%	29%	28%
55%	58%	54%	48%	44%	41%	38%	36%	34%	32%	30%	28%
60%	59%	54%	49%	45%	42%	39%	37%	34%	32%	31%	29%
65%	59%	54%	49%	45%	42%	39%	37%	34%	32%	31%	29%
70%	59%	54%	49%	45%	42%	39%	37%	34%	32%	31%	29%
75%	59%	54%	48%	45%	42%	39%	37%	34%	32%	31%	29%
80%	59%	54%	48%	45%	42%	39%	37%	34%	32%	31%	29%
85%	59%	54%	48%	45%	42%	39%	37%	34%	32%	31%	29%
90%	59%	54%	48%	45%	42%	39%	37%	34%	32%	31%	29%
95%	59%	54%	48%	45%	42%	39%	37%	34%	32%	31%	29%

DRAFT

Storage Volume (% of ESDv) required above surface for Pe =								1.8	inch		
	Af/Ai										
% Imp	2%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
5%	45%	43%	39%	34%	30%	27%	24%	22%	20%	18%	17%
10%	49%	46%	40%	35%	31%	28%	25%	23%	22%	20%	19%
15%	52%	48%	42%	37%	34%	31%	29%	27%	25%	24%	22%
20%	55%	50%	44%	40%	37%	34%	32%	30%	28%	26%	25%
25%	55%	50%	45%	41%	37%	35%	32%	30%	28%	27%	25%
30%	56%	51%	45%	41%	38%	36%	33%	31%	29%	28%	26%
35%	56%	51%	46%	42%	39%	36%	34%	32%	30%	28%	27%
40%	57%	52%	47%	43%	40%	37%	35%	33%	31%	29%	27%
45%	57%	53%	47%	44%	41%	38%	36%	33%	32%	30%	28%
50%	58%	54%	48%	44%	41%	39%	36%	34%	32%	30%	29%
55%	58%	54%	49%	45%	42%	39%	37%	35%	33%	31%	29%
60%	59%	55%	49%	45%	42%	40%	37%	35%	33%	31%	30%
65%	59%	55%	49%	45%	42%	40%	37%	35%	33%	31%	30%
70%	59%	55%	49%	45%	42%	40%	37%	35%	33%	31%	30%
75%	59%	55%	49%	45%	42%	40%	37%	35%	33%	31%	30%
80%	59%	55%	49%	45%	42%	40%	37%	35%	33%	31%	30%
85%	59%	55%	49%	45%	42%	40%	37%	35%	33%	31%	30%
90%	59%	55%	49%	45%	42%	40%	37%	35%	33%	31%	30%
95%	59%	55%	49%	45%	42%	40%	37%	35%	33%	31%	30%

Storage Volume (% of ESDv) required above surface for Pe =								1.9	inch		
	Af/Ai										
% Imp	2%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
5%	45%	43%	39%	35%	31%	28%	25%	22%	20%	19%	17%
10%	49%	46%	40%	35%	31%	28%	26%	24%	22%	21%	20%
15%	53%	49%	43%	38%	34%	32%	29%	27%	26%	24%	23%
20%	55%	51%	45%	41%	37%	34%	32%	30%	28%	27%	26%
25%	55%	51%	45%	41%	38%	35%	33%	31%	29%	28%	26%
30%	56%	51%	46%	42%	39%	36%	34%	32%	30%	28%	27%
35%	56%	52%	47%	43%	40%	37%	35%	33%	31%	29%	28%
40%	57%	53%	47%	43%	40%	38%	36%	33%	32%	30%	28%
45%	57%	53%	48%	44%	41%	38%	36%	34%	32%	31%	29%
50%	58%	54%	49%	45%	42%	39%	37%	35%	33%	31%	30%
55%	59%	55%	49%	45%	43%	40%	38%	36%	34%	32%	30%
60%	59%	55%	50%	46%	43%	40%	38%	36%	34%	32%	31%
65%	59%	55%	50%	46%	43%	40%	38%	36%	34%	32%	31%
70%	59%	55%	50%	46%	43%	40%	38%	36%	34%	32%	31%
75%	59%	55%	50%	46%	43%	40%	38%	36%	34%	32%	31%
80%	59%	55%	50%	46%	43%	40%	38%	36%	34%	32%	31%
85%	59%	55%	50%	46%	43%	40%	38%	36%	34%	32%	31%
90%	59%	55%	50%	46%	43%	40%	38%	36%	34%	32%	31%
95%	59%	55%	50%	46%	43%	40%	38%	36%	34%	32%	31%

Storage Volume (% of ESDv) required above surface for Pe =								2 - 2.6	inches		
	Af/Ai										
% Imp	2%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
5%	46%	43%	39%	36%	32%	28%	26%	23%	21%	19%	18%
10%	50%	46%	41%	36%	32%	29%	27%	25%	23%	21%	20%
15%	53%	49%	43%	39%	35%	32%	30%	28%	26%	25%	24%
20%	55%	51%	45%	41%	38%	35%	33%	31%	29%	28%	26%
25%	55%	51%	46%	42%	39%	36%	34%	32%	30%	28%	27%
30%	56%	52%	46%	42%	39%	37%	35%	32%	31%	29%	28%
35%	56%	52%	47%	43%	40%	38%	35%	33%	31%	30%	28%
40%	57%	53%	48%	44%	41%	38%	36%	34%	32%	31%	29%
45%	58%	54%	48%	45%	42%	39%	37%	35%	33%	31%	30%
50%	58%	54%	49%	45%	42%	40%	38%	36%	34%	32%	30%
55%	59%	55%	50%	46%	43%	41%	38%	36%	34%	33%	31%
60%	59%	55%	50%	46%	44%	41%	39%	37%	35%	33%	31%
65%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
70%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
75%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
80%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
85%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
90%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
95%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%

DRAFT

Intent

Bioretention, bioswales, rain gardens, and landscape infiltration treat runoff by allowing stormwater to filter through a layer of planting soil that is rich with micro-organisms. To be filtered effectively by the facility, stormwater must enter the soil media. If the filtering practice is located in a swale there is uncertainty about whether the flow will enter the media or runoff down the swale and bypass treatment. The same concern extends to bioretention, rain gardens, and landscape infiltration because the Environmental Site Design (ESD) volume for any facility served by an overflow device has the potential to prematurely flow out of the facility and bypass treatment. The only way to allow the ESD volume adequate opportunity to enter the filter media is by providing surface storage above the filter media to detain the runoff. But how much storage is necessary?

The Sediment and Stormwater Plan Review Division with help from the State Highway Administration (SHA) examined this question by applying hydrologic/hydraulic principals for a bioswale to a basic reservoir analysis. A "calculator" was developed that modeled the stormwater flows to the bioswale, flow rates through the media, and storage volume. (Refer to "**Bio-Swale Storage Calculator"** for more information.) The resulting output provides surface storage volumes necessary for treating ESD volume. Storage requirements vary significantly depending on the target rainfall (P_E) being treated, the surface area of the filter, and the imperviousness of the drainage area. For example, a facility with a larger surface area requires less surface storage than one with a smaller surface area. Because of the complexity of the Calculator, tables for design purposes were developed from a broad range of simulations. (Refer to "**Development of Tables**" for an explanation of how the tables were developed.)

Limitations

The Calculator assumes that the filter media is comprised of SHA bio-soil mix (BSM) with an infiltration rate of 1 inch per hour. The Surface Storage Tables are not valid for use on treatment facilities that have a different infiltration rate than SHA BSM. If a filter planting media is used that has a different infiltration rate from the SHA BSM, then 75% of the ESD volume (ESDv) should be provided above the surface of the filter. The Calculator and Surface Storage Tables also assume that the layer of planting media (SHA BSM) will be the limiting factor in determining the overall facility infiltration rate. The Surface Storage Tables will not be accurate for treatment facilities without an underdrain located on soils with an infiltration rate of less than 1 in./hr. In this situation the surface storage volume shall be at least equal to the 75% ESDv treatment requirement.

Using the Surface Storage Volume Tables

From the twenty tables provided, select the appropriate table for the respective target P_E (in), ranging from 0.1 inch to 2.6 inches. Note that the P_E correlates to the drainage area of the ESD facility. Enter the left side of the table for the imperviousness [%Imp = impervious area draining to facility (A_i)/drainage area to facility (A) = 100(A_i /A)] of the contributing drainage area to the ESD facility (negating the area occupied by the facility itself). Enter the top of the table for the ratio of the surface area of the facility (A_f) to the impervious area draining to the facility (A_i). The point where these two values intersect is the minimum required surface storage volume, expressed as a percentage of the ESDv. Multiplying this percentage by **100% of the required ESDv** gives the ponding volume that must be temporarily stored above the filter bed surface of the ESD facility in order to fully treat the respective P_E.

If the ESD facility provides the required surface storage and the minimum media depths given in MDE guidance, then the design requirements, including the 75% of the ESDv treatment requirement, will be satisfied.

DRAFT

Example 1 (insufficient surface storage)

Drainage area criteria

A 10,000 square foot area drains to a proposed micro biorention facility. (The drainage area includes facility.) The drainage area contains 4000 ft^2 of impervious area, and the hydrologic soil group is C.

Calculate $I = 4000\ ft^2/10{,}000\ ft^2 = 0.4 = 40\%$

$R_v = 0.05+0.009(I) = 0.05+0.009(40) = 0.41$

The target P_E for the drainage area to the facility is 1.8 inches.

$ESDv = (P_E)(R_v)(A)/12 = (1.8\ in)(0.41)(10{,}000\ ft^2)/(12in/ft) = 615\ ft^3$

Biorention facility geometry

The surface area of the filter is 800 ft^2.

The storage provided above the surface of the media is 185 ft^3.

Quantifying the target rainfall (P_E) treated

Using the table for P_E =1.8 inches, enter at %Imp = 40% and $A_f/A_i = 800\ ft^2/4000\ ft^2 = 20\%$. Read the required surface storage as 40%.

The provided surface storage is only $185\ ft^3/615\ ft^3 = 30\%$. Therefore, the P_E of 1.8 inch is not being completely treated. At this point, the designer needs to either (1) revise the design of the facility so that the required surface storage is provided or (2) calculate the P_E treated (or achieved) based on the current design.

(1) Revising the design of the facility to treat the full target P_E can be accomplished by:
   a. Providing more surface storage;
   b. Increasing the surface area of the filter; and/or
   c. Reducing the % Impervious in the drainage area to the filter.

(2) Calculate the P_E treated
   The proposed facility does not provide enough surface storage to treat the target P_E of 1.8 inches. The P_E treated is based on providing a surface storage volume that is a certain percent of the ESDv, but that ESDv changes depending on the P_E. Therefore, determining the P_E treated is an iterative process. Continue the iterations until the actual storage and required storage are equal. This is best demonstrated in a table.

Iteration	P_E	ESDv	required % surface storage from tables	actual % surface storage = ($185\ ft^3$ /ESDv)
1	1.8 in	$615\ ft^3$	40 %	30 %
2	0.9 in	$308\ ft^3$	31 %	60 %
3	1.2 in	$410\ ft^3$	35 %	45 %
4	1.4 in	$478\ ft^3$	37 %	39 %
5	1.5 in	$512\ ft^3$	38 %	36 %

The achieved P_E for this example is 1.45 inches, and the ESDv attained by the facility is 495 ft^3.

DRAFT

Example 2 (excess surface storage)

Drainage area criteria

A 10,000 square foot area drains to a proposed micro biorention facility. (The drainage area includes facility.) The drainage area contains 4000 ft^2 of impervious area, and the hydrologic soil group is C.

Calculate I = 4000 ft^2/10,000 ft^2 = 0.4 = 40%

R_v = 0.05+0.009(I) = 0.05+0.009(40) = 0.41

The target P_E for the drainage area to the facility is 1.8 inches.

ESDv = (P_E)(R_v)(A)/12 = (1.8 in)(0.41)(10,000 ft^2)/(12in/ft) = 615 ft^3

Biorention facility geometry

The surface area of the filter is 800 ft^2.

The storage provided above the surface of the media is 280 ft^3.

Quantifying the target rainfall (P_E) treated

Using the table for P_E =1.8 inches, enter at %Imp = 40% and A_f /A_i = 800 ft^2/4000 ft^2 = 20%. Read the required surface storage as 40%.

The provided surface storage is 280 ft^3/615 ft^3 = 46%. Therefore, more than enough surface storage is being provided. The excess storage means that the P_E being treated is larger than the target.

The P_E treated is based on providing a surface storage volume that is a certain percent of the ESDv, but that ESDv changes depending on the P_E. Therefore, determining the P_E treated is an iterative process. Continue the iterations until the actual storage and required storage are equal. This is best demonstrated in a table.

Iteration	P_E	ESDv	required % surface storage from tables	actual % surface storage = (280 ft^3 /ESDv)
1	1.8 in	615 ft^3	40 %	46 %
2	1.9 in	649 ft^3	40 %	43 %
3	2.0 in	683 ft^3	41 %	41 %

The achieved P_E for this example is 2.0 inches, and the ESDv attained by the facility is 683 ft^3.

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Bio-Swale Storage Calculator

The calculator modeled stormwater flows to a facility, flow rates through the media, and storage. Runoff was computed using SCS methodologies and the Method for Computing Peak Discharge for Water Quality Storm found in Appendix D.10 of the 2000 Maryland Stormwater Design Manual. This method was used to compute the Runoff Curve Number (CN) because conventional SCS methods underestimate the volume and rate of runoff for rainfall events less than 2 inches. The Ia/P value was calculated from the user-entered site information and based on Equations 2-2 and 2-4 found in Chapter 2 of the TR-55 Manual. The Calculator used the calculated Ia/P to determine the unit peak discharge that was used for each time interval. The Tabular Hydrograph Unit Discharges (csm/in) for Type II Rainfall Distribution tables from Chapter 5 of the TR-55 Manual for drainage areas with a Tc of 0.1 and an Ia/P of 0.1, 0.3, and 0.5 were included in the Calculator. The Calculator used linear interpolation to calculate the unit discharge for any drainage area with an Ia/P value between the Ia/P values supplied by the TR-55 tables. For Ia/P values smaller than 0.1 or larger than 0.5, the unit discharges corresponding to the Ia/P of 0.1 and 0.5 were used, respectively. An Excel forecast and match function was used to interpolate between the time intervals for the TR-55 supplied unit discharges to develop a table of unit discharges starting at hour 11 of the rainfall event to hour 26 at a constant time interval of 0.1 hour. The peak discharge into the bioswale was calculated at each time interval using equation 4.1 from Chapter 4 of the TR-55 Manual.

The volume of water that infiltrated into the media at each time interval was calculated using the surface area of the filter media (A_f) and a media filtration rate of 2 feet per day (1 inch per hour). This filtration rate was approved for use with SHA BSM in 2003. The porosity of the media was 40%. The bottom width of the bioswales was held at a constant 8 feet. The length of the bioswale was adjusted to achieve the A_f required to satisfy the user entered A_f /A_i ratio. The planting media depth was a constant 2 feet.

When the stormwater runoff volume that entered the treatment facility during the 0.1 hour time interval exceeded the volume of water infiltrated into the media bed, the volume of water that did not infiltrate was added to the temporary surface storage volume. As the temporary surface storage volume increased, the Calculator used Darcy's law to increase the infiltration rate slightly as the depth of the water stored above the filter bed surface generated hydraulic head. The Calculator assumed a constant surface storage depth across the entire treatment facility (i.e. 0% longitudinal bioswale slope). The Calculator also assumed that water is only stored directly above the filter bed (i.e., no side slopes). For every time interval where the volume of stormwater runoff that entered the treatment facility was greater than the volume of water that infiltrated into the filter bed media, the excess volume was added to the surface storage volume. Once the rate of the stormwater runoff entering the treatment facility decreased below the rate at which water infiltrated into the filter bed media, the water stored above the surface of the filter bed began to drain through the filter media. The surface storage volume used to calculate the surface storage requirement is the maximum surface storage volume achieved before the stormwater runoff entering the facility subsided to the point where the water stored above the surface will begin to decrease.

Development of Tables

The Calculator was used to develop the Surface Storage Volume Tables. Simulations were repeated for rainfalls ranging from 0.1 inches to 2.6 inches at 0.1 inch intervals. Each 24 hour rainfall rate was used to generate a separate surface storage table. The surface storage tables for rainfall from 2.0 to 2.6 inches were consolidated into one table because there were negligible differences between these tables. A drainage area of 1 acre was used. However, the drainage area does not affect the results of the Surface Storage Tables because the Calculator adjusts the surface area of the treatment facility (A_f) based on a user entered filter surface area to impervious area ratio (A_f /A_i). This causes the A_f to rise to match an increase in the drainage area. Within each target rainfall table, a specific A_f /A_i ratio and site impervious percent was used to calculate a surface storage volume requirement. This surface storage volume requirement is expressed as a percent of the 100% ESDv for the drainage area to the treatment facility.

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Clarification on Grass swale design for State and Federal Projects (2012)

DRAFT

April 23, 2012

Clarification on grass swale design for State and federal projects

Grass swales are included in the 2000 Maryland Stormwater Manual to encourage the use of open section roadway. The grass swale should parallel the contributing roadway, and the runoff from the impervious surface must sheetflow into the swale. Being a linear application, the grass swale must be as long as the surface it treats.

In accordance with the design criteria in Section M-8 of Chapter 5 from the Manual, all swales shall meet the following criteria:

- Swales shall have a bottom width between two and eight feet.
- The channel slope shall be less than or equal to 4.0%.
- The maximum flow velocity for the ESD_v shall be less than or equal to 1.0 fps.
- Swales shall be designed to safely convey the 10-year, 24-hour storm at a non-erosive velocity with at least six inches of freeboard.
- The channel side slopes shall be 3:1 or flatter.
- A thick vegetative cover shall be provided for proper function.

In addition, the following criteria apply to grass swales:

- Grass swales shall only receive sheetflow. If concentrated flow from curb cuts or storm drains is delivered to a grass swale, the flow must spread to mimic sheetflow prior to entering the grass swale.
- Grass swales shall be as long as the treated surface.
- The surface area (A_f) of the swale bottom shall be at least 2% of the contributing drainage area. A thick vegetative cover shall be provided for proper function.
- The channel shall have a roughness coefficient (Manning's n) value of 0.15.
- The maximum flow depth for ESD_v treatment shall be 4 inches.
- A P_E value based on Equation 5.3 shall be applied to the contributing drainage area.

Repeated questions have arisen about how to calculate the ESD_v provided by a grass swale. Because there is no storage volume in the practice, the provided ESD_v should be calculated based on the achieved P_E using Equation 5.3.

$$P_E = 10\,in. \times \frac{A_f}{DA} \text{ (Equation 5.3) and } ESD_v = \frac{P_E \times R_v \times A}{12\,in/ft}$$

Note that Equations 5.1, 5.2, and 5.3 in Chapter 5 are regarded as planning tools to be used for site layout during concept design. These equations provide a two-dimensional approximation of the respective three-dimensional ESD practice. However, in the case of grass swales, the practice is two-dimensional and Equation 5.3 provides an accurate assessment of the P_E. Equation 5.3 is effectively requiring the surface area of the grass swale to be 10% of the drainage area when treating a P_E of 1.0 inch. To treat a target P_E of 2.6 inches, the surface area would have to be 26% of the drainage area.

If the P_E achieved by the grass swale is less than the target P_E, additional ESD practices (i.e. "treatment train") will have to be provided.

Grass swales automatically meet recharge.

Grass Channel Credit for Parking Lots (2007 and 2003)

WATER QUALITY FOR ROADWAY/PARKING LOT SURFACES

For Projects that include roadway and/or parking lot construction, the following shall pertain:

Grassed Channel Water Quality Credit

Out of project (off-site) drainage area must be included when computing the peak discharge for the water quality storm for grassed channel credit. There may be no credit for existing impervious areas where new roadway widening reduces the length of the grassed (vegetated) area between the existing paving and the grassed waterway.

There may be no credit for existing impervious areas where open section roadway or parking is converted to closed section roadway/parking.

Lost Water Quality

The presence of an existing vegetated filter strip through which runoff sheet flows is an effective water quality measure for the runoff from existing open section paving. Also, the presence of an existing vegetated conveyance (swale or channel) that transports the runoff from a "one-inch rainfall" at a velocity of 1 fps or less, is an effective water quality measure.

When converting open section roadway or parking to closed section roadway or parking, the quality of runoff from the existing surface may be negatively impacted due to loss of these vegetative filtering and/or infiltration measures.

The lost water quality ("Existing water quality treatment") shall be determined as follows:

Step 1
- Determine the vegetated sheet flow grade and length
- Determine the filter efficiency from Figure 1

Step 2
- Determine the velocity of the runoff from the one-inch rainfall in the existing swale/channel.
- Determine the filter efficiency as follows:
  a velocity of 1 fps or less, equals 100% water quality (WQ) treatment; a velocity of 3 fps or greater equals 0% water quality treatment. The efficiency is directly proportional to the velocities of the one-inch rainfall within the existing conveyance.

Step 3
- The greater of the Step 1/Step 2 efficiencies is the percent of water quality lost due to conversion of open to closed section.

Conversion of closed section paving to open section paving may use Steps 1 through 3 above to determine water quality credit or compensation.

Compensating Water Quality Treatment

In drainage areas where it is not possible to provide water quality for all new paved areas, compensating water quality treatment of existing roadway paving, equal to 120% of the untreated new paved area, may be provided elsewhere within the project limits.

In order for existing roadway paving to qualify for compensating water quality treatment, there must be no "existing water quality treatment" for said existing paving.

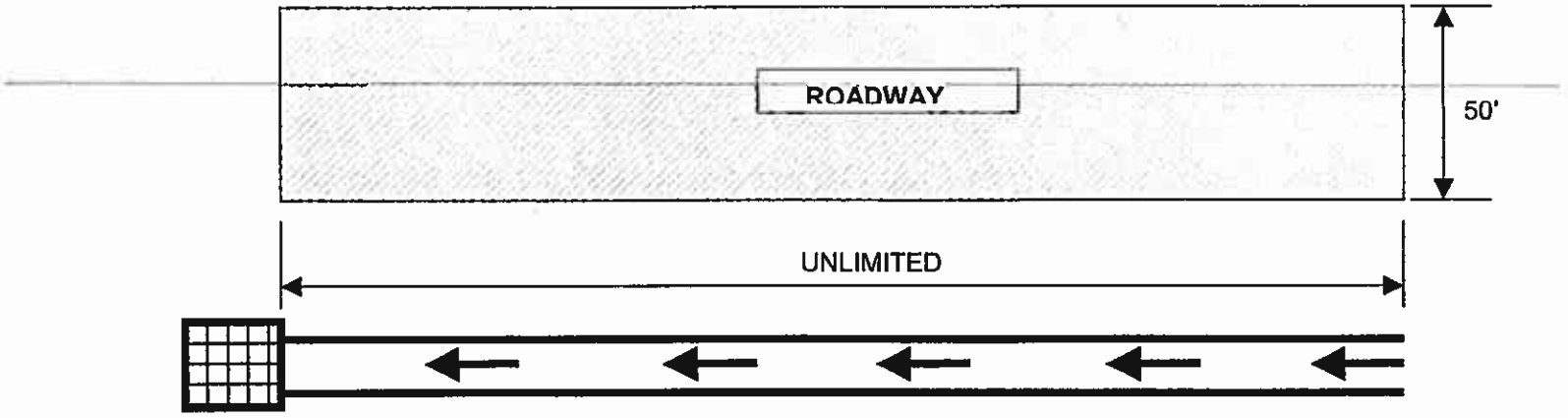
On-Line BMPs

Water quality practices that are placed On-Line (in median or roadside channels/ditches/swales) shall include offsite impervious area in the calculation of the water quality volume requirements.

Grass Channel Credit for Parking Lots

The Grass Channel Credit was initially intended for use as a device parallel to a street or highway. As such, the length of the Grass Channel was the same as the length of the parallel roadway, while the depth of the paving sheet flow (measured to the edge of pavement) was considered to be no more than fifty (50') feet. The channel length was unlimited as long as the following criteria were either met, i.e. the channel slope was no greater than 4%, the channel velocity was no greater than one (1) fps for 1" of rainfall, the bottom width was between two (2') feet and eight (8') feet, and the side slopes 3:1* or flatter.

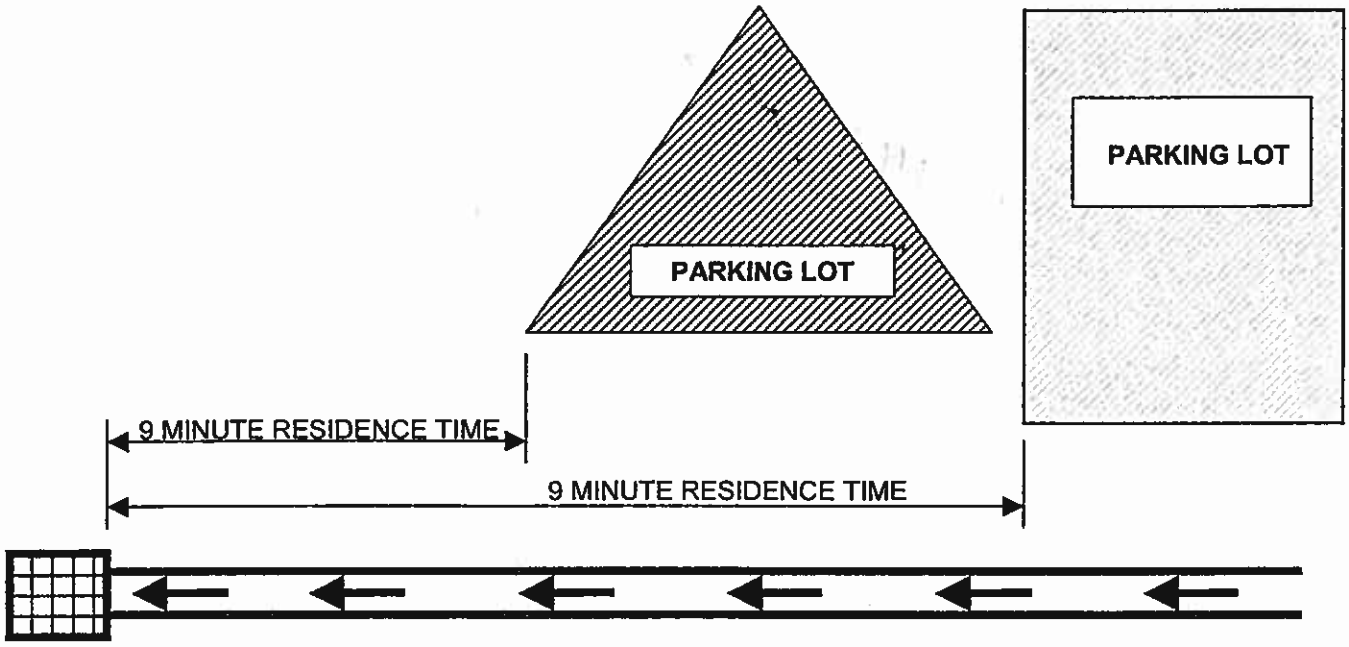
* An equivalent wetted perimeter is acceptable in the event other side slope values are in use.



The Grass Channel Credit may be used to provide treatment for sheet flow from parking areas with the following constraints. The governing criteria is that the length and slope of the grass channel shall provide a minimum of nine (9) minutes of detention time in the grass channel before any slope turndown or inlet interception and the channel configuration is acceptable. There is no limitation on the length or depth of the paving as long as the residence time is attained.

The length of the Grass Channel is defined as the distance between the final runoff entry point into the Grass Channel and any slope turndown or inlet interception. If the bottom width is between 2' and 8', with a maximum one (1) fps channel velocity, a 4% maximum slope, with 3:1 side slopes*, and a channel residence time of nine (9) minutes or greater is attained, the Grass Channel Credit requirements for the intercepted impervious area are satisfied.

* An equivalent wetted perimeter is acceptable in the event other side slope values are in use.

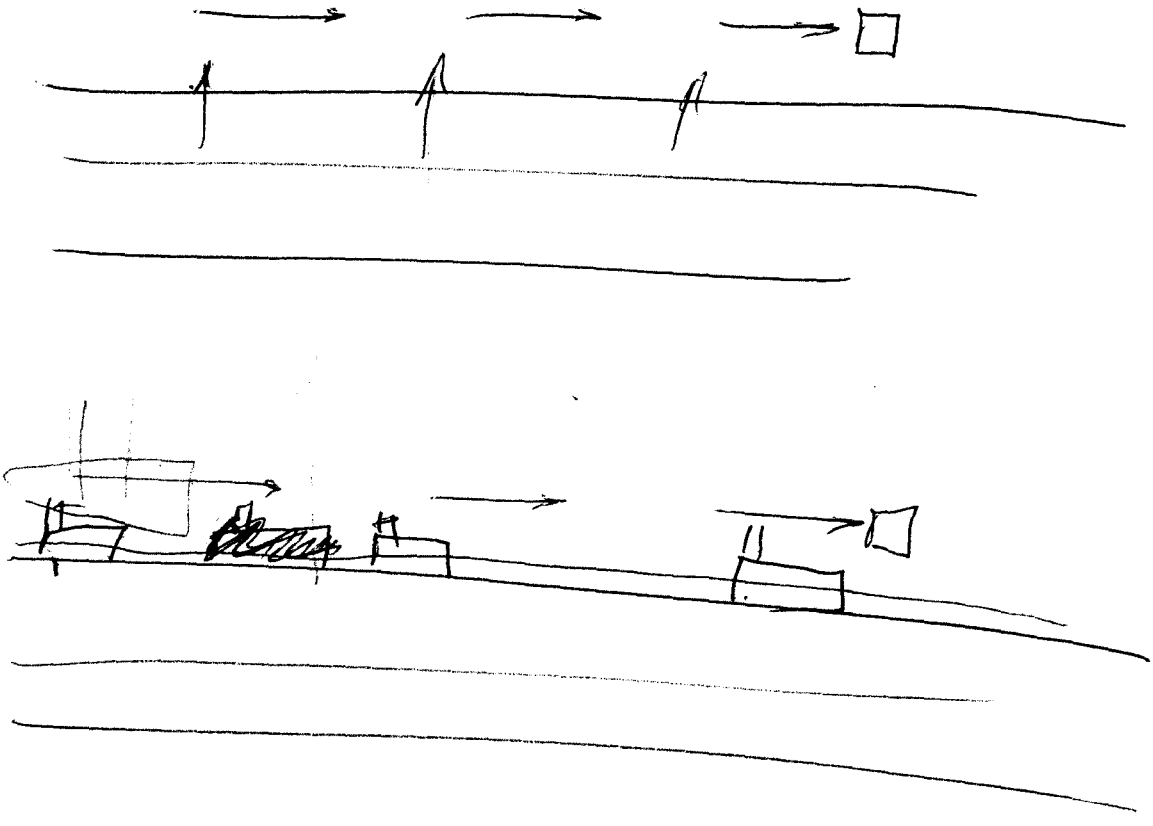


Grass Channel Credit (2010)

GRASS CHANNEL CREDIT

DESCRIPTION:

Grass channel credit may be given when shallow open channels are engineered to capture and treat the runoff from the water quality storm (one-inch rainfall).



MECHANISMS OF POLLUTANT REMOVAL:

Grass channel removes

- **Solids by gravity sedimentation and by filtration through vegetation**
- **Metals by adsorption and ion exchange on the soil surface**
- **Organics by bacterial decomposition on the vegetation, soils and adsorption in the soils**
- **Nutrients by plant uptake**

DESIGN CRITERIA:

Design variables for Grass Channel are summarized below:

Parameter	Criteria
Design Flow Rate	Runoff from One-Inch Rainfall
Average Flow Velocity	1 ft/sec maximum
Channel Width	2 ft min. 8 ft max.
Pretreatment	Storage = 0.1 inches per impervious acre for piped inflow
Channel Slope	4% Max.
Side Slope Ratio	3:1 and flatter
Manning's n	For d ≤ 4", n = 0.15 For 4" < d < 12", n = 0.207 - 0.0145 x (d) Where d = Flow Depth (in)
Grass Buffer	Maintain existing ratio of grass buffer length to contributing impervious flow length

Maximum Velocity for 10-year event	non-erosive with required freeboard (see SHA Drainage Manual)

Criteria at or below minimum values can be used on a case by case basis with approval of MDE when compensatory adjustments are made to the standard design.

For examples:

1. A triangular channel can qualify for Grass Channel Credit if it can be demonstrated that the wetted perimeter of the triangular channel is greater than a flat-bottomed channel with 2 feet bottom and 3:1 side slopes.

2. A channel with longitudinal slope of 4 to 6 percent may qualify for grass channel credit if check dams are provided every 50 to 100 feet along the length of the

channel. The check dam may be constructed of:

a) Riprap with 2:1 side slopes
b) A railroad tie with weep holes and riprap on the down stream side to prevent scour.

3. If the existing ratio of buffer length to impervious length can not be maintained due to site or R/W constraints, the integration of landscape design to mitigate the loss of buffer may be acceptable.

CHANNEL DESIGN:

The following steps are recommended to complete a channel design for the Grass Channel Credit:

1. Estimate the runoff flow rate for one-inch of rainfall using method outlined in Appendix D-10.
2. Establish the slope of channel.
3. Establish the channel width (B).
4. Select a value of flow depth and corresponding Manning's n and

solve the Manning's equation by Trial and Error method.

5. Compute the flow velocity using Continuity equation.
6. Check design for channel capacity and stability for a 10-year event.
7. Check design for maintenance of the existing ratio of buffer length to impervious flow length.

DESIGN EXAMPLE

1	Estimate Runoff Flow rate				
	1a	Site Area = A	Contributing drainage area inclusive of off-site and on-site	4	acres
	1b	Total impervious area	Existing + new + offsite	0.95	acres
	1c	percentage impervious area = I	I = 1b divided by 1a	23.8	%
	1d	rainfall = P	P = 1.0 inch	1	inch
	1e	Volumetric Runoff coefficient = Rv	Rv = 0.05 +(.009) (I)	0.26	
	1f	Time of concentration = Tc	Tc using TR -55 method	0.1	hr
	1g	Runoff Volume = Qa	Qa = P * Rv	0.2	inches
	1h	CN for WQ storm	CN using Appendix D.10	88	
	1i	Initial Abstraction = Ia	I a = (200/CN)-2	0.27	
	1j	Compute Ia/P		0.27	
	1k	Unit Peak discharge = qu	fr TR 55 exhibit 4-II	915	csm/in

	1l	Water Quality Peak Flow = Qw	Qw =(qu csm/in) * (A mi^2)* (Qa in)	1.49	cfs
2	Estimate Slope of Channel = S		slope in ft per ft	0.04	ft/ft
3	3a	Select channel Shape	Flat bottom ditch with side slope - Z : 1	3	
	3b	Select the Bottom Width = B	For Flat bottom ditch	2	ft
4	Solve the Manning's equation				
5	5a	Computed Velocity = V	V = Qd/A	1.03	fps
	5b	Computed Flow Depth = d	from worksheet	5.25	in.
6	Check Design for 10-year event				
	6a	10- year discharge	from ditch comps. Or TR-55	13	cfs
	6b	Manning's n	n = .04		
	6c	Solve Manning's equation	V =(1.49 * R ^ 0.67 * S ^ 0.5) / n	3.68	fps
7	Grass Buffer				
	7a	Existing Ratio	from typical section ex. grass length= 35' and contributing impervious flow length = 34'. Ratio = 35/34	1.03	

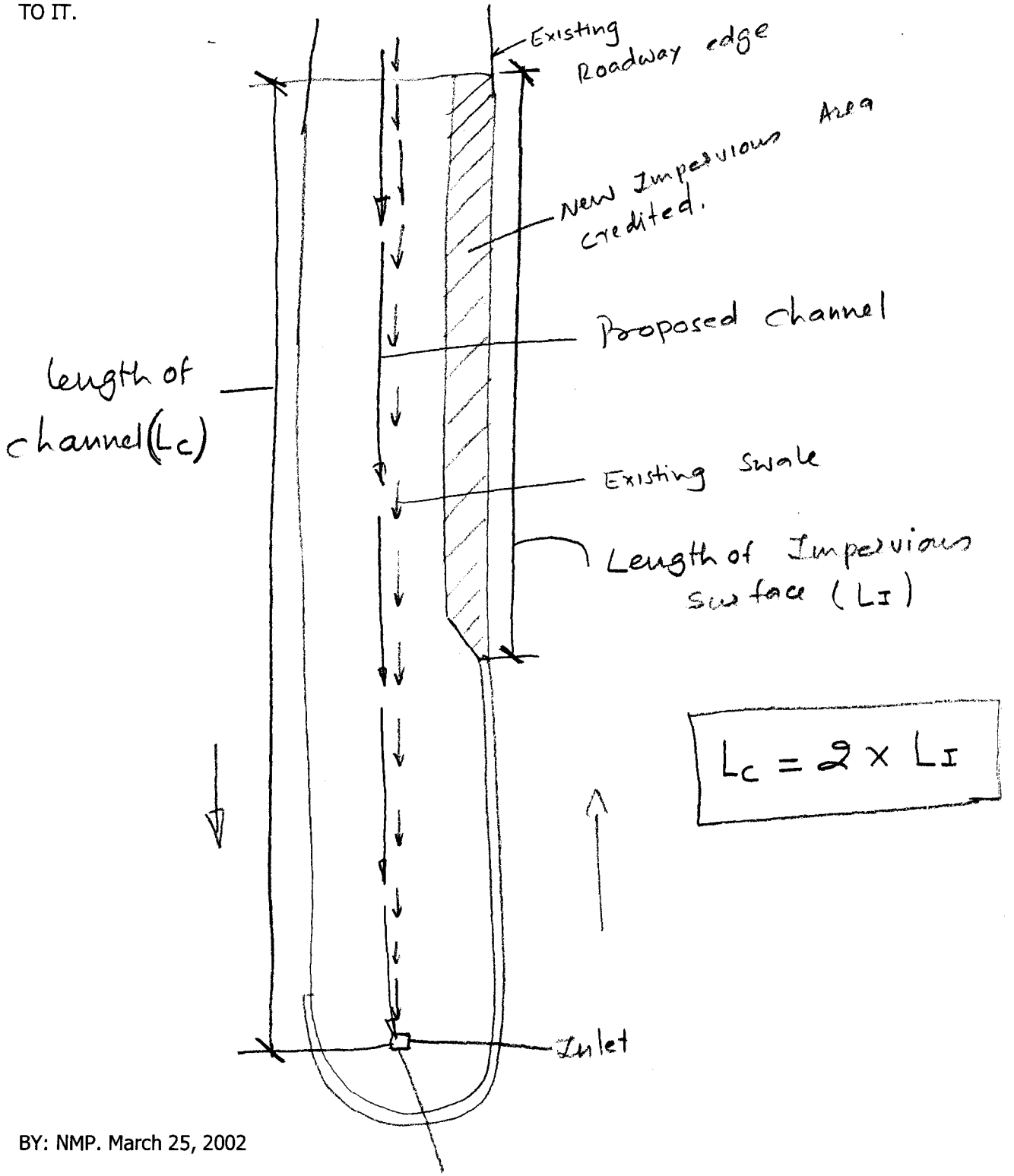
	7b	Proposed Ratio #	from typical section prop. grass length= 23' and contributing impervious flow length = 46'. Ratio = 23/46	0.5	

 # proposed ratio indicates the loss of grass buffer. Due to R/W constraints it is not feasible to maintain existing buffer. Therefore, with approval of MDE, integrate landscape design to mitigate the loss of buffer.

GRASS CHANNEL CREDIT

MITIGATION OF LOSS OF BUFFER:

CHANNEL LENGTH SHALL BE TWO TIMES THE LENGTH OF IMPERVIOUS SURFACE DRAINAING TO IT.



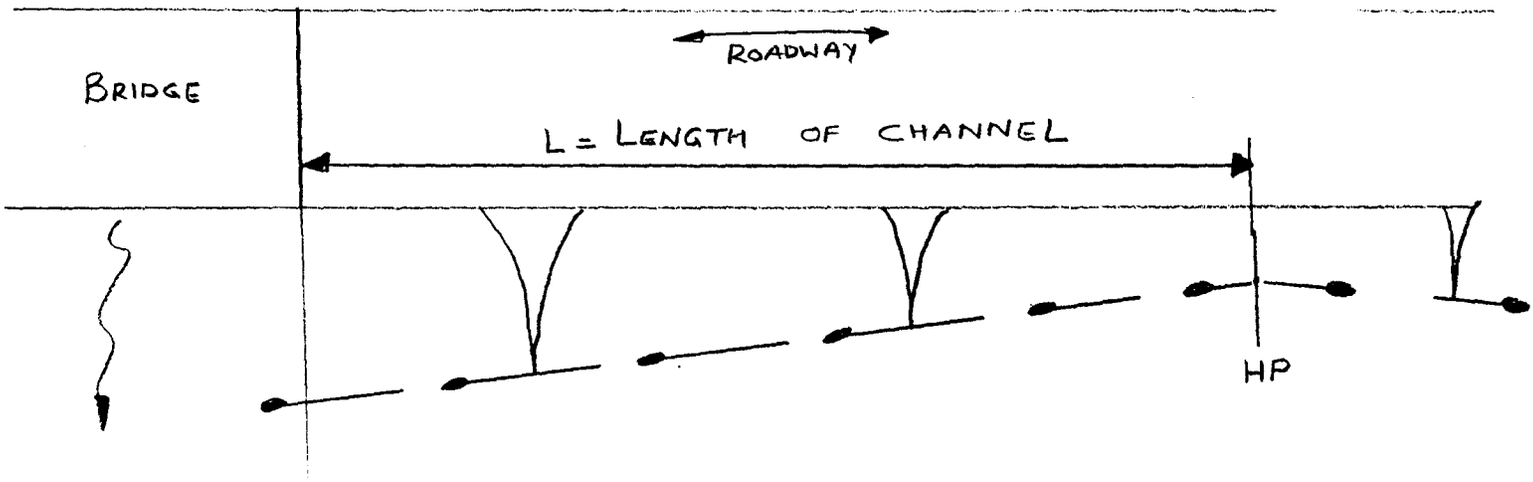
BY: NMP. March 25, 2002

GRASS CHANNEL CREDIT

Determination of Grass channel length: Please follow the following procedure to determine the minimum length of grass channel required to ensure adequate water quality treatment:

CASE I: **Flow to channel via sheet flow condition (Open section highway):**

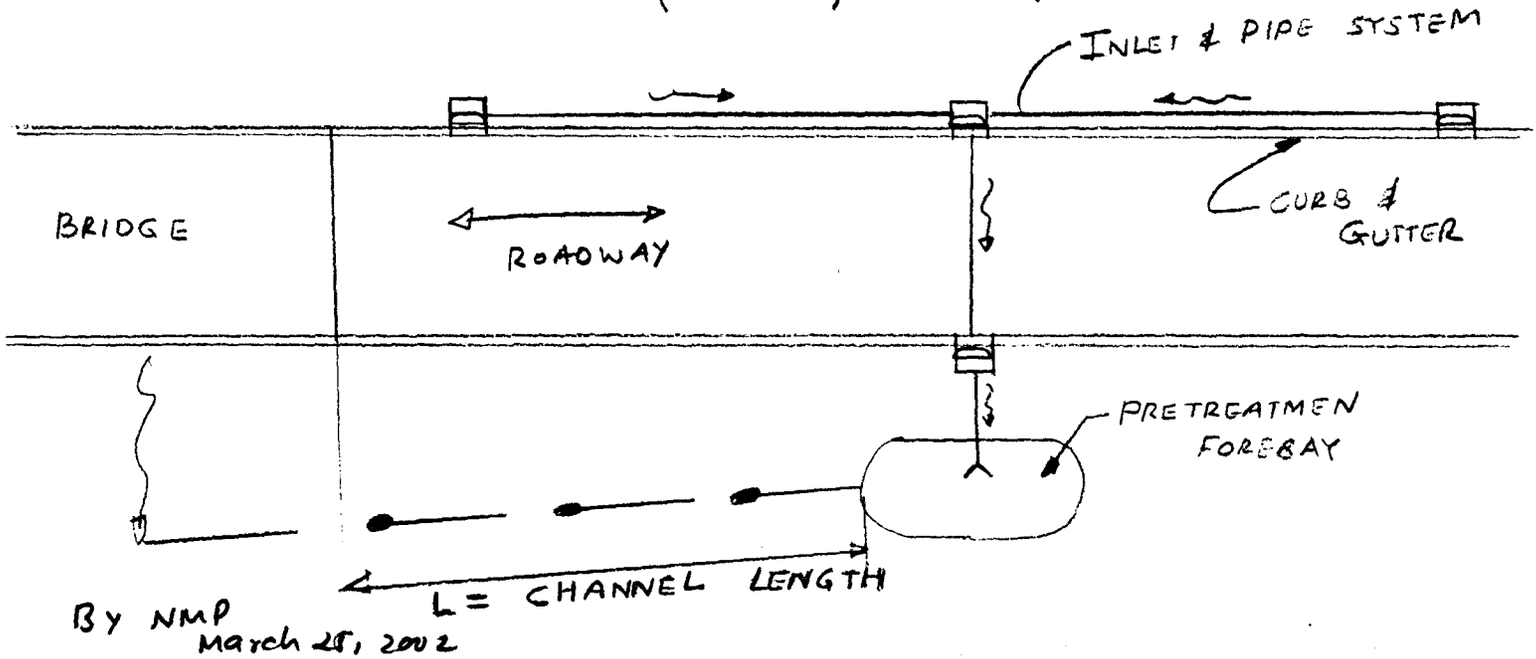
Channel length shall be directly proportional to open section roadway length



CASE II: **Flow to channel via pipe outlet (closed section highway with storm drain outfall):**

Channel length should be maximized to achieve minimum of nine (9) minutes of the residence time, or "contact time". Residence time can be calculated using the following formula:

$$t_c = \left(\frac{L_{FT.}}{V_{FT/sec}}\right)\left(\frac{1\ MIN.}{60\ SEC}\right)$$



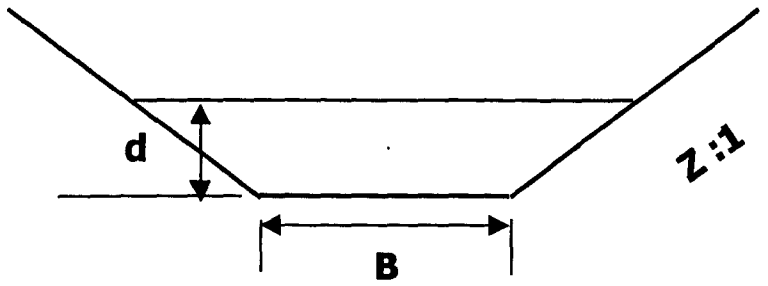
BY NMP
March 25, 2002

SOLUTION TO MANNING'S EQUATION

MANNING'S EQUATION $$Q = \frac{1.49\ A\ R^{2/3}\ S^{0.5}}{n}$$

CONTINUITY EQUATION $$V = \frac{Q_d}{A}$$

TRAPEZOIDAL SWALE GEOMETRIC FORMULAS:



Cross-Sectional Area (A) $$A = B\,d + Z\,d^2$$

Wetted Perimeter (P) $$P = B + 2\,d\,(Z^2 + 1)^{1/2}$$

Hydraulic Radius (R) $R = A/P$ $$R = \frac{B\,d + Z\,d^2}{B + 2\,d\,(Z^2 + 1)^{1/2}}$$

Qd 1.49 cfs **S** 0.04 ft/ft **Z** 3

B (ft)	Y (in)	n	A (sf)	R (ft)	R^2/3	AR^2/3	Q (cfs)	Qd (cfs)	V (fps)
2	4	0.15	1.00	0.24	0.39	0.39	0.77	1.49	
2	5	0.13	1.35	0.29	0.44	0.60	1.32	1.49	
2	5.1	0.13	1.39	0.30	0.45	0.62	1.39	1.49	
2	5.2	0.13	1.43	0.30	0.45	0.64	1.46	1.49	
2	**5.25**	**0.13**	**1.45**	**0.30**	**0.45**	**0.66**	**1.49**	**1.49**	**1.03**

QUANTIFY EXISTING WATER QUALITY TREATMENT

Location	Step 1	Step 2	Step 3
	Efficiency Based On Filter Length	Efficiency Based On Velocity	Greater Of Step 1/Step 2 Efficiencies
Ditch 1	0[a]	100[b]	100
Ditch 2	24[c]	0[d]	24

Prop.

Ex

a	Existing slope = 16.66 %, 6:1 Out Of Fig. 1 Limit
b	Velocity For One-Inch Rainfall Event < 1.0 fps
c	Existing Slope = 8.33 %, Length Of Existing Filter = 35 feet, Required Filter Length From Fig. 1 = 146 feet, Ratio = 35/146 = 0.24

Water Quality Summary		
DA	Impervious Area (Treated) ac	Impervious Area (Required Water Quality) ac
1	0.44 + 0.15 =.59 *	20 % of the existing disturbed impervious area + new impervious area = 0.02 +0.15 = 0.17 ac
2	0	(20 % of the existing disturbed impervious area + new impervious area) X 1.2 ** = (0.01 + 0.1) X 1.2 = 0.132 ac
Total	0.59	0.17 + 0.132 = 0.302

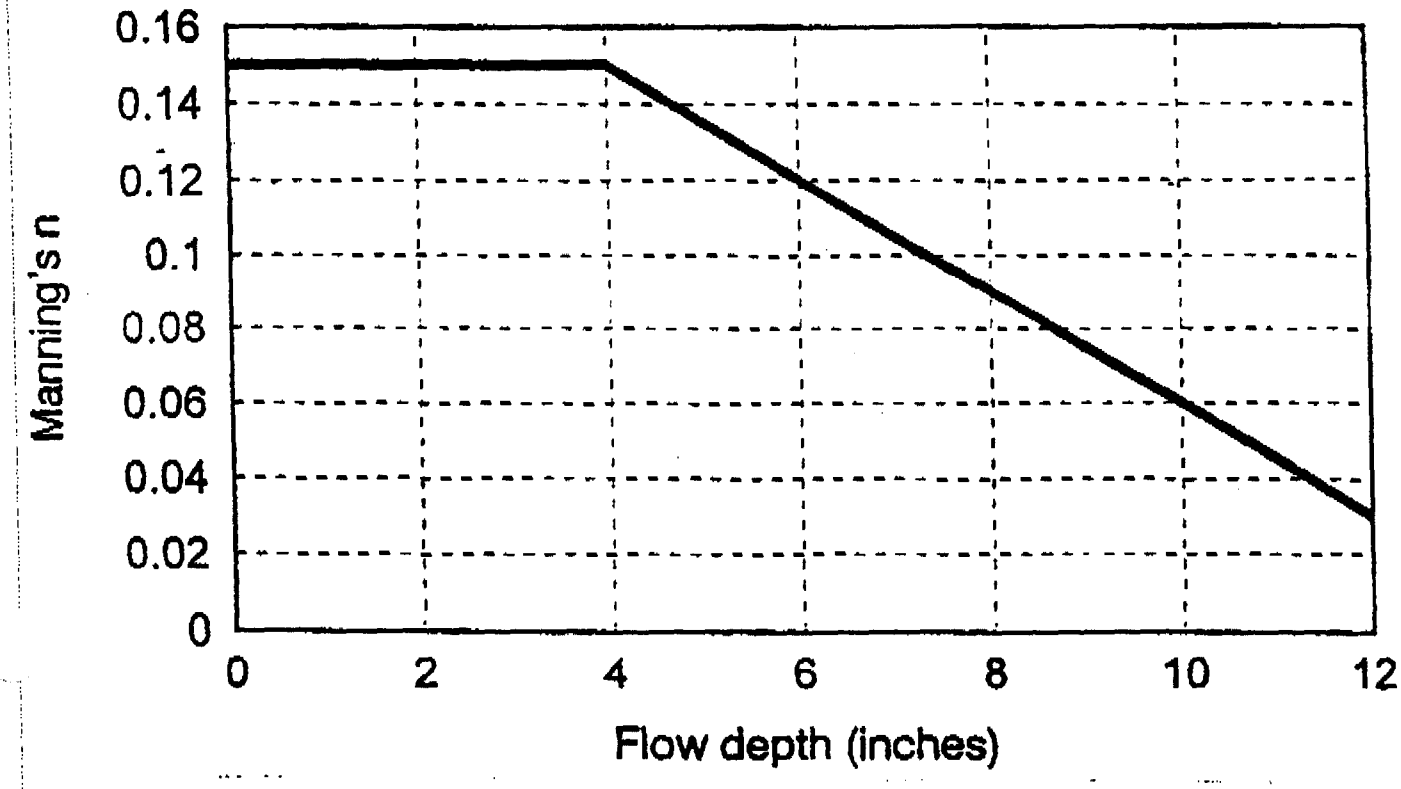
Credit to Water Quality Bank = 0.59 - 0.302 = 0.288 ac

* Exisitng + new impervious area,
Existing - Ditch 1,
0.22 ac x (100 - efficiency)/100 = 0.22 x (100 -100)/100 = 0.0 ac
Existing - Ditch 2,
0.58 ac x (100 - efficiency)/100 = 0.58 x (100-24)/100 = 0.44 ac
New impervious area = 0.15 ac

20 % surcharge for achieving water quality elsewhere on the project for the drainage area

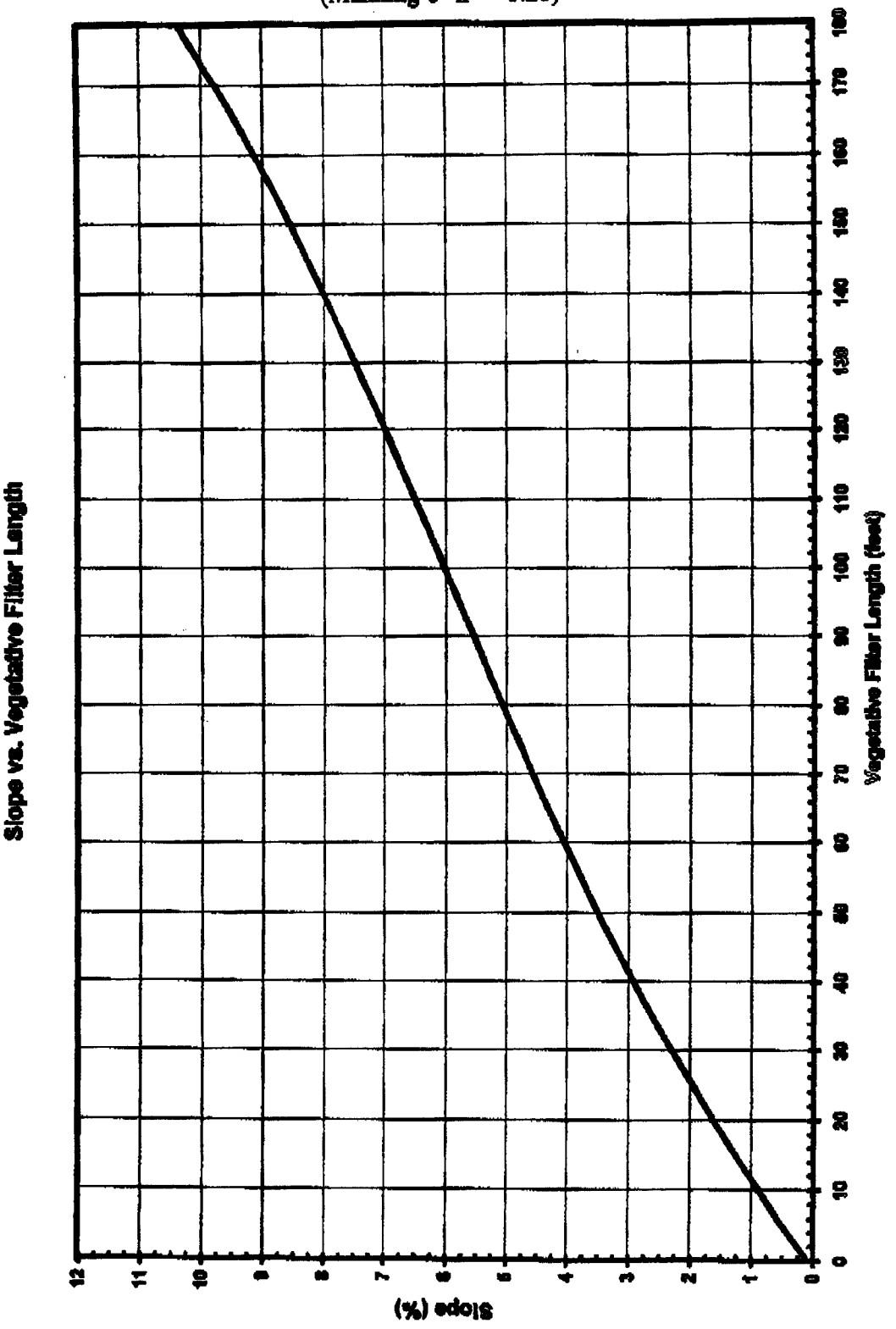
On the plan, specify the following features for the channel

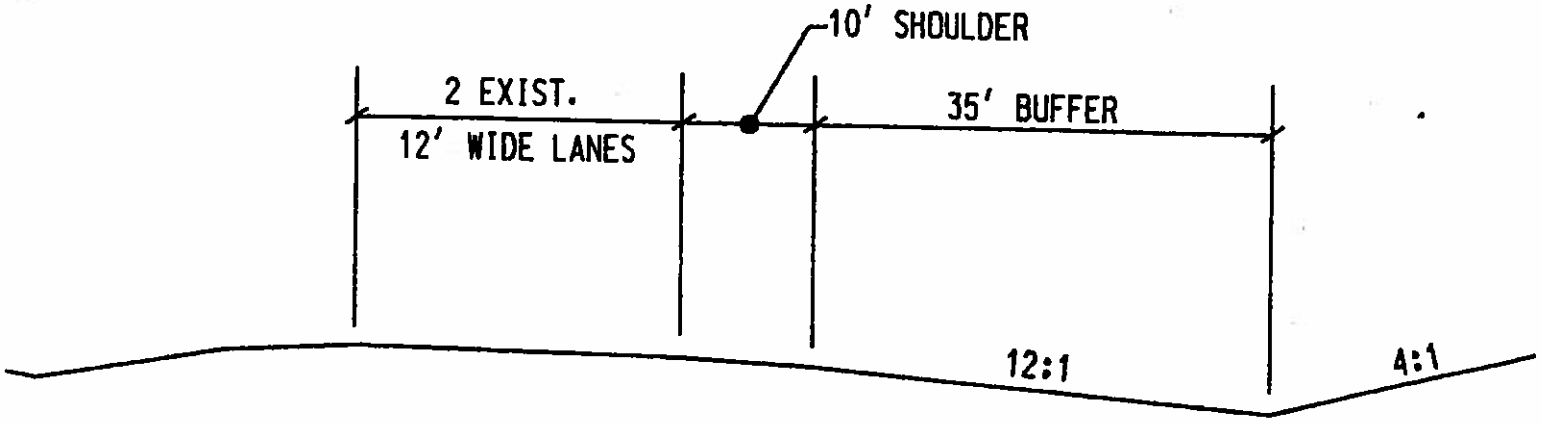
Location	Sta. A to Sta. B
Bottom Width (ft)	2
Slope of Channel (%)	4
Side Slopes (Z : 1)	3
Type of Stabilization	Type "A "matting
Treated Impervious Area (ac)	0.59



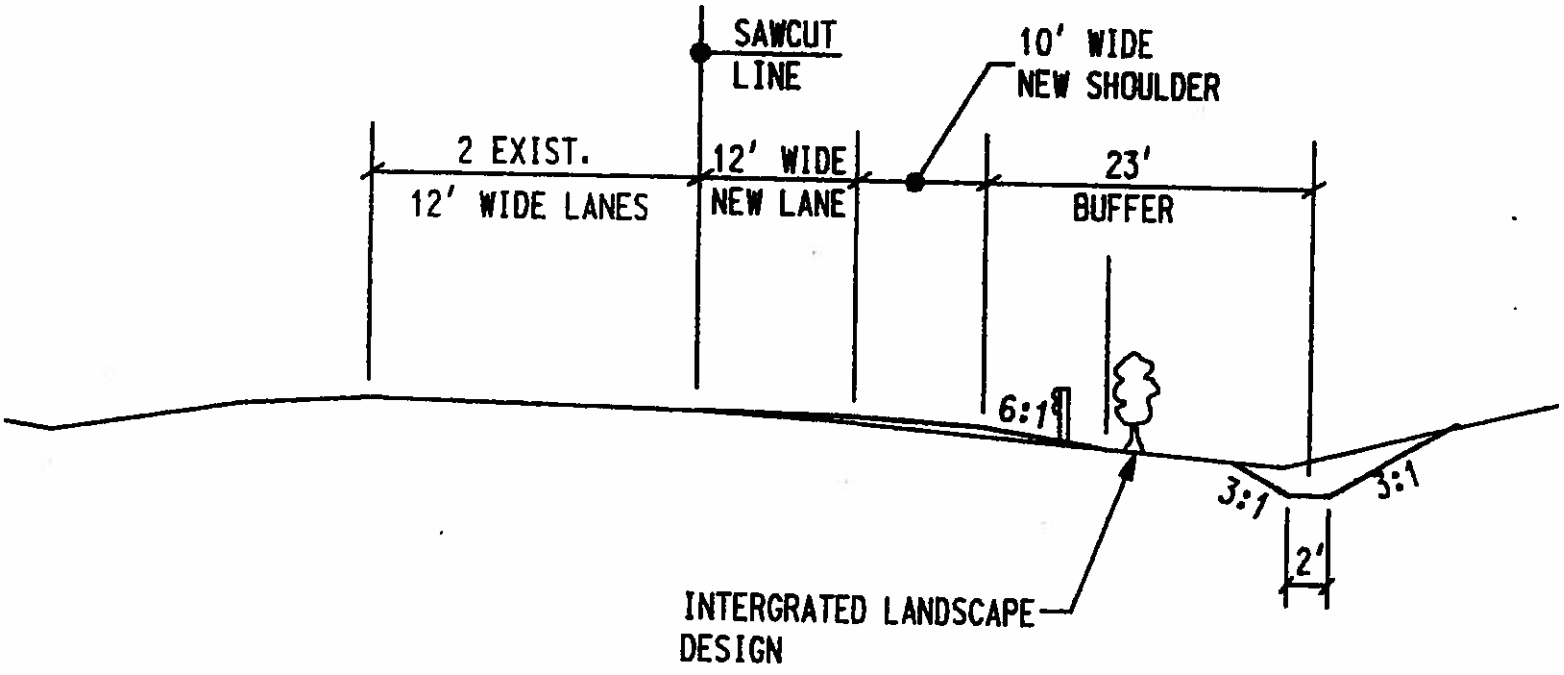
Variable Manning's n with Varying Flow Depth

Figure 1. Minimum Vegetative Filter Length Requirements To Meet TSS Removal Goals (Manning's "n" = 0.20)





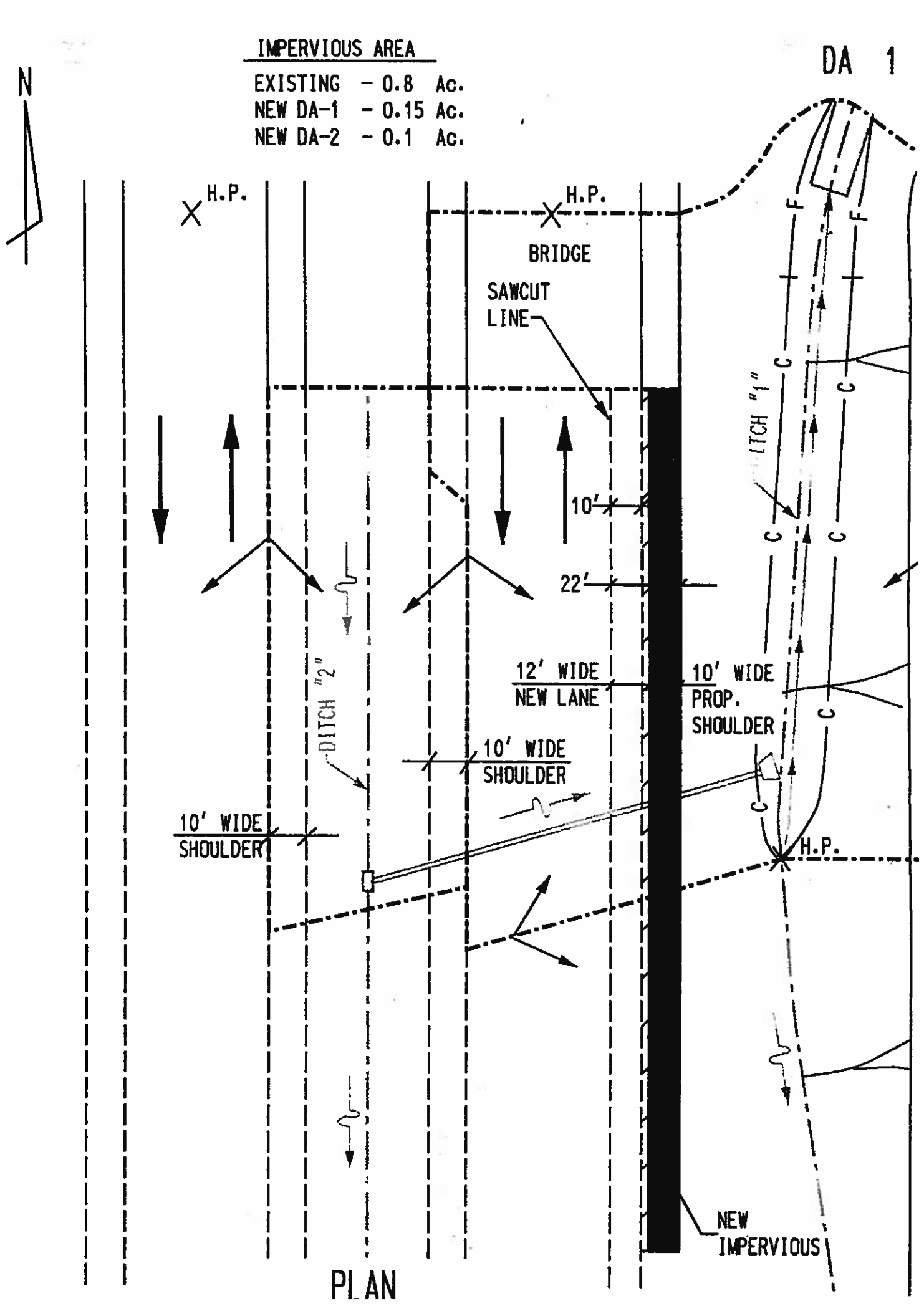
EXISTING CONDITION



PROPOSED CONDITION

TYPICAL SECTIONS

NTS

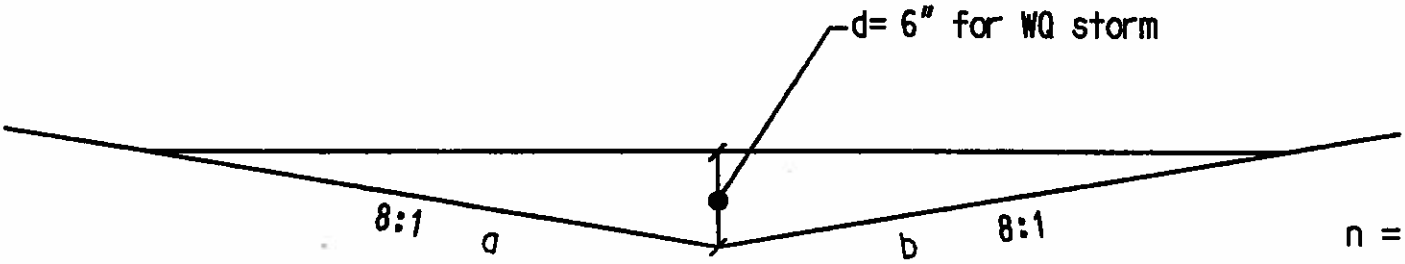

IMPERVIOUS AREA
EXISTING - 0.8 Ac.
NEW DA-1 - 0.15 Ac.
NEW DA-2 - 0.1 Ac.
N
DA 1
H.P.
H.P.
BRIDGE
SAWCUT LINE
DITCH "1"
10'
22'
12' WIDE NEW LANE
10' WIDE PROP. SHOULDER
DITCH "2"
10' WIDE SHOULDER
10' WIDE SHOULDER
H.P.
NEW IMPERVIOUS
PLAN

DESIGN DATA

Q_d=1.38 CFS

S =0.02 FT/FT

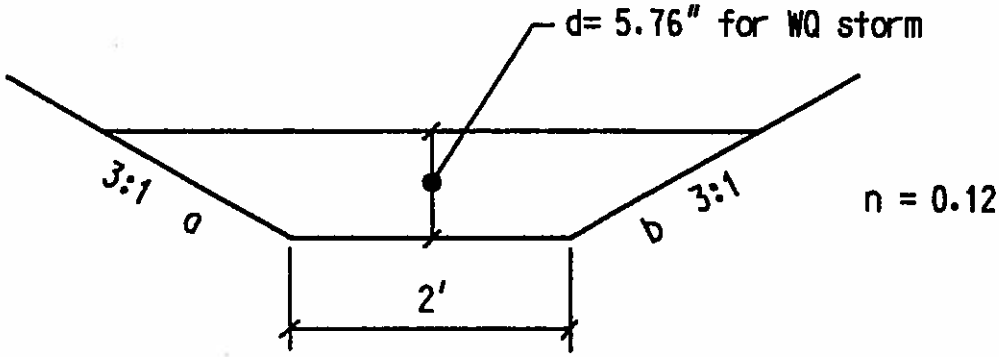
TRIANGULAR CHANNEL



Wetted Perimeter P= a+b= 8.06 FT

TRAPEZOIDAL CHANNEL

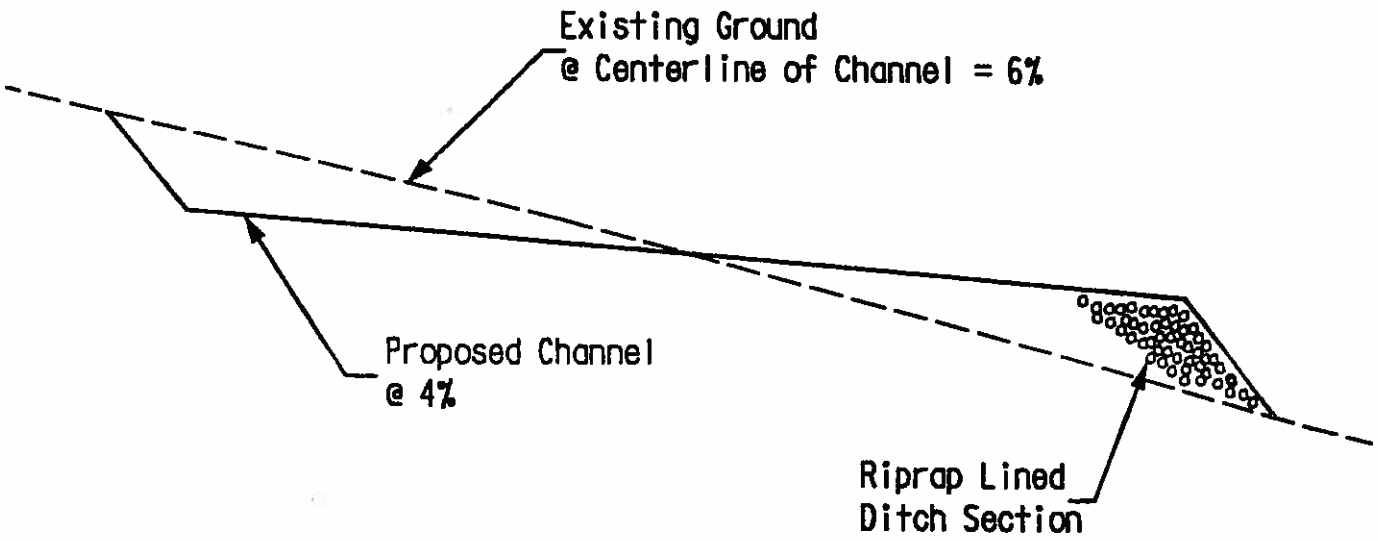
(Minimum Criteria)



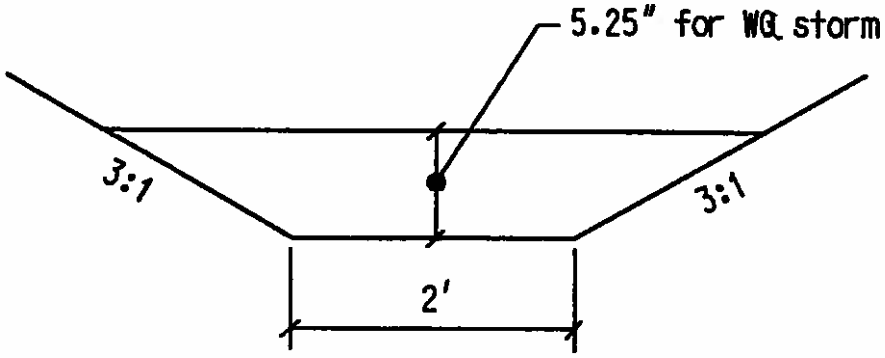
Wetted Perimeter P= a+2+b= 5.04 FT

Wetted Perimeter for Triangular Channel > Wetted Perimeter of 2' bottom / 3:1 Side Slope Channel

* Triangular Channel can qualify for credit



CHANNEL PROFILE
NTS



CHANNEL SECTION
NTS

A trapezoidal channel with side slopes 2:1 can qualify for Grass Channel Credit if the bottom width can be maximized such that the wetted perimeter of the engineered channel is greater than a flat-bottomed channel with 3:1 side slopes. See attached example:

PROJECT	123		
CONTRACT NO.	123	BY	123
LOCATION	123	DATE	

WATER QUALITY SWALE

SELECT HWY SECTION	OPEN SECTION

DESIGN PARAMETERS	FLAT BOTTOM/TRIANGULAR SWALE	MINIMUM WETTED PERIMETER FOR TRIANGULAR SWALE
BOTTOM WIDTH (ft)	2	2
LEFT SIDE SLOPES (N:1)	3	3
RIGHT SIDE SLOPES (N:1)	3	3
SLOPE (ft/ft)	0.02	0.02
LENGTH (FT)	9	9
OUTPUT		
DESIGN DISCHARGE (CFS)	1.7	
VELOCITY (fps)	0.89	
FLOW DEPTH (inches)	6.2	
MANNING'S "N"	0.12	
WETTED PERIMETER (ft)	5.27	

PROJECT	123		
CONTRACT NO.	123	BY	123
LOCATION	123	DATE	

WATER QUALITY SWALE

SELECT HWY SECTION	OPEN SECTION

DESIGN PARAMETERS	FLAT BOTTOM/TRIANGULAR SWALE	MINIMUM WETTED PERIMETER FOR TRIANGULAR SWALE
BOTTOM WIDTH (ft)	3.5	2
LEFT SIDE SLOPES (N:1)	2	3
RIGHT SIDE SLOPES (N:1)	2	3
SLOPE (ft/ft)	0.02	0.02
LENGTH (FT)	9	9
OUTPUT		
DESIGN DISCHARGE (CFS)	1.7	
VELOCITY (fps)	0.83 < 1	FPS
FLOW DEPTH (inches)	5.4	
MANNING'S "N"	0.13	
WETTED PERIMETER (ft)	5.51 >	5.27

∴ Maximization of Bottom width to compensate 3:1 slope Requirements.

SHA-MDE Stormwater Management Process Agreements and Interpretations (April 2003)

SHA-MDE Stormwater Management Process Agreements and Interpretations

As of April 2003

The 2001 Maryland Department of the Environment (MDE) Stormwater Management Guidelines for State and Federal Projects introduced the first major changes to the stormwater management design process at the Maryland State Highway Administration (SHA). Since the 2000 Maryland Stormwater Design Manual was incorporated by reference into the regulations, the changes caused a steep learning curve among designers as well as reviewers. Since July 2001, many implementation problems have been discovered by MDE and SHA, and several discussions took place to develop solutions and agreements in order to ease compliance while meeting the intent of the regulations. This document is intended to serve as a growing list of items discussed and agreed by the two agencies for the benefit of practicing engineers.

1 Waivers and Variances

1.1 Maintenance and Redevelopment

The definition of site as indicated in the Guidelines does not directly apply to SHA projects. An entire project is often not redeveloped or newly developed. Generally, any given project can have activities that are treated as maintenance, redevelopment or new development by MDE. It is important to understand the nature and intent of the work segments in order to properly assess each part of the project for stormwater management. In general, any new pavement is considered new development.

1.1.1 Sidewalks

Construction of new sidewalks will be considered new development; however, sidewalks 6 ft and narrower will be eligible for quantity management waiver, unless new curbs are also being installed. Where new curbs are being installed, hydrologic analyses are required to evaluate the need for quantitative management. New sidewalks constructed using impervious material such as concrete or asphalt will be subject to water quality requirements.

As per discussions in 2001 between SHA and MDE, exact replacement of broken up and old sidewalks will be treated as a maintenance activity. However, if the replacement results in alteration of use for purposes other than repairing the existing sidewalks, redevelopment requirements will apply.

1.1.2 Resurfacing, Patching, etc.

- Resurfacing is a non-earth disturbance activity and, therefore, considered as maintenance. Spot patching for the purposes of repairing the pavement is also considered maintenance. Extensive reconstruction, such as a long patch for an entire lane will be considered redevelopment.
- Reconstructing shoulders with to increase traffic-bearing strength will be considered redevelopment.

- Localized patching performed as part of a culvert or bridge replacement project to backfill after an open-cut will be considered maintenance. Reconstructing approach roadways in such a situation will be considered redevelopment.

1.1.3 Bridges and Culverts

- Bridge deck replacement is considered maintenance.
- Replacement of culverts is also considered maintenance. Any approach roadway reconstruction may be considered redevelopment, and any widening will be considered new development.
- Bridge deck over open water will receive variance from water quantity management. Water quality requirements still apply. The rationale is that existing open water surfaces do not infiltrate stormwater.

1.2 Variances

1.2.1 Minimal Addition of Impervious Areas

Since minimal additions of impervious area do not increase discharges noticeably, each point of study (POS) where stormwater leaves right-of-way that has less than 0.5 acres of additional impervious area will be considered for a variance to quantity management requirements. If multiple outfall channels that lead to a confluence before their drainage area doubles outside the right-of-way will be considered as one in counting towards the 0.5 acre increase. Cumulative additions due to multiple projects will also be considered. Variances require stable and adequate conveyance.

1.2.2 Qp Variances

Increases in Qp will be considered for variances if downstream conveyance is adequate and downstream property owners accept the increases in writing.

1.2.3 Drainage Area Shifting

Shifts in drainage areas will be considered for quantity management variance if the peak discharge increase due to a 1-year storm is less than 2 cfs at the points of study where drainage additions are proposed.

1.3 Other Waiver Interpretations

1.3.1 Quantity Waivers

- Points of Study (POS) must be at a point where concentrated discharge leaves right-of-way.
- In calculating comparative discharges, all of the drainage area, including off-site areas, should be included.
- If post-construction 1-year discharge is less than 2 cfs, all quantity management (Qp, Cpv, Q100) will be considered for waiver.
- Outfall channel adequacy should be evaluated for the entire length of channel to a point where drainage area doubles that at the POS, and should include capacity and stability assessments.

- For connections to publicly owned stormdrain system, evaluations should include capacity of the stormdrain system based on the owner's standards, and include outfall channel of the drainage system if the drainage area is still less than twice that at POS.
- Q100 management requirement will be considered not just as managing 100-year peak discharge at the POS, but in terms of the impact of the proposed project on the floodplains of the interjurisdictional streams: Jones Falls, Gwynns Falls, Herring Run and Carroll Creek. Specific approaches for each case should be discussed with MDE to receive agreement.

1.3.2 Sound Barriers

- Sound barriers qualify for quality and quantity waivers only if the drainage patterns are maintained and water quality treatment is not reduced.
- Rock trench drains under sound barriers that maintain existing sheet flow patterns are accepted by MDE for waiver.

2 Plan Requirements

2.1 As-built certification

- As-built certification by a PE, PS or RLA is required for all structural best management practices (BMP). As-built checklist is required to be placed on the plans. Some of the as-built certification templates are available at SHA Highway Hydraulics Division.
- As-built certification special provision samples are also available at SHA Highway Hydraulics Division.

2.2 Maintenance

- The Guidelines require that maintenance check list be placed on plans. Since SHA has a Stormwater Management Facilities Inspection and Remediation Program, MDE has agreed to accept a note on the plans certifying that the BMPs will be maintained in accordance with the SHA program.
- Each structural BMP will be assigned a unique tracking number by SHA at about 65% plan stage. This number must prominently appear on the stormwater facility plans. The BMP number can be obtained by completing a request form and submitting to the SHA hydraulics project manager or the SHA BMP Program Manager.

3 Design Issues

3.1 Grass Channels

3.1.1 New Grass Channels

- For new roadways and new grass channels, design should be in accordance with the Design Manual to obtain Rev and WQv credit towards meeting the project requirements.
- Length of the grass channels should be the same as the roadway contributing the runoff it is to treat. If the grass channel is interrupted by driveway culverts, MDE has agreed to count such culverts as part of the channel length.
- For non-linear pavement such as parking lots, a grass channel needs to have 9 minute residence time in order to qualify for project water quality credit. The dimensions 2 ft bottom, 3:1 side slopes and maximum 4% slope still apply.

- Grass channels with wetted perimeter equivalent to the standard dimensions will be acceptable.

3.1.2 Existing Grass Channels

- Grass channels are considered to provide water quality treatment if the velocities for a WQv storm are less than 3 ft per second (as per Guidelines). Flow diverted away from such channels should be accounted as loss of water quality treatment.
- If widening is proposed to the pavement draining towards the grass channel, pavement to buffer ratio criteria must be met (see separate grass channel guidance) if water quality is to be maintained.
- If sheet flow to grass channel is eliminated due to curbs or barriers, all treatment will be considered lost.
- Pretreatment can be replaced as follows:
  - Using a peagravel filter for 10% of the WQv where the water reaches the grass channel via "frequent" curb openings or curb cuts.
  - Using pretreatment using depressed inlet with the required pretreatment volume before the stormwater is released into the grass channel.
  - Other means acceptable to MDE.

3.2 Bioretention

3.2.1 Soil Specifications

- MDE has agreed to accepting SHA bioretention specifications and soil mix for SHA projects.
- MDE has agreed to allow the use a permeability of 2.0 ft/day when specifying SHA bioretention specifications. 1.0in/hr

3.3 Dry Swales

3.3.1 Dry Swale Soil Mix

MDE is allowing the use of a soil mix of 50% sand and 50% loam, with a permeability of 1.5 ft per day.

3.4 Sand Filters

3.4.1 WQv

WQv should be the volume captured, including the ponding above the filter plus the water in the voids of the sand filter media itself.

3.4.2 Specifications

MDE has accepted the following specification changes:

- Concrete sand ASTM C-33 is acceptable instead of sand particle size range of 0.02"-0.04".
- AASHTO No. 57 stone for underdrain gravel, instead of 0.375"-0.75".
- Accept SHA nonwoven PE Type I geotextile instead of the geotextile specification in the Design Manual.
- MDE also accepts 4" peagravel layer is acceptable in-lieu of geotextile. This is preferred by SHA to the use of geotextile filter.

- MDE is now requiring gravel instead of top soil for a portion of the surface towards the downstream end of the sand filter. There are also other detail changes such as a Class 0 riprap trench for erosion protection between forebay and filter bed. Contact SHA for specific requirements.

3.4.3 Cpv in Sand Filters

- Providing Cpv is acceptable using sand filters as long as the facilities draw down within 72 hours.
- Overflow inlets should be placed near the forebay to avoid resuspending the pollutants.

3.5 Ponds

3.5.1 Micropool ED Pond Volumes

WQv and CPv need to be treated separately, and there is no guidance in the Design Manual on the sizing, MDE has decided that

1) for Use III and USE IV watersheds, one-third of the WQv should be provided in micropools and forebays.
2) For other watersheds, 50% of WQv should be provided on micropools.

Forebays will still need to contain a minimum of 0.1" of runoff.

3.5.2 Pond Cpv Volume

Pond Cpv should be computed above the permanent pool.

3.5.3 Dam Safety Division Approval for Use III Watersheds

- Dam Safety Division approval is not required simply because a pond is in Use III or IV watersheds. MDE Plan Review Division approval is sufficient.
- For higher class embankments, Dam Safety review is still needed.

4 Alternative Approaches

4.1 Offsetting Cpv

Providing Cpv storage closer to the POS sometimes is difficult since the entire drainage area must be considered while designing a storage pond. The purpose of Cpv is to make the proposed project insignificant to the receiving channels. MDE will consider the following approaches:

- Providing Cpv storage at an upstream location in the watershed where the pavement draining to that location is the same as the new pavement added in the drainage area to the POS.
- Providing a drainage area/watershed based storage using microscale or traditional facilities that can imitate the hydrograph in the existing conditions. In its ideal condition, this "low impact" management system will meet all stormwater management requirements for the project area.

4.2 Water Quality Banking

A new water quality banking system, building on the previous bank, was developed. See separate guidance on this. The use of the bank to meet the water quality needs of a project should be considered only after on-site opportunities are not practical.

4.3 Stream Restoration in-lieu of stormwater management

SHA has developed a method to estimate the benefits of stream restoration projects. Currently, data is sparse on this subject. SHA and MDE have agreed to introduce stream restoration as an alternative to water quality as well as water quantity management for projects. This is to be evaluated on a case-by-case basis using certain agreed-upon parameters, and requires significant work to establish water quality benefits. This approach will be constantly refined as technology develops. Please contact SHA Highway Hydraulics Division and request evaluation if this approach is appropriate for the project you are working on.

SWM Meeting Conclusions 4/6/00 and 4/19/00

Maryland Department of Transportation
State Highway Administration

Parris N. Glendening
Governor
John D. Porcari
Secretary
Parker F. Williams
Administrator

June 9, 2000

RE: Meeting Conclusions 4/6/00 & 4/19/00
SWM and E&S

For your information

Post-it® Fax Note 7671	Date 6/9/00	# of pages ▶ 4
To Richard Sobbotk	From Mustafa - F.	
Co./Dept. DCI	Co. SHA/HHD.	
Phone #	Phone #	
Fax # 992-7038	Fax #	

Mr. James Tracy, Chief
Plan Review Division
Water Management Administration
Maryland Dept. of the Environment
Building 30- 1st Floor
2500 Broening Highway
Baltimore, MD 21224

Dear Mr. Tracy:

Thank you for your time in meeting with SHA on April 6 and April 19 to discuss several items concerning Stormwater Management and Erosion and Sedminet Control as it pertains to our projects and permits. In follow up to that meeting, we have prepared the following summary of the conlsuions reached during the meetng, in the order they were discussed from the agenda. Those Attending the meeting:

Jim Tracy, MDE
Brian Clevenger, MDE (4/19 only)
Stewart Comstock, MDE, (4/19 only)
Raja Veeramachaneni, SHA
Stephen Udzinski, SHA (4/6 only)
Karuna Pujara, SHA
Mike Lynch, SHA

1) Stormwater Management Guidelines

a) 2.3(a)(1) Waivers –Infiltration feasible, but not enough for quantity?
- **Jim** will speak with Ken Pensyl to confirm this issue, but believes if infiltration is feasible this waiver does not apply to quantity. In the meantime, a variance can be requested and no downstream property owner concurrence would be required. The request for a variance should state that SHA is responsible for any erosion/flooding occurring as a result of the increased flows.

b) 2.3(a)(3) Waivers -Definition of 6' Linear Disturbance?
- This waiver does not apply where any significant amounts of curb and gutter are being added or drainage patterns have been altered. Slight extensions of curb in the order of 20'-30' can be allowed. 6' of disturbance can apply to both sides of the roadway, that is 6' on the RT and 6' on the LT for a total of 12' may still apply for this waiver. Any changed drainage patterns.

Maryland Department of Transportation
State Highway Administration

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1) **Stormwater Management Guidelines**
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My telephone number is _____

Maryland Relay Service for Impaired Hearing or Speech
1-800-735-2258 Statewide Toll Free

Mde_letter.doc

Mailing Address: P.O. Box 717 • Baltimore, MD 21203-0717
Street Address: 707 North Calvert Street • Baltimore, Maryland 21202

or the addition of curb preclude the waiver. The 6" linear disturbance should not be confused with 6" additional paving.

c) Infiltration Trench Details (Sand Layer necessary?)
- The sand layer at the bottom of the detail is not needed. For calculating storage in the trench, the height should be taken as from the bottom to the invert of the ditch(which is the bottom of the riprap in a riprap ditch.). 2:1 Sideslopes may be used for computing the storage volume; however the infiltration rate should be calculated using the plan view area of the bottom of the trench only.

d) Guideline for inclusion of existing Pavement in open to closed section project? (And vice-versa)
- As an interim measure: Use the discharge calculation in the Draft SWM Manual for 1" over the contributing area to the ditches. Next, calculate the velocity in the ditch using manning's equation. Then, use the following guideline:

  $0 \leq V \leq 1$ use 100% Water Quality Credit/Debit

  $1 < V \leq 3$ use an interpolated Water Quality Credit/Debit

  $3 < V$ Use 0% Water Quality Credit.

  Additionally, where sheet flow leaves the right of way and continues as sheet flow, this would be considered 100% Water Quality Credit/Debit.

e) Water Quality needs for shoulder edge drop-off?
- Millings, CR-6, or stone does not require Water Quality Debit.

f) Guideline: How far downstream should outfall stability be verified?
- A reasonable Guideline for checking downstream stability is to the confluence of a significant tributary or at the point where the drainage area approximately doubles. Jim Tracy noted Comar 27.17.02.08(3)(a)i to (3)(a)(ii).

g) Water Quality Credit/Debit placed in permit or follow up letter noting approved debit/credit?
- **Karuna** will have a consultant start tracking all Water Quality Bank Sheets at MDE. **Charlie** will provide approved sheets back to SHA on a monthly or regular basis. Approved Sheets will require a team leader signature at SHA and **Jim Tracy** Signature at MDE. **Raja** will see that the Bank sheet has signature blocks added to the blank and distribute it accordingly.

h) Code 378

i) Current accepted version?
- As of April 14, 2000, the January 2000 version of Code 378 is accepted by MDE. **Jim Tracy** will forward a clean copy

ii) What must be shown on SHA Plans?
- **Steve Udzinski** is developing a special provision for Code 378 pond Specifications. The special provision will include a requirement for as-built plans with a Professional Engineer seal. The inspection checklist and As-built Certification note should be included on the SHA design plans. Additionally a pay item or incidental description may be required for the as-builts. As-builts should be channeled to Highway Hydraulics(**Ray Burns**) at SHA. **Steve Udzinski** will provide a copy of the SP to Jim Tracy for concurrence.

2) **Erosion and Sediment Control**

a) Guidelines for required topsoil depth?
- **Jim Tracy** will provide a letter to clarify this issue. 4" topsoil will be required within median and up to hinge points on outside(areas frequently mowed). All other areas will receive 2" topsoil.

b) Sequence of Construction for IFB only Project?
- Safety and Resurfacing or General Maintenance does not require a sequence of construction. The 4 page Special Provision addresses the MDE notifications.

c) Infiltration basins as sediment traps. Specific Requirements?
- The infiltration basin must be 2' below the sediment trap elevation.

d) Confirm Inlet protection (other than CIP) up to 1-acre disturbance?
- SIP and CIP 0.25 acres drainage area
- stone or chain link fence modification 0.25<SIP<1.0 acre drainage area
- MIP and AGIP 1.0 acre drainage area

e) 24 hour vs. 72 hr. stabilization?
- Same day in sensitive areas
- Use 24 hours from initial disturbance(since average rainfall return is 72 hrs. and stabilization should be done before) in nonsensitive areas.

f) Jurisdiction over In-Stream Construction?
- E&S approval is required before approval of instream work can be approved
- Stream Diversions is reviewed/approved by wetland/waterways Division. and by E&S if part of an upland project.

g) 3" Gravel Under dewatering silt bag?
- 3" Gravel under dewatering silt bags will not be required. Only one surface of bag can be used as the area providing filtration of pumped water. This will determine the size of bags required based on pumping rate.

3) **General**

a) Innovative SWM and E&S ideas MDE could share with SHA
- *Not discussed*

4) **Reviewers**

a) Email accounts for reviewers?
- Reviewers' computers will be getting MDE email accounts in the future. (reviewer's share computers)

b) Provide Digital copy of MDE comments?
- Raja will arrange a meeting with the reviewer and get email addresses. Draft versions of comments letters may be provided digitally.

5) **Joint Use Stormwater Management**

a) Procedure or Guideline for MDE Review

- MDE will use the SHA access permit Hydraulic File number for their files for projects that do not involve a SHA Contract. SHA will review the Access Permit proposal and when it is acceptable to SHA. SHA will forward a copy to MDE for review and comment/approval.
- SHA will provide a courtesy copy of plans for SWM in the right-of-way constructed by developers and approved by the county for roadway improvements required as part of an access permit.

b) Ownership & Maintenance of Joint-use Facilities

- SHA will develop a list of Joint Use Facilities for MDE
- MDE will require a minimum of SHA easement or a recorded agreement on land records to consider joint use.
- Maintenance may be provided by either party in joint use, but MDE will have regulatory authority over SHA to enforce maintenance.

6) **Draft MDE SWM Manual**

a) When does it become effective?

- The Draft manual will become effective for SHA projects on Jan, 2001. It should become official by July 1, 2001

b) What projects may be grandfathered?

- Any projects under review at MDE before Jan1, 2001 will be grandfathered into the current regulations.

c) Guidelines for State and Federal Projects?

- Guidelines for State and Federal projects are currently under development. A draft version will be prepared and SHA will have the opportunity to provide comment by July 1, 2000. **Jim Tracy** will provide them to SHA for review and comment. **Raja** will be part of the team developing the guidelines

If you have any questions, feel free to call Mike Lynch of Highway Hydraulics at (410) 545-8407

Sincerely,

Raja Veeramachaneni, Chief
Highway Hydraulics Division

RV MFL

Cc: All HHD Engineers
Kerry Rexroad, KCI
Paul Clement, JMT
Dan O'leary, Parsons
Frank Grabowski, STV
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Best Available Guidance from MDE on ESD to the MEP (February 2010)

Best Available Guidance from MDE on ESD to the MEP for SHA as of February 17, 2010

Subject to change -- Jim Tracy stated that none of this guidance should be considered carved in stone! You have been warned.

Grandfathering

- Projects that receive Final Approval for both SWM and ESC and have 'permits-in-hand' before May 4, 2010 must begin construction activities within two years of the permit date or will require being completely re-designed under the new regulations. Construction activities have been defined by MDE as actual earth disturbance, not Notice to Proceed (NTP). Projects that receive approval prior to the deadline must also be completed within 5 years of permit issuance.

DRAFT Guidelines for State and Federal Projects

- Mid-March.

Water Quality Bank

- Terms and conditions have yet to be negotiated. Discussions have indicated that we may have banking for water quality and quantity. More to come.

Meeting the MEP

- You have an active role to help define MEP for your project and is uniquely justified depending on the circumstances. Your design must be reasonable and practicable. Please refer to the MEP scenario flowchart.

Waivers

- All waivers must be justified and demonstrated and cannot merely be 'selected from a menu' to apply.

- Quality (WQv + Rev or P_E = 1") – None.
- Quantity (Cpv or $P_{E\,(required)}$ – 1"):
    - Discharge to an adequate existing closed stormdrain system;
    - Discharge directly to a major waterway;
    - Discharge directly to tidal waters.

Design/Build

- No updates.

Redevelopment

- For linear projects, the 40% criteria for redevelopment will be considered the LOD.
- For redevelopment projects where %I>40 within the site area, 50% of the existing impervious area within the LOD must be removed or an equal amount of treatment must be provided. Because alternative options do include off-site management (after ESD to the MEP is achieved) the actual treatment and removal can occur outside of the LOD.
- As a general rule, when you expose erodible earth where impervious area exists, it's considered redevelopment. HOWEVER, there are times that this activity can be considered maintenance when you include appropriate justification. When the activity, such as full-depth patching and full-depth reconstruction, is needed to save the roadway; improve motorist and pedestrian safety; to maintain the roadway surface or loading capability (relates to safety of use); can explain why the level of patching or reconstruction is needed (i.e. may need to explain roadway life expectancies, safety aspects, etc.) and explain how MEP fits in, it may be considered maintenance. Some examples that may qualify as maintenance include: reconstructing the approaches to a bridge for a bridge deck replacement with no portions being widened; streetscape full-depth patching or reconstruction with no widening; reconstruction of roadway shoulders to create a reduced shoulder width and sidewalk within the original shoulder footprint; repairing or placing a utility, stormdrain pipe, or culvert without increasing the sizes; reconstructing a driveway; reconstructing an entrance; installing ADA ramps on sidewalks where ramps did not exist; replacing existing sidewalks. **YOU MUST JUSTIFY OR MAKE THE CASE THAT SUCH ACTIVITIES ARE MAINTENANCE; DO NOT ASSUME THAT THESE ACTIVITIES WILL ALWAYS OR EVER BE CONSIDERED MAINTENANCE.**
- Cpv is not required for redevelopment, only P_E = 1" (WQv + Rev) is required.
- When delineating drainage areas to POIs and designating land use, to obtain an accurate amount of impervious area within the DA, be sure to use the assumed amount of impervious

area for residential, commercial, industrial and other similar land uses since this will affect the overall %I and affect the amount of SWM required. Refer to TR-55 documentation for information, or contact your favorite HHD personnel.

Maintenance

- Do not provide SWM for maintenance activities; it's unnecessary.
- Grinding and resurfacing continues to be considered maintenance; do not include resurfacing within the LOD.
- Full-depth patching may be considered maintenance and when it is, do not include full-depth patching within the LOD. Refer to the 'Redevelopment' Section for more detail.
- Full-depth reconstruction may, under certain circumstances, be considered maintenance; refer to the 'Redevelopment' Section for more detail.
- Bridge deck replacement may be considered maintenance and when it is, do not include bridge deck replacement within the LOD. Refer to the 'Redevelopment' Section for more detail.

Retrofits

- When retrofitting a SWM facility and an ESD option is proposed for the retrofit, **all aspects of ESD must be met.** Aspects include maximum drainage areas, slopes, volumes, and all other criteria as specified in the Manual and SHA. If ESD requirements cannot be met, then the facility must be replaced functionally 'in-kind.' This only applies to retrofits to restore functionality to a failing or failed facility rather than a retrofit to accommodate roadway improvements.
- Retrofits to accommodate roadway improvements do not meet ESD and alternate designs meeting ESD must be pursued.

Over-treatment and Under-treatment

- An ESD facility can be designed to handle up to P_E=2.6" and no more.
- For any ESD facility that treats more than the required P_E, the excess can be applied to another drainage area within the project as long as the drainage areas discharge to the same stream; however the P_E treated in any one facility cannot exceed 2.6".
- The entire P_E for a drainage area must be treated. If the required P_E = 1.4" and you design a facility that can treat 1.3", 0.1" must still be treated. Another ESD facility sized for P_E = 0.1", or a structural facility could be used; however first priority must be ESD.

- For redevelopment areas where %I>40, 50% treatment is necessary for existing impervious areas. If you are able to 100%, the excess treatment may be applied as a credit to other drainage areas within the project site when the drainage areas discharge to the same POI. However, P_E in any ESD facility cannot exceed 2.6". The MDE review will also consider local concerns, stable conveyance, and special watershed conditions, and an evaluation will be made on a case by case basis to determine if any excess can be accrued for usage in other drainage areas in the project.
- If non-disturbed impervious areas are retrofitted such that ESD facilities treat 100% of the impervious area, excess treatment credit can be applied to other drainage areas as long as the drainage areas discharge to the same POI. The MDE review will also consider local concerns, stable conveyance, and special watershed conditions, and an evaluation will be made on a case by case basis to determine if any excess can be accrued for usage in other drainage areas in the project.
- If you have two separate storm drain systems that both eventually drain to the same channel at some point downstream, and one outfall requires P_E = 1.2" while the other requires P_E=1.4", there is a chance that if you can meet P_E = 2.6" at the outfall where P_E= 1.2" is required, it will negate the P_E of 1.4" at the other outfall. However, the MDE review will consider local concerns, stable conveyance, special watershed conditions, and an evaluation will be made on a case by case basis and cannot be give a blanket guarantee.

How To

Table 5.7. ESD Sizing Factors for Non-Rooftop Disconnection

Ratio of Disconnection Length to Contributing Length					
Impervious Ratio	0.2:1	0.4:1	0.6:1	0.8:1	1:1
Pervious Ratio	0.1:1	0.2:1	0.3:1	0.4:1	0.5:1
P_E (in.) =	**0.2**	**0.4**	**0.6**	**0.8**	**1.0**

To use the above chart:

For the Impervious Area ratio:

The ratio of the disconnect length to the contributing length. The disconnect is the pervious area that runoff from the developed area will drain to. The contributing length is the length of the impervious area draining to the disconnected area. So for example a 50 foot driveway draining to a 25 foot vegetated area will give a ratio of 25:50, or 0.5:1, and therefore will provide treatment for 0.5 inches of rainfall (P_E).

For the pervious area ratio:

The ratio of the disconnect length to the contributing length. The disconnect length again is the pervious area that runoff from the developed area will drain to. The contributing length is the length of the pervious area draining to the disconnected area. In this case the "contributing length" will apply to ball fields, managed turf areas, parks, etc.

Table 5.3, when

- HSG 'A', I= 20%, RCN = 37. Then PE = 1.2"
- HSG 'B', I= 20%, RCN = 55. Then PE = 1.2"
- HSG 'C', I= 25%, RCN = 70. Then PE = 1.2"
- HSG 'D', I= 30%, RCN = 77. Then PE = 1.2"
- HSG 'A', I = 100%. Then PE > 2.6" so use PE = 2.6" and calculate the additional storage area needed to achieve an RCN of 38. The additional storage area would likely be a structural facility, but if ESD can be used, then it must be.
- HSG 'B', I = 100%. Then PE = 2.6"
- Additional design comps examples will not be provided. It was pointed out that some of the methods are confusing. For example, both dry wells and landscape infiltration need to store the ESDv and completely infiltrate within 24-48 hours. But the landscape infiltration uses a P_E equation to get the A_f and dry wells appear to be sized based solely on the ESDv. Typically, the volume of a dry well is more closely related to the depth of the well; however, for other practices such as micro-bioretention and landscape infiltration, the volume provided is more closely related to the surface area. This is why the equation is not provided for a dry well.

General

- Qe is the runoff depth used in the ESDv equation for determining the volume required.
- If you have an ESD facility and must also use another facility for Cpv, the Cpv facility does not require pre-treatment when the ESD facility overflows into the Cpv facility.
- Riprap is considered pervious in some cases. For example, if you remove a concrete channel to get pavement removal credit and velocities through the channel are too erosive for a vegetated channel, the channel may be replaced with a riprap channel and the concrete removed can be used as pavement removal credit.
- Existing grass channel credits that were obtained prior to ESD are no longer valid and projects in areas that were previously treated by grass channels will be considered untreated for SWM purposes and ESD will need to be applied.

- The redevelopment / new development criteria may be applied to the entire project, or on a drainage area / study point basis. Specific projects will be evaluated case-by-case and no blanket guarantees can be made.
- The Impervious Area Requiring Treatment (IART) methodology previously utilized to determine water quality treatment needs no longer applies. (This involved identifying new development, redevelopment and removal areas and applying the treatment requirement percentages to each in order to determine an overall 'IART'.) However, you can still determine how much impervious area is required for treatment. The difference now is that to meet the redevelopment criteria, for either removing or treating 50% of the existing impervious area, the P_E target will be 1.0 inch (the WQv). When impervious area is increased for a project, the net increase will need to be treated like new development which means the P_E target will be 2.6" (the ESDv). From a practical standpoint, it is important to note that an individual ESD practice might treat as little as 0.1" to as much as 2.6", so it might be a better to view the project in terms of storage area requirements for the entire project and that total storage can collectively meet requirements for the redeveloped portion plus the new developed portion of a project.
- ESD facilities do not generally require pre-treatment unless specifically required by the MDE Manual or by SHA criteria. **Important note: ESD facilities that receive concentrated flow require pre-treatment.** SHA SWM criteria are under development and will be forthcoming.
- Some ESD facilities cannot receive concentrated flow – ever. An example: conservation areas.
- Management of Overbank Flood Protection Volume (Q10) and Extreme Flood Volume (Q100) is according to different jurisdictions as previously required, so pay attention!
- If, for existing conditions, runoff flows off an open section roadway and leaves the R/W via sheet flow for a certain length, a Study Line is utilized to represent this situation (as opposed to a Study Point). If, in proposed conditions, the roadway is converted to closed section, thereby eliminating the sheet flow pattern along the Study Line, it will be required that you still return the runoff from the site to woods in good condition.
- If a volumetric flow splitter is placed upstream of a proposed facility, the facility should be sized for the required ESDv and the excess should be bypassed for diverted.
- For ESD facilities that utilize the SHA BSM filter media, the presently accepted k=2.0 ft/day will remain in effect for SHA projects.
- Grass swales may be designed as on-line.
- For stream crossings or where large, off-site areas travel into and through SHA R/W, the off-site areas should be diverted around any ESD facilities proposed for the roadway.
- Steep slopes are 15% or greater. When showing steep slope areas for the purpose of map requirements, the steep slopes apply to existing slopes prior to proposed improvements. Impacts to steep slopes should be minimized. Slopes of 25% or greater, especially for highly erodible soils, should be completely avoided. New CADD standards are forthcoming.

- Disconnection methods can apply to roadways or roadway shoulders as long as the specified design criteria are met and the area is contained within SHA right-of-way or easement.
- In some cases, large off-site areas drain to existing or proposed SHA drainage systems. Sometimes it is impossible or impractical to divert the flow. Because a pre-development 'wooded condition' curve number will be applied to the entire drainage area, which includes on-site and off-site areas, as the basis of the post-development design, the ESDv will be elevated as a consequence – even when off-site areas are cultivated or open space. There will be some relief in cases where the off-site drainage area appears to control the discharge to a design point, but it will be a case-by-case basis.
- For micro-bioretention and similarly related facilities, the Manual specifies a depth of 2' to 4' of filter media. A depth of 4' is the default requirement. Anything less must be approved and it must be demonstrated that mitigating circumstances exist. Filter media depth can never be less than 2'.
- Concept SWM Reports must contain comps that demonstrate that the proposed ESD facilities can actually work. Design details, such as sub-drain, inlets, pipes, specs, etc., are not necessary, but slopes, velocities, and other pertinent design information to demonstrate feasibility must be included.
- Even when ESD is used to the MEP, it is necessary to verify that the CN reduction has been met. This is especially true for projects in which over-treatment is done in one drainage area to reduce treatment requirements in another. (Refer to the 'Over-Treatment Versus under-Treatment' section of this document). If the CN has not been sufficiently reduced, additional facilities, likely structural, would be necessary to reduce the CN to the target level. This information is also needed in the Concept SWM Report.
- Concept SWM Reports must include all of the information specified in Chapter 5, at a minimum.
- Concept SWM Reports must include the E&S approach, the LODs, and demonstrate integration with ESD. Major E&S items must be shown, i.e. sediment traps and basins; but silt fence, inlet protections, and similar items need not be included.
- At each review phase, comments will be all-inclusive, meaning that some comments received need not be addressed to get approval for that particular phase but will need to be addressed at a future phase to receive Final Approvals and permits.
- Depending on how much a project scope changes or how different the design may be progressing, MDE may require a re-submittal of the Concept SWM Report and re-approval.

Remaining Questions Still Requiring Further Guidance

1. For the sub-base of permeable pavements, should it be ¾" stone or C-33? The two are quite different and will result in different infiltration behaviors. ***[SHA prefers ¾" stone, a.k.a. #57. It's stronger, contains more void space, and is subject to less clogging and faster infiltration.]***

2. Under ESD, it appears that the loss of water quality doesn't exist, and it appears that the only requirement is to restore runoff to woods in good condition. Is this correct? So if an open-section is converted to closed section, and ESD is used to treat 100%, it is considered no loss to water quality? ***[First impression is of concurrence, but the CN must be restored to woods in good condition, i.e. it must be demonstrated that the CN has been reduced and restored to 'woods in good condition' in spite of closing an open section. An additional follow-up is warranted.]***

3. If a DA requires PE = 2.4" and ESD facilities treat P_E = 2.3", it was previously stated that the P_E=0.1" would still require treatment. If ESD could not be used to treat PE=0.1" and a structural means was to be used, would the entire Cpv require treatment? If not, how would a structural facility be sized to meet P_E = 0.1"? Or would Cpv = 0.1"? ***[First impression is that it would just be the fraction, but a follow-up is warranted.]***

4. Will there be a penalty for loss of water quality credit?
[It appears that for going from open section to closed section, as long as we restore the CN to woods in good condition, no penalty would be incurred.]

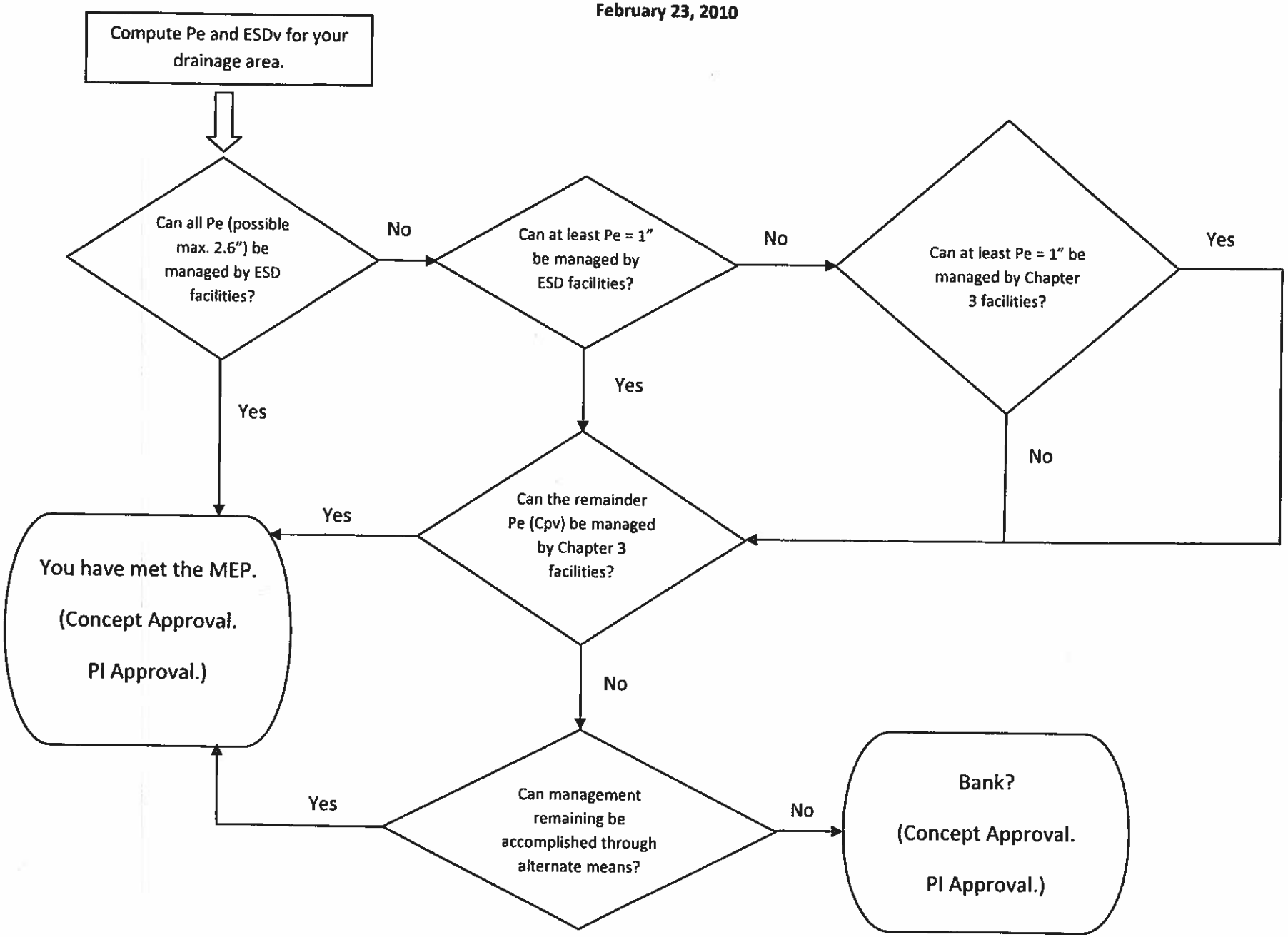
5. Do existing grass channels need to be retrofitted to meet ESD requirements or will previously established credits still be valid? ***[The facilities will be considered valid and functional unless reconstruction occurs in areas that drain to them, at which point a retrofit would be needed. An additional follow-up is warranted.]***

6. To get an NPDES Permit now, must the SWM and ESC approvals be obtained concurrently? ***[Rumor has it that this is now the case.]***

7. When retrofitting a SWM facility and an ESD option is proposed for the retrofit, it is understood that all aspects of ESD must be met. Aspects include maximum drainage areas, slopes, volumes, and all other criteria as specified in the Manual. If ESD requirements cannot be met, can the facility be replaced functionally 'in-kind'? (This would only apply to retrofits to restore functionality of a failing or failed facility.) ***[We believe that this would be a reasonable approach and request confirmation.]***

ESD to the ME Scenarios

February 23, 2010



Best Available Guidance from MDE on ESD to the MEP as well asl ESC (November 2011)

Best Available Guidance from MDE on ESD to the MEP as well as ESC for SHA as of November 21, 2011

SUBJECT TO CHANGE – NOT AN OFFICIAL AGREEMENT – NO GUARANTEES ARE EXPRESSED OR IMPLIED – INFORMATION HAS BEEN OFFERED IN GOOD FAITH – YOU HAVE BEEN WARNED.

Grandfathering

- Projects that receive Final Approval for both SWM and ESC and have 'permits-in-hand' prior to May 4, 2010 must begin construction activities within two years of the permit issuance date or will be assigned a new MDE number and must be re-designed following the new regulations.
    - Construction activities are defined as actual earth disturbance, not Notice to Proceed (NTP).
- Grandfathered projects must be completed within 5 years of permit issuance date.
- Extensions may be granted if the Plan Review Division and the Program Review Division concur. Because of NPDES Permit constraints, concurrence may be unlikely.

Water Quality Bank

- Terms and conditions are under negotiation. MDOT and all modals will have identical agreements – no exceptions. We are working closely with Amanda Malcolm and Navrang Patel.
    - NEW! Credits to the WQ Bank will not be recorded until MDE has approved the As-Built Certification package; however, debits will apply immediately.

SWM As-Built Certifications

- Upon MDE approval, SWM as-builts will be made available to SHA for electronic scanning. The electronic files will be stored on Projectwise and made available to SHA and MDE and also linked through the GIS server. After scanning, the original hard copies will need to be returned to MDE unless directed otherwise.

Meeting the MEP

- You have an active role to help define MEP for your project. Each project has unique justifications and is highly dependent upon the specific circumstances. Your design must be reasonable, practicable, and fulfill the intent of the regulations. Please refer to the MEP scenario flowchart on the HHD Intranet site.

Waivers

- All waivers must be justified and demonstrate need; they cannot merely be 'selected from a menu' to apply.
- Quality (WQv + Rev or P_E = 1"): ***No waivers are available.***
- Quantity (Cpv or $P_{E\ (required)}$ above 1"): Some waivers are available, and the need must be demonstrated to qualify for:
  - Discharge to an adequate existing closed stormdrain system;
  - Discharge directly to a major waterway listed in the Guidelines;
  - Discharge directly to tidal waters.
- Use of a waiver does not necessarily exempt a project from Q2, Q10, or Qp management. Eastern Shore counties require Q2 management. Most other counties require Q10 management when downstream flooding problems are known to exist. You will need to demonstrate that no downstream issues exist with every project.

Design/Build

- SHA must obtain the concept SWM approval prior to Advertisement.

Calculating %I

- In an e-mail from Jim Tracy on 11/21/2011 10:16 AM:

  Good Morning Karuna and MDE reviewers:

  Last week I sat down with James Fritz, Amanda Malcolm, Navrang Patel, and Mike Lynch to discuss a number of policy and procedure items relating to plan review of State and federal projects. One issue that we discussed was how to calculate percent imperviousness (I) for the 40% threshold used in determining whether reconstruction is treated as new development or "redevelopment". Because of the problems with the 40% threshold not encouraging reconstruction and impervious removal the way environmental regulations should, we feel that it is acceptable for SHA when calculating %I to use either the LOD or the ROW, whichever gives the more favorable result (i.e. the higher %I). If the ROW is used it should be from station to station for the project limits. Also, please understand that this %I is different than the %I used to for sizing a BMP.

  Please don't hesitate to contact either myself or Amanda if you have any questions.

Redevelopment

- As a general rule, if erodible earth is exposed in existing impervious areas, it's redevelopment; HOWEVER, there are limited instances in which this activity may be sometimes considered maintenance – **BUT THIS REQUIRES ADEQUATE JUSTIFICATION. COST, CONVENIENCE, AND/OR PROJECT SCHEDULE ARE NOT SUFFICIENT.** Examples that may qualify with adequate justification:
    - Full-depth patching and full-depth reconstruction when:
        - It's necessary to save the roadway and maintain loading capacity to avoid imminent catastrophic failure, is linear in nature, and is small in area;
        - It preserves and improves public and pedestrian safety from an immediate threat to human life, is linear in nature, and is small in area;
        - It is reconstruction of roadway shoulders to create a smaller-width shoulder width;
        - It is placement of sidewalk where shoulder exists;
        - It is repairing or placing a single utility, stormdrain pipe, or culvert without increasing the sizes (refer to the MDE manual);
        - It is reconstructing a driveway apron or entrance within the same footprint; or
        - It is replacing existing sidewalks within the same footprint.
    - ESD to the MEP must still be fully justified, when granted the above variance, and the areas must still be included in the LOD.
    - Installation of ADA ramps on sidewalks where ramps did not exist may be considered maintenance.

  CAUTION! YOU MUST MAKE THE CASE THAT SUCH ACTIVITIES ARE MAINTENANCE. DO NOT ASSUME THAT THESE ACTIVITIES WILL ALWAYS OR EVER BE CONSIDERED MAINTENANCE. NO GUARANTEES ARE EXPRESSED OR IMPLIED. FOR ASSISTANCE, PLEASE CONTACT STEVE BUCKLEY OR CHRISTIE MINAMI.

- Widening sidewalks up to one foot to meet ADA compliance: WQ treatment must be provided for the additional foot or debited from the WQ Bank. Because new impervious requires quantity (Cpv) treatment, Cpv must be provided for the additional foot or a variance be exempt quantity treatment must be requested. Existing sidewalk, up to 4 feet wide, is considered maintenance.
- Cpv is not required for redevelopment, only P_E = 1" (WQv + Rev) is required.
- When delineating drainage areas to POIs and designating land use, to obtain an accurate amount of impervious area within the DA, use the assumed amount of impervious area for residential, commercial, industrial and other similar land uses since this will affect the overall %I and affect the amount of SWM required. Refer to TR-55 documentation for information, or contact your favorite HHD personnel.

Maintenance

- Do not provide SWM for maintenance activities unless the area drains to a SWM facility and cannot be diverted – it may be included as extra credit towards offsetting other pervious areas to the same POI or added to the WQ Bank.
- Grinding and resurfacing projects are maintenance activities. Do not include resurfacing work within the LOD.
- Bridge deck replacement is considered maintenance as long as the bridge deck is not widened.
- Widening sidewalks up to one foot to meet ADA compliance: WQ treatment must be provided for the additional foot or debited from the WQ Bank. Because new impervious requires quantity (Cpv) treatment, Cpv must be provided for the additional foot or a variance be exempt quantity treatment must be requested. Existing sidewalk, up to 4 feet wide, is considered maintenance. Because earth disturbance occurs, include within the LOD.

Retrofits/Rehabilitation/Etc

- For facilities that treat WQ only a.k.a. REHABILITATION:
  - The new facility must be sized for $P_E = 1"$.
  - Chapter 3 facilities may be replaced with Chapter 5 facilities. Example: a failed infiltration trench can be replaced with a bioswale as long as all design criteria for the bioswale can be met for $P_E = 1"$.
- For facilities that treat both quality and quantity or quantity only:
  - When reconstructing a Chapter 3 SWM facility with a Chapter 5 option, all aspects of ESD must be met. Aspects include maximum drainage areas, slopes, volumes, and all other criteria as specified in the MDE manual and SHA criteria. If Chapter 5 facility requirements cannot be met, then the facility must be replaced functionally 'in-kind,' i.e. it cannot be enlarged to accommodate additional pavement, etc., and uses 'old' sizing rules for another type of Chapter 3 facility and only applies to rehabilitations to restore functionality to a failing or failed facility rather than a reconstruction to accommodate roadway improvements.
- Expansion of Chapter 3 facilities accommodate roadway improvements is not considered ESD to the MEP unless adequately justified and MDE concurs.
- A retrofit is when you create a SWM facility where one did not previously exist to treat solely existing pavement. When doing retrofit projects, ESD must still be implemented to the MEP and facilities must be sized for the total amount of impervious area draining to it.

Over-treatment and Under-treatment

- An ESD facility is designed to handle up to P_E=2.6" and no more.
- For any ESD facility that treats more than the required acres of pavement, the excess may be applied to another drainage area within the project; however the P_E treated in any one facility for water quality cannot exceed 1" and the drainage areas must have a common POI.
- The entire target P_E for a drainage area must be treated. If the required P_E = 1.4" and you design a facility that can treat 1.3", Cpv is still required. Another ESD facility or a structural facility may be used; however, first priorities are ESD facilities.
- For redevelopment areas where %I>40, 50% of impervious area treatment is necessary. If you are able to treat 100%, the excess acreage of treatment may be applied as a credit to other drainage areas within the project site when the drainage areas have a common POI. The MDE review will also consider local concerns, stable conveyance, and special watershed conditions, and an evaluation will be made on a case-by-case basis to determine if any excess can be accrued for usage in other drainage areas in the project. Excesses may also be credited towards the WQ Bank.
- If non-disturbed impervious areas are retrofitted such that ESD facilities treat 100% of the impervious area, excess treatment credit can be applied to other drainage areas as long as the drainage areas have a common POI. The MDE review will also consider local concerns, stable conveyance, and special watershed conditions, and an evaluation will be made on a case-by-case basis to determine if any excess can be accrued for usage in other drainage areas in the project. Excesses may also be credited towards the WQ Bank.
- If you have two separate storm drain systems that both eventually drain to the same channel at some point downstream, and one outfall requires P_E = 1.2" while the other requires P_E=1.4", there is a chance that if you can meet P_E = 2.6" at the outfall where P_E= 1.2" is required, it may negate the P_E of 1.4" at the other outfall. However, the MDE review will consider local concerns, stable conveyance, special watershed conditions, and an evaluation will be made on a case-by-case basis only.

How To

Table 5.7. ESD Sizing Factors for Non-Rooftop Disconnection

Ratio of Disconnection Length to Contributing Length					
Impervious Ratio	0.2:1	0.4:1	0.6:1	0.8:1	1:1
Pervious Ratio	0.1:1	0.2:1	0.3:1	0.4:1	0.5:1
P_E (in.) =	**0.2**	**0.4**	**0.6**	**0.8**	**1.0**

To use the above chart:

For the Impervious Area ratio:

The ratio of the disconnect length to the contributing length. The disconnect is the pervious area that runoff from the developed area will drain to. The contributing length is the length of the impervious area draining to the disconnected area. So for example a 50 foot driveway draining to a 25 foot vegetated area will give a ratio of 25:50, or 0.5:1, and therefore will provide treatment for 0.5 inches of rainfall (P_E).

For the pervious area ratio:

The ratio of the disconnect length to the contributing length. The disconnect length again is the pervious area that runoff from the developed area will drain to. The contributing length is the length of the pervious area draining to the disconnected area. In this case the "contributing length" will apply to ball fields, managed turf areas, parks, etc.

Table 5.3, when

- HSG 'A', I= 20%, RCN = 37. Then PE = 1.2"
- HSG 'B', I= 20%, RCN = 55. Then PE = 1.2"
- HSG 'C', I= 25%, RCN = 70. Then PE = 1.2"
- HSG 'D', I= 30%, RCN = 77. Then PE = 1.2"
- HSG 'A', I = 100%. Then PE > 2.6" so use PE = 2.6" and calculate the additional storage area needed to achieve an RCN of 38. The additional storage area would likely be a structural facility, but if ESD can be used, then it must be.
- HSG 'B', I = 100%. Then PE = 2.6"
- Additional design comps examples will not be provided. It was pointed out that some of the methods are confusing. For example, both dry wells and landscape infiltration need to store the ESDv and completely infiltrate within 24-48 hours. But the landscape infiltration uses a P_E equation to get the A_f and dry wells appear to be sized based solely on the ESDv. Typically, the volume of a dry well is more closely related to the depth of the well; however, for other practices such as micro-bioretention and landscape infiltration, the volume provided is more closely related to the surface area. This is why the equation is not provided for a dry well.

Soil Borings

- There is no set number for minimum soil borings required. Request recommendations from SHA's Geotechnical Division, basing the request on what we seek to achieve. MDE is open to Geotech's recommendations and reserve the right to require additional borings.

Pervious Pavement

- Permeable pavement is not a stand-alone SWM facility and cannot be used to treat other areas. It is used to reduce the amount of imperviousness in a drainage area and improve the RCN.

Swales

- May be on-line.
- Cannot be placed in fill areas.
- UNCORROBORATED INFORMATION – There is a question about bio-swales: some claim you can just design a swale with media below, others say, no, it needs to be designed like a dry swale with berms separating the chambers. ***[CLARIFICATION IS REQUIRED]***

Micro-bioretention, Bio-swales, and Similar Facilities

- The MDE manual specifies a depth of 2' to 4' of filter media. A depth of 4' is the default requirement. Anything less must be approved by the HHD Division Chief and it must be demonstrated that mitigating circumstances exist. Filter media depth can never be less than 2'.
- Per the MDE manual, the filtration practice may be designed to temporarily store 75% of ESDv as ponding in the facility. (The remaining 25% is assumed to be in the filter media area itself.) If you are already including the filter media area for storing water, you must design the facility for 100% of ESDv.
- When moving into the final design of micro-bioretention or bioswale facilities, the Chapter 3 filter bed area equations must be used to provide a more accurate design. The equations in Chapter 5 were derived from the Chapter 3 equations, and should only be used for 'planning' or 'concept' purposes only.

Facilities with Sub-Drain

- Recharge held in a stone reservoir below the underdrain of facilities like microbioretention, rain gardens and bioswales is still required. Basically, all facilities must use enhanced filters. While ESDv doesn't have a separate 'recharge' component, refer to chapter 3 for the equations to use to size the enhanced filters. Even though on page 5.25 it says that when ESD practices meet the targets, Rev, Wqv and Cpv requirements are satisfied; however, Rev is <u>not</u> satisfied when underdrain (sub-drain) is used. Chapter 5 practices assume that the facilities will be designed to infiltrate, and that underdrains are 'optional' design features, not 'standard.'

General

- Qe is the runoff depth used in the ESDv equation for determining the volume required.
- If you have an ESD facility and must also use another facility for Cpv, the Cpv facility does not require pre-treatment when the ESD facility overflows into the Cpv facility.
- Riprap is considered pervious in some cases.

- Example: if you remove a concrete channel to get pavement removal credit and velocities through the channel are too erosive for a vegetated channel, the channel may be replaced with a riprap and the concrete removed can be used as a pavement removal credit; however, this technique only applies towards water quality and does not provide any quantity management that may be required for new impervious areas.

- Existing grass channel credits that were obtained prior to the implementation of the new regulations are no longer valid. Projects in areas that were previously treated by grass channels will be considered untreated for SWM purposes and the channels must be redesigned and reconstructed to meet ESD criteria.
- The redevelopment / new development criteria is applied on a drainage area / POI basis.
- The Impervious Area Requiring Treatment (IART) methodology previously utilized to determine water quality requirements no longer applies. (This involved identifying new development, redevelopment and removal areas and applying the treatment requirement percentages to each in order to determine an overall 'IART'.) However, you can still determine how much impervious area is required for treatment. The difference now is that to meet the redevelopment criteria, for either removing or treating 50%, the P_E target will be 1.0 inch (the WQv). When impervious area is increased for a project, the new impervious requires that the P_E target is 2.6" (the ESDv). From a practical standpoint, it is important to note that an individual ESD practice might treat as little as 0.1" to as much as 2.6", so it might be a better to view the project in terms of storage volume requirements for the entire project and that total storage can collectively meet requirements for the redeveloped portion plus the new developed portion of a project.
- ESD facilities do not generally require pre-treatment unless specified by the MDE manual or by SHA criteria; **HOWEVER, any ESD facilities that receive concentrated flow require pre-treatment.** Specific SHA SWM criteria are under development and will be forthcoming.
- Some ESD facilities cannot receive concentrated flow – ever. An example: conservation areas.
- Management of Overbank Flood Protection Volume (Q10) and Extreme Flood Volume (Q100) is according to different jurisdictions as previously required, so pay attention!
- If, for existing conditions, runoff flows off an open section roadway and leaves the R/W via sheet flow for a certain length, a Line of Interest is utilized to represent this situation (as opposed to a POI). If, in proposed conditions, the roadway is converted to closed section, thereby eliminating the sheet flow pattern along the Line of Interest, you must still return the runoff from the site to woods in good condition per the ESD methodology of Chapter 5.
- If a volumetric flow splitter is placed upstream of a proposed facility, the facility must be sized for the required ESDv; the excess must be bypassed or diverted.
- For ESD facilities that utilize the SHA BSM, the presently accepted k=2.0 ft/day remains in effect for SHA projects.
- For stream crossings or where large, off-site areas travel into and through SHA R/W, the off-site areas should be diverted around any SWM facilities proposed for the roadway.

- Steep slopes are 15% or greater. When showing steep slope areas for the purpose of map requirements, the steep slopes apply to existing slopes prior to proposed improvements. Impacts to steep slopes should be minimized. Slopes of 25% or greater, especially for highly erodible soils, should be completely avoided. New CADD standards are forthcoming.
- Disconnection methods can apply to roadways or roadway shoulders as long as the specified design criteria are met and the area is contained within SHA right-of-way or easement.
- In some cases, large off-site areas drain to existing or proposed SHA drainage systems. Sometimes it is impossible or impractical to divert the flow. Because a pre-development 'wooded condition' curve number will be applied to the entire drainage area, which includes on-site and off-site areas, as the basis of the post-development design, the ESDv will be elevated as a consequence – even when off-site areas are cultivated or open space. There will be some relief in cases where the off-site drainage area appears to control the discharge to a design point, but it will be a case-by-case basis.
- Concept SWM Reports must contain comps that demonstrate that the proposed ESD facilities can actually work. Design details, such as sub-drain, inlets, pipes, specs, etc., are not necessary, but slopes, velocities, and other pertinent design information to demonstrate feasibility must be included.
- Even when ESD is used to the MEP, it is necessary to verify that the RCN reduction has been met. This is especially true for projects in which over-treatment is done in one drainage area to reduce treatment requirements in another. (Refer to the 'Over-Treatment Versus under-Treatment' section of this document). If the CN has not been sufficiently reduced, additional facilities, likely structural, would be necessary to reduce the CN to the target level. This information is also needed in the Concept SWM Report.
- Concept SWM Reports must include all of the information specified in Chapter 5, at a minimum.
- Concept SWM Reports must include the E&S approach, the LODs, and demonstrate integration with ESD. Major E&S items must be shown, i.e. sediment traps and basins; but silt fence, inlet protections, and similar items need not be included.
- At each review phase, comments will be all-inclusive, meaning that some comments received need not be addressed to get approval for that particular phase but will need to be addressed at a future phase to receive Final Approvals and permits.
- Depending on how much a project scope changes or how different the design may be progressing, MDE may require a re-submittal of the Concept SWM Report and re-approval.
- Drainage areas to a facility should not include the facility itself for computational purposes.
- There will not be an official 3-permit process. Instead, MDE will issue an 'acceptance' of the design, when appropriate, for concept and site development phases.
- Facilities that contain sub-drain (underdrain) must have a stone reservoir for recharge beneath it. In other words, such facilities require an enhanced filter (refer to Chapter 5).
- The 0.9" used in the western zone for determining the water quality volume is still acceptable for use in determining the water quality volume under the SWM Act of 2007.

Erosion and Sediment Control

- The new ESC Standards will become effective January 1, 2011. All projects must use the new standards, even though they are presently in draft form. Projects under construction after January 1 must comply with the new ESC Manual unless they receive final approval by December 31, 2010.
- Please be advised that the details have changed. Of particular interest are the 1994 details for TSOS and TGOS. MDE has found them to be flawed and as a result, the 2010 details include differences that may result in additional right-of-way impacts. ***Make sure you have enough space. You may even need more survey data.*** There are now storage requirements. In lieu of storage, you may be able to use another layer of gabion to get more storage, but then the sides need to be higher and wider. You'll also need to show the grading around them. If the drainage is flat enough, grading may not be needed, but otherwise, when you have slopes, you need to show the grading.
- ESC permit modifications cannot be constructed without approval. MDE has indicated several instances in which receipt of the permit mod request came after the mod was already constructed. This renders a project to non-compliance. It must be understood that field engineers can't do whatever they want and then submit a modification. This tends to be prevented when the E&S QA inspector is there.
- Because contractors have requested an expedited mod review process, MDE is looking to possibly assign a person devoted exclusively to permit mods, including personal site visits. HHD is looking to do the same.
- To get an NPDES Permit, the SWM and ESC approvals be obtained concurrently.

Specific Questions

1. For the sub-base of permeable pavements, should it be ¾" stone or C-33? The two are quite different and will result in different infiltration behaviors. ***[SHA prefers ¾" stone, a.k.a. #57. It's stronger, contains more void space, and is subject to less clogging and faster infiltration.]***

2. Under ESD, it appears that the loss of water quality doesn't exist, and it appears that the only requirement is to restore runoff to woods in good condition. Is this correct? So if an open-section is converted to closed section, and ESD is used to treat 100%, it is considered no loss to water quality? ***[First impression is of concurrence, but the CN must be restored to woods in good condition, i.e. it must be demonstrated that the CN has been reduced and restored to 'woods in good condition' in spite of closing an open section. An additional follow-up is warranted.]***

3. Will there be a penalty for loss of water quality credit? ***[It appears that for going from open section to closed section, as long as we restore the CN to woods in good condition, no penalty would be incurred.]***

4. Do existing grass channels need to be retrofitted to meet ESD requirements or will previously established credits still be valid? ***[The facilities will be considered valid and functional unless reconstruction occurs in areas that drain to them, at which point a retrofit would be needed. An additional follow-up is warranted.]***

5. How do you model the hydrology when Cpv is required for multiple ESD facilities draining to the same POI? ***[See the design example for determining the required Cpv, page 5.23 in the Stormwater Design Manual.]***

6. How you do model the peak flow for the 2, 10, and 100 year storms since the reduced curve numbers for areas treated by ESD only apply to the design storm? Must routing be performed through each micro-facility? ***[Use the methodology presented in 'Modeling Infiltration Practices Using the TR-20 Hydrologic Program (1983).]***

Water Quality Volume How Much? (January 2002)

Water Quality Volume

The water quality volume (WQv) calculation is a function of area "A;" however, defining that area "A" is ~~tricky.~~ The ~~calculation~~ is found on page 2.2 of the SWM Manual. Below is a recommended sequence for computing WQv for a given project. Because projects involve more than one drainage area, this procedure specifies that the points of investigation should be selected first. The total impervious area required for water quality treatment is then determined in step 2. This is based on an accounting of new and redeveloped impervious areas for each point of investigation. The final step involves ~~checking~~ that the required impervious area, determined in step 2, will drain to the proposed BMP and then calculating the water quality volume.

It is important to emphasize that when calculating the WQv requirements (and Rev) for a project, the first thing to determine is how much impervious area must be managed for water quality, not how much volume.

1. Identify the points of investigation (POI) where stormwater discharges leave the project (property line).

2. Quantify the amount of impervious area for which WQv is required for each POI. This will be equal to:
   a) 100% of the new impervious area*
   b) plus 20% of the redeveloped area **
   c) plus 120% of any impervious area that is to be managed as compensating water quality treatment from another POI. ~~This~~ will be required when a portion of the new impervious area does not drain to the proposed BMP. Note that a surcharge for treating existing pavement in lieu of new pavement does not apply if the two areas being traded drain to the same POI or possibly even if flow from the said POIs drains to the same point within some reasonable distance beyond the project limits. Also note that implicit to the compensating water quality treatment is that there must be no existing water quality treatment for the existing pavement being traded.
   d) minus any ~~applicable~~ water quality credits per Chapter 5 of the SWM Manual

3. Locate and size the BMPs.
   a) The impervious area draining to the BMP(s) must be >= ~~than~~ the impervious area requiring treatment (i.e. the area from step 2). AND, the BMP must be designed to provide WQv for all the impervious area draining to it. For example, if 1 acre of impervious area is required to be treated, and 5 acres of impervious area drains to the BMP, then the BMP must be sized to treat the 5 acres. However, the BMP ~~can~~ be designed off-line so that it only receives the 1 acre, ~~but the same rule still applies – the BMP must be designed for everything that gets to~~ it.
   b) Calculate the required WQv based on the drainage area to the BMP. Size the structure so that the actual physical volume provided ~~exceeds~~ the required WQv.

*New impervious area is determined by subtracting the ~~total proposed~~ impervious area by the existing impervious area.

**Redeveloped impervious area is that area where reconstruction, removal, or alteration, of or on, existing impervious area occurs.

4/1/32

SPLITTERS FOR WQv

A BMP needs to be sized to manage the entire drainage area flowing to it. When designing a BMP located in a drainage area that is relatively large compared to the ART, three design alternatives are typical.

1. Locate the BMP in the upper reaches of the drainage area (watershed) where the contributing drainage is essentially limited to the ART.
2. Locate the BMP elsewhere in the drainage area (such as the bottom of the watershed) and size it manage the entire contributing drainage area.
3. If (2) results in an overly large structure, a splitter can be provided to limit the runoff to the BMP. Because the travel time for the impervious areas within the drainage area is faster than the travel time for the pervious portions of the drainage area, the splitter is able to artificially reduces the drainage area to the BMP. The splitter should preferably be volume based, rather than flow based, contrary to the example in the Design Manual.

FROM: Amanda Malcolm

THROUGH: Jim Tracy

TO: all plan reviewers

DATE: January 28, 2002

SUBJECT: **Water Quality Volume – How Much?**

Finally, the results of my survey… Actually, consensus is more appropriate. My question was poorly worded, but with retrospect that was a good thing since the responses and discussions that ensued touched on many relevant topics. As we know, the design manual is not "cut and dry" with regard to many design considerations. Apparently, that was the intent of the authors (right Stewart?). However, my brain has a hard time with gray areas (and, yes, Dorsey gray matter too). I also think (and everyone seems to agree on this matter) that there should be continuity among us reviewers. So after digesting everyone's feedback, I have attempted to outline a review strategy that hopefully can be applied across the board. I think that I for one was approaching the water quality volume calculation from the wrong angle. I had it in my mind that when checking water quality volume (and Rev) management for a project, the first thing to calculate would be the required WQv for the project. Well, I now know that the first thing that needs to be determined is how much impervious area must be managed for water quality volume. I think most of you inherently realized this and I thank you for enlightening me. Now hopefully, I can spell it out in terms we all can agree upon, follow and even pass on to the designers who are equally, if not more confused than I was.

Below is a sequence of how to assess WQv requirements for a site:

1. Identify the points of investigation (POI) for the project. For most projects, such as SHA, a point of investigation will have to be identified at every point where runoff from the disturbed area leaves the property line. However, this may not be the case for projects occurring within large sites such as college campuses and military bases. Maybe Jim T. has some rule of thumb.

2. Consider water quality credits per Chapter 5 of the SWM manual.

3. For each POI, quantify the amount of impervious area for which WQv is required. This will be equal to:

    - the new impervious area
    - plus 20% of the redeveloped area
    - plus 120% of any impervious area that is to be managed as compensating water quality treatment from another POI. Note that a surcharge for treating existing pavement in lieu of new pavement does not apply if the two areas being traded drain to the same POI. Also note that implicit to the compensating water quality treatment is that there must be no existing water quality treatment for the said existing pavement.
    - minus any applicable water quality credits

Water Quality Volume

The water quality volume (WQv) calculation is a function of area "A;" however, defining that area "A" is ~~tricky.~~ The ~~calculation~~ is found on page 2.2 of the SWM Manual. Below is a recommended sequence for computing WQv for a given project. Because projects involve more than one drainage area, this procedure specifies that the points of investigation should be selected first. The total impervious area required for water quality treatment is then determined in step 2. This is based on an accounting of new and redeveloped impervious areas for each point of investigation. The final step involves ~~checking~~ that the required impervious area, determined in step 2, will drain to the proposed BMP and then calculating the water quality volume.

It is important to emphasize that when calculating the WQv requirements (and Rev) for a project, the first thing to determine is how much impervious area must be managed for water quality, not how much volume.

1. Identify the points of investigation (POI) where stormwater discharges leave the project (property line).

2. Quantify the amount of impervious area for which WQv is required for each POI. This will be equal to:
   a) 100% of the new impervious area*
   b) plus 20% of the redeveloped area **
   c) plus 120% of any impervious area that is to be managed as compensating water quality treatment from another POI. ~~This~~ will be required when a portion of the new impervious area does not drain to the proposed BMP. Note that a surcharge for treating existing pavement in lieu of new pavement does not apply if the two areas being traded drain to the same POI or possibly even if flow from the said POIs drains to the same point within some reasonable distance beyond the project limits. Also note that implicit to the compensating water quality treatment is that there must be no existing water quality treatment for the existing pavement being traded.
   d) minus any ~~applicable~~ water quality credits per Chapter 5 of the SWM Manual

3. Locate and size the BMPs.
   a) The impervious area draining to the BMP(s) must be >= ~~than~~ the impervious area requiring treatment (i.e. the area from step 2). AND, the BMP must be designed to provide WQv for all the impervious area draining to it. For example, if 1 acre of impervious area is required to be treated, and 5 acres of impervious area drains to the BMP, then the BMP must be sized to treat the 5 acres. However, the BMP ~~can~~ be designed off-line so that it only receives the 1 acre, ~~but the same rule still applies – the BMP must be designed for everything that gets to it.~~
   b) Calculate the required WQv based on the drainage area to the BMP. Size the structure so that the actual physical volume provided ~~exceeds~~ the required WQv.

*New impervious area is determined by subtracting the ~~total proposed~~ impervious area by the existing impervious area.

**Redeveloped impervious area is that area where reconstruction, removal, or alteration, of or on, existing impervious area occurs.

~~when it has reached its design capacity~~ and the remaining acres will not enter the BMP and will bypass.

14. Stream projects should be exempt from:

    2:1 slope
    Top soil requirements
    Fill material requirements
    In stream E&S up to top of bank

15. Maintenance of Streamflow - Should be under NTW Division review –not under Plan Review Division. Right?

16. Though the required channel-protection volume is provided, will it be required to have 1-year peak management at the outfall?

17. For projects such as a new highway, it may be very difficult the capture all new pavement to a Cpv facility. In this case, is it acceptanle to provide Cpv based on the increased runoff depth rather than equivalent impervious area?

Attachment to Proposal

18. SHA's approach for Cpv waiver determination and accounting for cumulative affects of development in phases.

19. Sand filter capture volume – shouldn't the WQv = ponded volume (including storage in filter media)?

20. Water Quality Bank Form

21. MDE currently does not allow for additional storage for WQv beyond what can be supported by wet storage in a retention (extended detention) facility. The SHA should get credit for providing additional storage, which would be available for storage of the WQv, even if it is above the wet pool that can be supported based on drainage area and soil conditions. ?

22. Is TR-55 acceptable for computing grass credit? According to the manual it is. If MDE is not allowing TR-55 computations for grass channels, then the manual should be revised. ?

23. The increase in impervious area is considered as new development. For projects that have very small additional impervious area require new development and require Cpv, Qp and Qf when the added impervious area is more than 6 feet linearly but are still very small. These projects are for instance; geometric improvements, new bridge parapet, taper areas at the bridge replacements, culvert and bridge widening and/or approach work and new sidewalks to fill in gaps. For those, often it is very difficult to isolate the runoff from these areas from the existing areas of redevelopment or maintenance. Can these areas be considered as redevelopment with regard to Cpv, Qp and Qf; however, WQv should still be provided.

24. MDE move and old SWM reports

"Issue paper" – getting information out
– describe issue
– describe solution
} SHA would like to use this approa

MEMORANDUM AND SURVEY

****

TO: all plan reviewers Fred

FROM: Amanda Malcolm

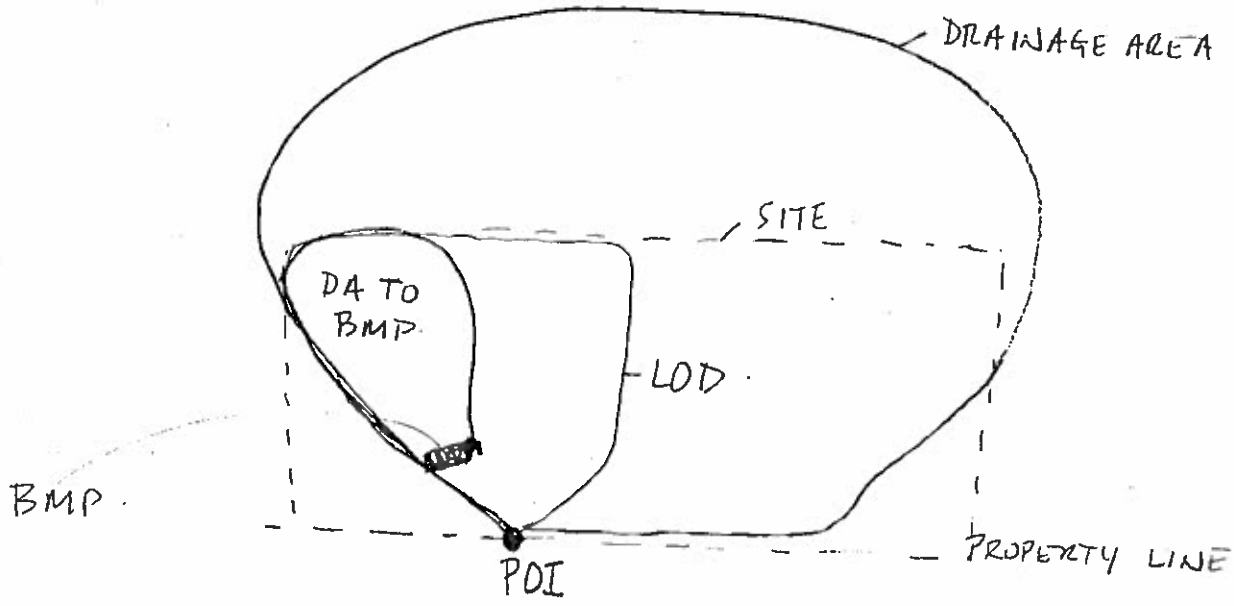
DATE: January 7, 2002

SUBJECT: defining "A" area

****

I'm working on a project which has me stumped. Of course, the issue has to do with the new regulations, specifically how the area "A" is defined in the calculation for water quality volume. My experience with this issue is that the feedback differs depending on from whom I solicit input. So I've decided it would be fun, and hopefully beneficial to us all, if I were to conduct a survey regarding my question. I recognize that more so than ever projects need to be considered on a case-by-case basis, but just the same it will be interesting to see whether there's any sort consensus among us. Besides, I for one, have no idea what "A" should be.

QUESTION: For the scenario below, should area "A" in the equation WQv=PRvA/12 be defined as the disturbed area, the site area or the drainage area to the POI?



Please e-mail me or drop off your responses at my desk sometime this week, and then I'll compile the results.

Water Quality Volume (March 2003)

3/11/03 DRAFT
plz give comments
to Amanda

WATER QUALITY VOLUME

$WQv=[(P)(R_v)(A)]/12$ in/ft
P=1.0 inch or 0.9 inch depending on rainfall zone
Rv=0.05+0.009(I) where I=percent impervious cover
A=area

The above equation for water quality volume (WQv) is presented on page 2.2 of the Stormwater Design Manual. WQv is a function of area (A), but the Manual is ambiguous with regard to defining area A. Correctly defining A is critical to quantifying the WQv. Yet, 18 months after the adoption of the new Stormwater Design Manual, discussions continue to ensue regarding the correct definition of A. In an attempt to achieve understanding and consistency among designers and reviewers alike, this document has been drafted to present the framework for correctly calculating a project's water quality requirements.

It is important to emphasize that when calculating the WQv requirements (and Rev) for a project, the first thing to determine is how much impervious area must be treated for water quality, not how much volume. The BMP must be located/sized so that the amount of impervious area draining to it equals or exceeds the amount of impervious area requiring treatment.

Below is the recommended sequence for computing A and the WQv for a given project. Because projects involve more than one drainage area, this procedure specifies that the points of investigation should be selected first. The total impervious area requiring water quality treatment is then determined in step 2. This is based on an accounting of newly developed and redeveloped impervious areas for each point of investigation. The third step is to ensure that the impervious area requiring treatment (determined in step 2) drains to the proposed BMP. And finally, the required water quality volume (WQv) is calculated.

1. Identify the point(s) of investigation (POI) where stormwater discharges leave the project (property line).
2. For each POI, quantify the amount of impervious area requiring WQv treatment. This will be equal to:
   a) 100% of the newly developed area. The newly developed area is determined by subtracting the pre-development impervious area from the post-development impervious area.
   b) plus 20% of the redeveloped area. The Redeveloped area is the existing impervious area that is being altered by reconstruction, demolition or removal.
   c) minus any impervious area attaining a water quality credits per Chapter 5 of the SWM Manual
   d) plus, if applicable, 120% of impervious area from a different project for which BMP is

Note: If a water quality credit area drains to a BMP, this area cannot be considered as also being treated by the BMP. I.e. "double dipping" is not permissible.

Note: MDE will allow "compensating water quality treatment", meaning existing impervious area may be treated in lieu of new impervious area if the existing pavement being traded is not already being treated for water quality.

Note: A 20% surcharge is applied when a BMP is designed to provide compensating water quality treatment for a different project.

3. Locate and size the BMPs.

   a) The total impervious area draining to the BMP(s) must be > or = to the impervious area requiring treatment. For example, if 1 acre of impervious area is required to be treated, and 3 acres of impervious area drains to the BMP, then the BMP must be sized to treat the 3 acres. However, the BMP may be designed off-line so that it only receives the runoff from 1 impervious acre, and runoff from the remaining 2 acres bypasses the BMP.

   b) The BMP must be designed to provide WQv for the entire area draining to it. Calculate the required WQv based on the total contributory drainage area to the BMP.

   c) Size the structure so that the actual physical volume provided exceeds the WQv requirements for the selected BMP.

A number of new variables have been defined to mathematically illustrate how WQv and Re_v are calculated as described above.

ART_{WQv} = **Area Requiring WQv Treatement**
ART_{NEW} = portion of **Area Requiring Treatement** attributed to the newly developed area
$ART_{REDEV'L}$ = portion of **Area Requiring Treatement** attributed to the redeveloped area
ART_{REv} = **Area Requiring Re_v Treatement**
$ART_{REv} = ART_{NEW}$

P=1.0 inch or 0.9 inch depending on rainfall zone
A= drainage area to the BMP in acres or ft^2
A_I=impervious area in drainage area in acres or ft^2. **A_I must be => ART_{WQv}**
I=percent impervious cover=$(A_I/A)x100$
R_v=0.05+0.009(I) is dimensionless

required WQv=water quality volume in ac-ft or ft^3=$[(P)(R_v)(A)]/12$ in/ft
provided WQv=storage volume in structure, applying a void ratio = 0.4 when applicable

$$ART_{WQv} = \left[\text{post-development impervious area} - \text{pre-development impervious area}\right] + \left[0.20 \times \text{existing impervious area being altered}\right] - \left[\text{Water Quality Credit Area}\right] + \left[1.2 \times ART_{WQv} \text{ as compensation for differ. project with WQv debit}\right]$$

$$ART_{NEW} = \text{post-development impervious area} - \text{pre-development impervious area}$$

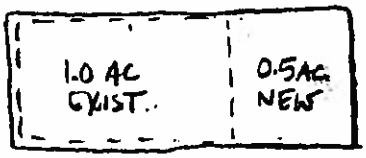
$$ART_{REDEV'L} = 0.20 \times \text{existing impervious area being altered}$$

$$ART_{WQv} = ART_{NEW} + ART_{REDEV'L} - \text{Water Quality Credit Area} + \left[1.2 \times ART_{WQv} \text{ as compensation for different project with WQv debit}\right]$$

ART_{WQv} = 100% new dev'l + 20% redev'l

ART_{Rev} = 100% new dev'l

EXAMPLE # 1 (p. 7 OF SWM GUIDELINES)



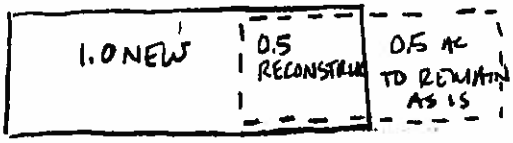
1.5 AC PROPOSED.

post-dev'l imp area = 1.5 AC
pre-dev'l = 1.0 Ac.
re-dev'l = 1.0 AC
> Δ = 0.5 AC new dev'l

ART_{WQv} = 0.5 + 0.2(1.0) = 0.7 AC ✓

ART_{Rev} = 0.5 AC

EXAMPLE # 2 (p. 7 OF SWM GUIDELINES)



post-dev'l = 2.0 AC
pre-dev'l = 1.0 AC
re-dev'l = 0.5 AC
> Δ = 1.0 AC new dev'l

ART_{WQv} = 1.0 AC + 0.2(0.5) = 1.1 AC ✓

ART_{Rev} = 1.0 AC.

EXAMPLE # 3

post-dev'l = 1.0 AC
pre-dev'l = 1.0 AC
re-dev'l = 1.0 AC
> Δ = 0

ART_{WQv} = 0 + 0.2(1.0 AC) = 0.2 AC ✓

What's ART_{Rev}? Is it 0 or is it 0.5 AC.? **0**

Because on p-2.5 of The Manual it states that the intent of the recharge criteria is to maintain existing groundwater recharge rates at development sites.

EXAMPLE #4

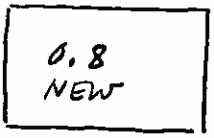
post dev'l = 1.0
pre-dev'l = 1.0
re-dev'l = 1.0
> $\Delta = 0$

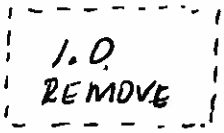
$ART_{WQv} = 0 + 0.2(1.0\,AC) = 0.2\,AC$

$ART_{Rev} = 0$

What's ART_{Rev}? Is it 1.0ac or 0? (zero)

EXAMPLE #5





post dev'l = 1.0ac
pre-dev'l = 0.8ac
re-dev'l = 1.0 ac
> $\Delta = -0.2ac$

$ART_{WQv} = -0.2ac + 20\%(1.0ac) = 0$

Water Quality Volume (WQv) and Impervious Area Requiring Treatment (IART) (January 2005)

Water Quality Volume (WQv) and Impervious Area Requiring Treatment (IART)

The following design aid has been developed by the Sediment and Stormwater Plan Review Division of MDE. It is directed at **State and Federal Projects** that are required to provide water quality volume (WQv) treatment. The purpose of this document is to establish a clear framework for calculating a project's WQv requirements.

The equation for calculating WQv is presented on page 2.2 of the Stormwater Design Manual. This equation is a function of area (*A*), but defining *A* is not as simple as saying *A* equals the site area or *A* equals the drainage area. Therefore, the Plan Review Division has developed an area parameter for quantifying a project's water quality requirements. This area is the impervious area requiring treatment (IART). The IART is based on an accounting of new and redeveloped impervious areas.

The recommended sequence for computing the IART and the WQv for a given project is outlined herein. It is important to emphasize that when calculating the WQv requirements for a project, the first thing to calculate is how much impervious area must be treated, not how much volume.

SEQUENCE FOR COMPUTING IART AND WQv

1. **Calculate IART**. Quantify the IART for the project as a whole or for each POI.

An Excel spreadsheet for calculating IART is available from MDE. Use of this spreadsheet is optional unless the project is utilizing the Water Quality Bank. The instructions for the worksheet are not explained here, however, for consistency, the letters assigned to the variables here are the same as those used in the worksheet.

The impervious area requiring treatment (IART) is equal to 100% of the net new development plus 20% of the redevelopment. The net new development is equivalent to the change in impervious area and equals the net increase or decrease in impervious area; it is determined by subtracting the pre-development impervious area from the post-development impervious area. Redevelopment is the existing impervious area that is being altered by reconstruction, demolition, and/or removal and is determined by adding the reconstructed impervious area and the impervious area removed. *(see Note 1) The equation for IART is derived below:

IART = 100%(net new development) + 20%(redevelopment)

IART = 100%(B−D) + 20%(C+D)	Since 100% (net new development) = (Δ impervious area) = (post − pre) = [(B+C)−(C+D)] = (B−D) and 20%(redevelopment) = 20%(C+D)
IART = 100%(B) + 20%(C) − 80%(D)	Simplify equation. Here IART is represented as 100% of the new development plus 20% of the reconstructed area minus 80% of the impervious area removed.
IART = 100%(B) + 20%(C) − 80%(D) + E	Add E to IART because treatment is required for existing impervious areas losing water quality benefits. This is the equation used in the spreadsheet.

where,

IART= impervious area requiring treatment
B= new development (new impervious area constructed over existing pervious area)
C= re-constructed impervious area
D= existing impervious area removed
E= existing impervious area that is losing water quality benefits

NOTE 1: Existing impervious area being removed (i.e. demolition) is considered redevelopment. The SWM Regulations require redevelopment projects to reduce their impervious area by 20%. Demolition removes 100% of the existing impervious area; therefore, after satisfying the redevelopment charge of 20%, the excess is only 80%. This 80% may be utilized as compensatory management. This means that one acre of removal is only equivalent to managing 0.80 acres of impervious area and that an acre of new development cannot be "managed" by removing an acre of existing impervious area. The point is MDE will not allow a 1:1 trade-off between impervious area being removed and impervious area requiring treatment. Recognizing that the reciprocal of 0.8 is 1.25, the equivalent impervious area removal for 1.0 acre of new development is 1.25 acres (a 1.25:1 trade-off). The equivalent impervious removal for 1.0 acre of redevelopment is 0.25 acres (a 0.25:1 trade-off). The reason that the trade-offs are not 1.20:1 and 0.20:1 respectively is that the impervious area being removed is subject to the redevelopment rule.

For example, if a one acre parking lot were demolished and replaced by a one acre parking garage in the same location then IART would equal 0.20 acres. Likewise, if a one acre parking lot were demolished on one side of a site and a one acre parking garage were constructed on the other side of the site, the IART would still be 0.20 acres. Comparatively, if the existing parking lot were replaced by a 0.8 acre parking garage, zero WQv management would be required.

NOTE 2: No distinction will be made between impervious area being removed for project purposes and impervious area being removed for compensatory SWM purposes. Both areas will be subject to the redevelopment rule. (This is not necessarily true for the August 2003 SHA Bank.)

NOTE 3: No distinction will be made between different types of impervious area, most notably pavement and roof-top.

2. **Implement an environmentally sensitive site design to reduce the IART.** Prior to designing a structural BMP, MDE encourages the designer to employ an environmentally sensitive site design that reduces the generation of stormwater from the site. Chapter 5 of the SWM Manual, entitled Stormwater Credits, presents a number of non-structural water quality practices that should be considered during conceptual site design. Note that if water quality credits are utilized, the impervious area treated by those features will be subtracted from the IART. However, if a water quality credit area also drains to a structural BMP, that area cannot be counted as treated by both the non-structural feature and the BMP (i.e. "double dipping" is not permissible). If the impervious area treated by non-structural features equals or exceeds IART, then a structural BMP is not necessary.

3. **Locate the BMP.** The BMP(s) must be located so that the actual impervious area (A_i) draining to the structure(s) equals or exceeds the IART less any adjustments for water quality credit [i.e. A_i must be $\geq$ IART from step 1 less any applicable water quality credit areas from step 2]. Note that MDE will allow "compensating water quality treatment" within the project, meaning existing impervious area may be treated in lieu of new impervious area if the existing pavement is not already being treated for water quality. Also, note that impervious areas within different points of investigation (POIs) can be traded equally so long as there is sufficient untreated impervious area to provide over-management in one POI as compensation for under-management in another POI.

4. **Calculate the required WQv.** The BMP must be designed to provide WQv for the entire area draining to it unless the drainage area is artificially reduced by a flow splitter or bypass. For example, if the IART equals 1 acre, but 3 acres of impervious area drains to the BMP, then the BMP must be sized to treat the 3 acres of impervious area. However, the design may incorporate a flow splitter or bypass that artificially reduces the drainage area to the BMP from 3 acres to 1 acre.

   Calculate the required WQv using the equation from page 2.2 of the Stormwater Design Manual. Clarifications to the equation have been made in **bold** text:

   Required WQv = water quality volume **in ac-ft or ft^3** $=[(P)(R_v)(A)]/(12\ in/ft)$

   where P = 1.0 inch or 0.9 inch depending on rainfall zone
   A_i = impervious area **draining to BMP (acres or ft^2).**
   A_i must be ≥ IART less any applicable water quality credit areas
   A = **contributory drainage** area **to BMP (acres or ft^2)**
   I = percent impervious cover = $(A_i/A)x100$
   $R_v = 0.05+0.009(I)$ **(dimensionless)**

5. **Size the BMP.** Size the structure so that the actual storage volume provided in the structure meets or exceeds the required WQv or fraction thereof in accordance with the specific BMP design criteria in the Stormwater Design Manual. Apply a void ratio of 0.4 where applicable.

NOTE ABOUT RECHARGE VOLUME.
Recharge volume treatment is not required for redeveloped area. Therefore, the area requiring Rev treatment is limited to the net new development (which equals the increase in impervious area or (B-D), as defined above). For projects involving only new development R_{ev} equals S x WQv.

Water Quality Inlets (Oil/Grit Separators) (1991)

WATER QUALITY

INLETS

(OIL/GRIT SEPARATORS)

JANUARY, 1991

MARYLAND DEPARTMENT OF THE ENVIRONMENT

BY: Vincent H. Berg, P.E.

Structural certification should be required for structures subject to traffic loadings, an H-20 loading is generally required. The four foot depth of water has been used because this depth reduces the possible resuspension of the accumulated grit on the bottom and is a safe depth to stand up in, if an accident occurs.

WHEN ARE OIL/GRIT SEPARATORS USED

The use of separators is not encouraged due to lack of information on effectiveness and their need to be maintained frequently. When they are used, their use is generally in existing urban redeveloping areas where other more effective water quality control methods are not feasible due to space limitations. All development both new and redeveloping areas should be required to address stormwater management quality controls. You can also utilize separators as a pre-filtering device when the site is tributary to another stormwater management (wet pond) facility. This is especially important when the proposed development has an intense land use such as a fast food restaurant, convenience store, gas station, etc. These types of land uses place a heavy water quality load on the downstream stormwater management facility. The owners of the downstream facility do not like having to clean up the visible and easily identifiable trash of commercial businesses. Many transportation agencies are reluctant to utilize these facilities in their right of ways, but where appropriate they should be used if other stormwater management techniques are not appropriate or feasible.

CONSTRUCTION

The construction of structurally sound (only concrete structures should be allowed), water tight separators are critical to the proper functioning of these facilities. The use of pre-cast concrete structures can reduce the cost of each separator, but a shop drawing should be required to be approved prior to manufacture to assure adequate dimensions and steel placement. A proper method of making the structure water tight must also be specified. We have required butyl rubber gasket material between the sections and that all joints and pipe openings be grouted inside and out with a non-shrink grout to make the precast structures water tight.

The design plan should also include an inspector's checklist which is used to remind the contractor and inspector of the required inspection steps.

MAINTENANCE

The maintenance of separators is an issue that needs attention. A stormwater management easement and maintenance covenant should be required for each facility. The maintenance covenant requires the owner of the separator(s) to periodically clean the structure. Certified copies of the cleaning bill can be used by the inspection agency to reduce its frequency of inspection. To date about 500 have been installed in Maryland and only a handful have been maintained. The regular inspection and cleaning of these facilities is not being done regularly. The lack of periodic cleaning has caused the accumulated material and oil to be discharged from the structure during very intense thunderstorms. Observations indicate that cleaning at the beginning of each change in season is a minimum schedule and for the more intense land uses such as gas stations cleaning may be needed every other month.

WATER QUALITY STRUCTURES

DESIGN AND GENERAL NOTES:

1. Use poured-in place concrete for the entire structure.

2. Refer to Maryland State Highway Administration for materials and methods of construction.

3. Wall thickness shall be as follows:

   Minimum 8 inches thick for the first 8'-0" of depth, 12 inch thick walls between 8'-0" and 12'-0' of depth and 16 inch thick walls for depth greater than 12'-0". Depth to be measured from top of top slab to crown of outgoing pipe.

4. f'c = 3,500 psi at 28 days.

5. All reinforcing steel to be ASTM A615, GR.60.

6. For details concerning throat openings, refer to MCDOT Standard No. 55.

Throat Length	Number of Pipe Supports
5'	0
10'	1
15'	2
20'	3

   Pipe supports to be spaced at 5'-0" O.C.

7. For details not noted in this standard, refer to MCDOT Standard No. 55.

8. The top 4 inches of walls may be brick masonry for leveling, if required. Brick masonry shall comply with the latest SHA Specification.

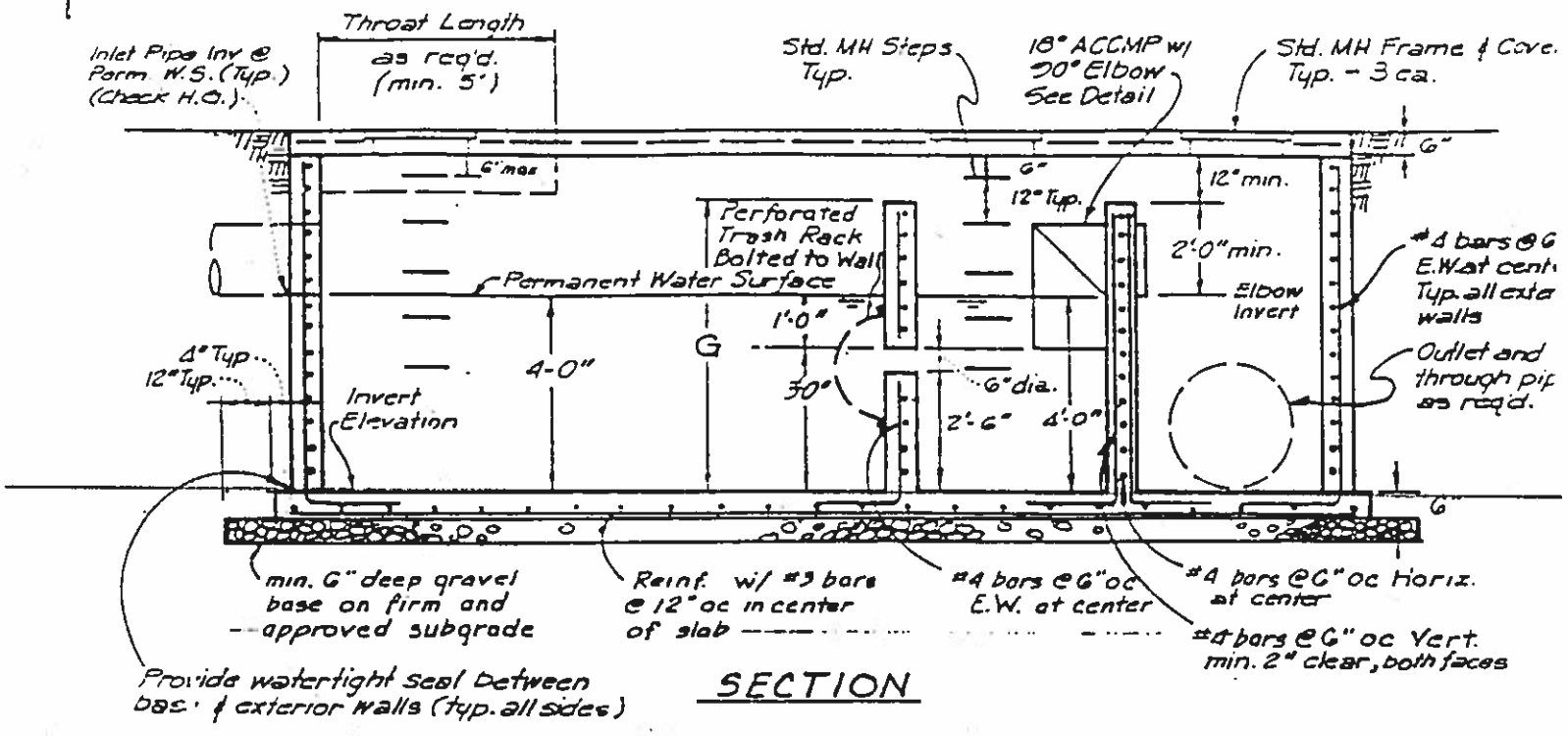
9. When drainage grate opening is used, refer to the appropriate SHA Standard for details. Details shall be shown on the plans.

10. When inside width of structure is greater than 4'-0", reinforcing shall be revised as needed.

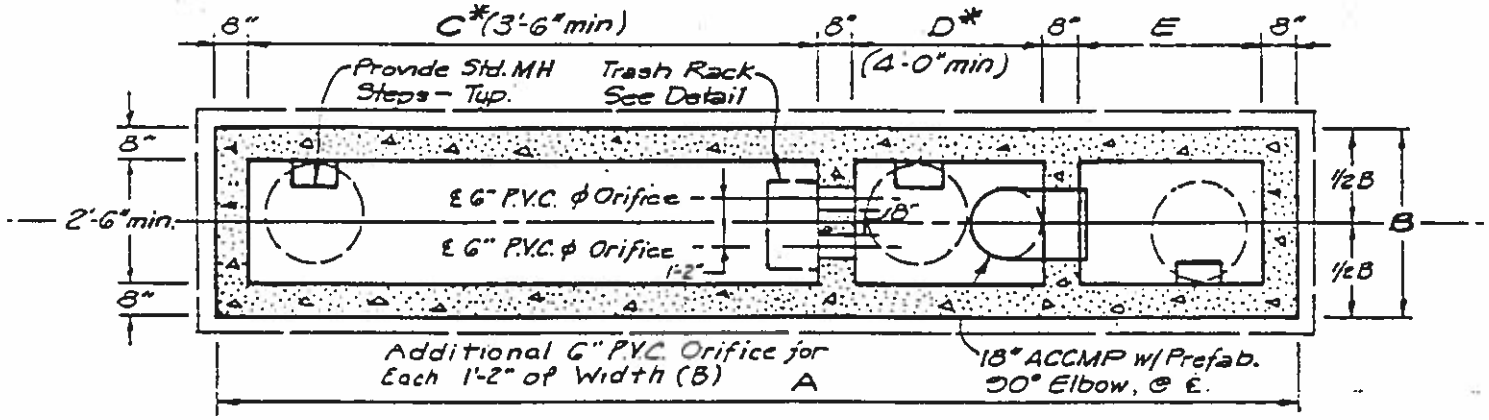
11. When structure is subject to traffic loading, reinforcing shall be designed for the appropriate traffic loads. Design loads shall be indicated on the plan.

12. All inlets and incoming pipes shall be checked for possible backwater or tailwater problems.

RECYCLED PAPER

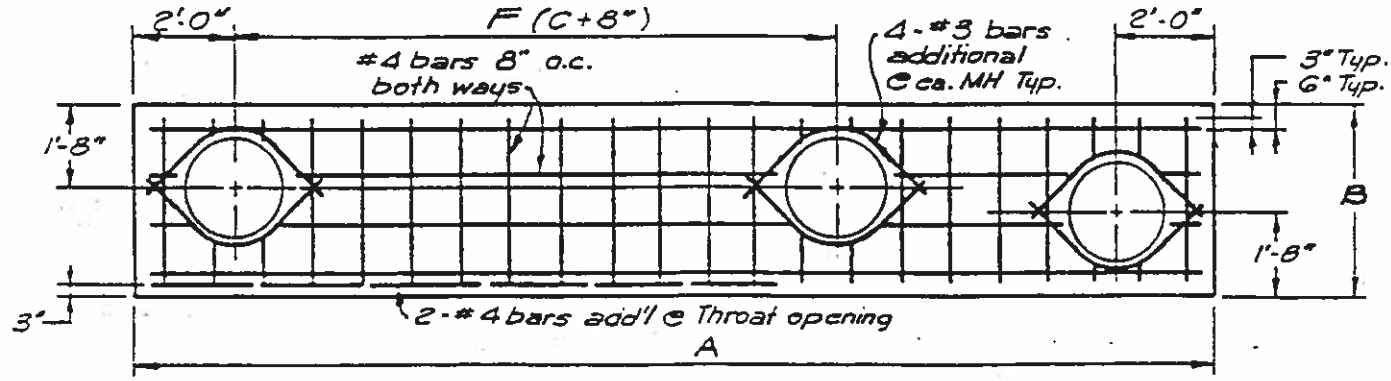


SECTION



PLAN VIEW

* When combined length of oil and grit chambers exceeds 12 ft., C = 2/3 total and D = 1/3 total.

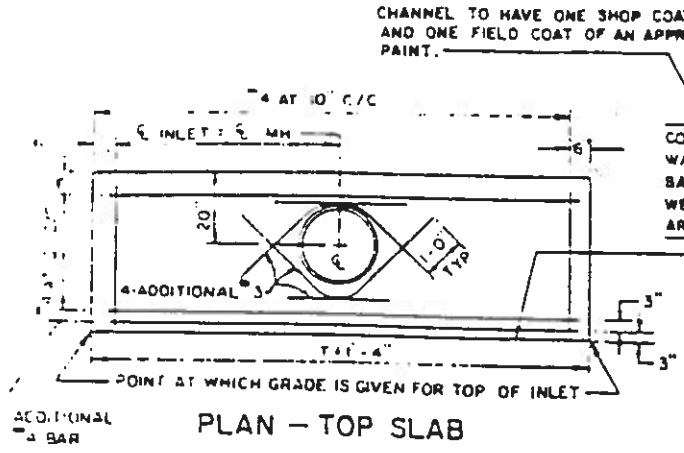


PLAN VIEW of TOP SLAB

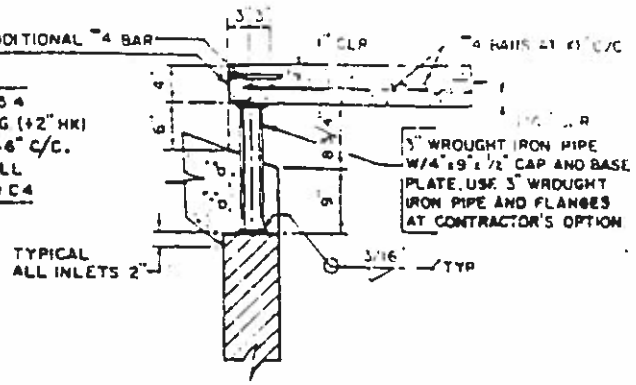
WATER QUALITY CONTROL STRUCTURE

SCALE: 1/4" = 1'-0"

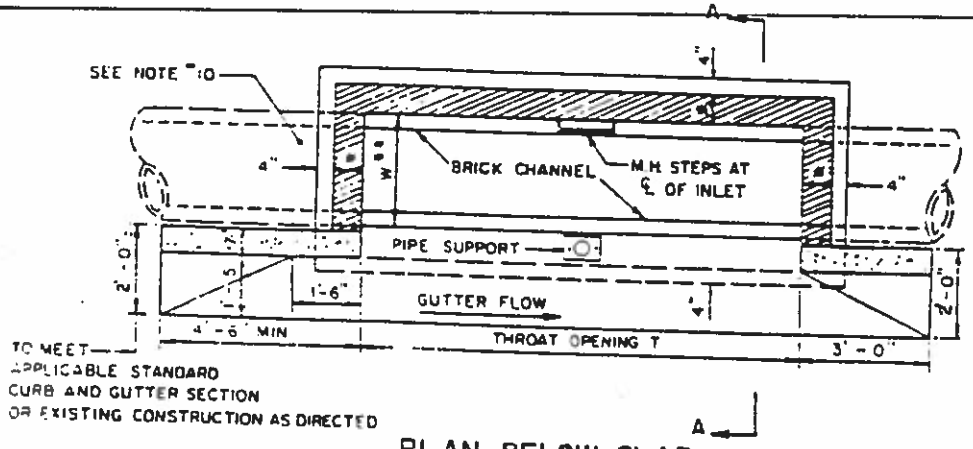
Revised 7-



PLAN – TOP SLAB



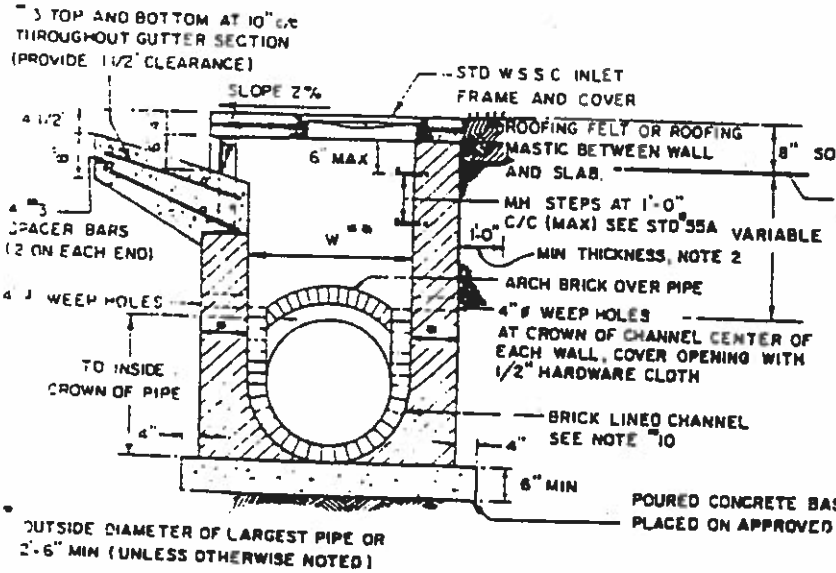
SECTION THROUGH PIPE SUPPORT



PLAN BELOW SLAB

GENERAL NOTES

1. USE SOLID MASONRY (BRICK OR CONCRETE BLOCK) OR POURED CONCRETE FOR WALLS
2. INSTALL FOUNDATION DRAINAGE MATERIAL AROUND STRUCTURE FROM BOTTOM OF WEEP HOLES TO WITHIN 8" OF SURFACE
3. MORTAR SHALL CONFORM TO ASTM SPECIFICATION C270 TYPES M OR S.
4. REFER TO MARYLAND STATE HIGHWAY ADMINISTRATION FOR MATERIALS AND METHODS OF CONSTRUCTION
5. WALL THICKNESS WILL BE THE FOLLOWING: 8" THICK WALLS FOR THE FIRST 8'-0" OF DEPTH, 12" THICK WALLS BETWEEN 8'-0" AND 12'-0" OF DEPTH, 16" THICK WALLS FOR DEPTH GREATER THAN 12'-0" DEPTH TO BE MEASURED FROM TOP OF CURB TO CROWN OF OUTGOING PIPE
6. f'_c = 3500 PSI AT 28 DAYS
7. ALL REINFORCING STEEL TO BE ASTM A615, GR 60
8. FOR PIPES 30" AND LARGER, PROVIDE STEPS IN CHANNELS OF STRUCTURES SEE STANDARD #55B
9. ON TERMINAL INLETS, THE INLET BOTTOM SHALL BE SLOPED TO OUTLET PIPE WITH SEWER BRICK OR CONCRETE, 9" MIN. FALL
10. FOR ACTUAL PIPE LOCATIONS, REFER TO STORM DRAIN PLANS AND CONSTRUCT BRICK CHANNEL TO PIPE CONFIGURATIONS BRICK CHANNEL SHALL BE SEWER BRICK ON EDGE AND BUILT TO THE CROWN OF THE PIPES.



SECTION A-A

DESIGNATION	T THROAT OPENING	NUMBER OF PIPE SUPPORTS
A-5	5'-0"	0
A-10	10'-0"	1
A-15	15'-0"	2
A-20	20'-0"	3

PIPE SUPPORTS TO BE SPACED 5'-0" O C

REVISED
1/12/82

MONTGOMERY COUNTY
DEPARTMENT OF TRANSPORTATION

APPROVED: 3/11/81

CHIEF, DIV. OF TRANS. ENG.

DIRECTOR

STANDARD "A" INLET

STANDARD No. 55

CHECK-OFF LIST TO BE PLACED ON
STORMWATER MANAGEMENT
WATER QUALITY PLANS

Sequence of Construction and Inspector's Check-Off List for Water Quality Structures				
Stage	Developer's/Engineer Approval		Inspector's Approval	
1. Preconstruction Meeting.*	Initials	Date	Initials	Date
2. Installation of separator and associated storm drainage:* a. Footing subgrade prior pouring.*				
b. Footing formed and steel set prior to pouring.*				
c. Structure sides formed and steel set prior to pouring.*				
d. Prior to top slab and manholes being set, Inspector must inspect all cast-in-place and pre-cast structures for proper assembly.*				
3. Site is permanently stabilized, sediment control measures removed and all sediment and debris removed from the structure				
4. Final inspection.*				

NOTE: See Construction Specification for detailed requirements.
* Mandatory notification/approval of Inspector prior to proceeding with next stage.
Call prior to 12:00 noon on the preceding day to arrange for notification/inspection.

RECYCLED PAPER

DEPARTMENT OF THE ENVIRONMENT
SEDIMENT & STORMWATER ADMINISTRATION
2500 BROENING HIGHWAY
BALTIMORE, MARYLAND 21224
PHONE: (301) 631-3563

_____
_____
Engineer/Phone No.

_____
Assigned To

SEPARATOR REVIEW CHECKLIST

Type: _____

Submittal Dates	Review Dates and Initials
_____	_____
_____	_____
_____	_____

Design Acceptable Date

_____

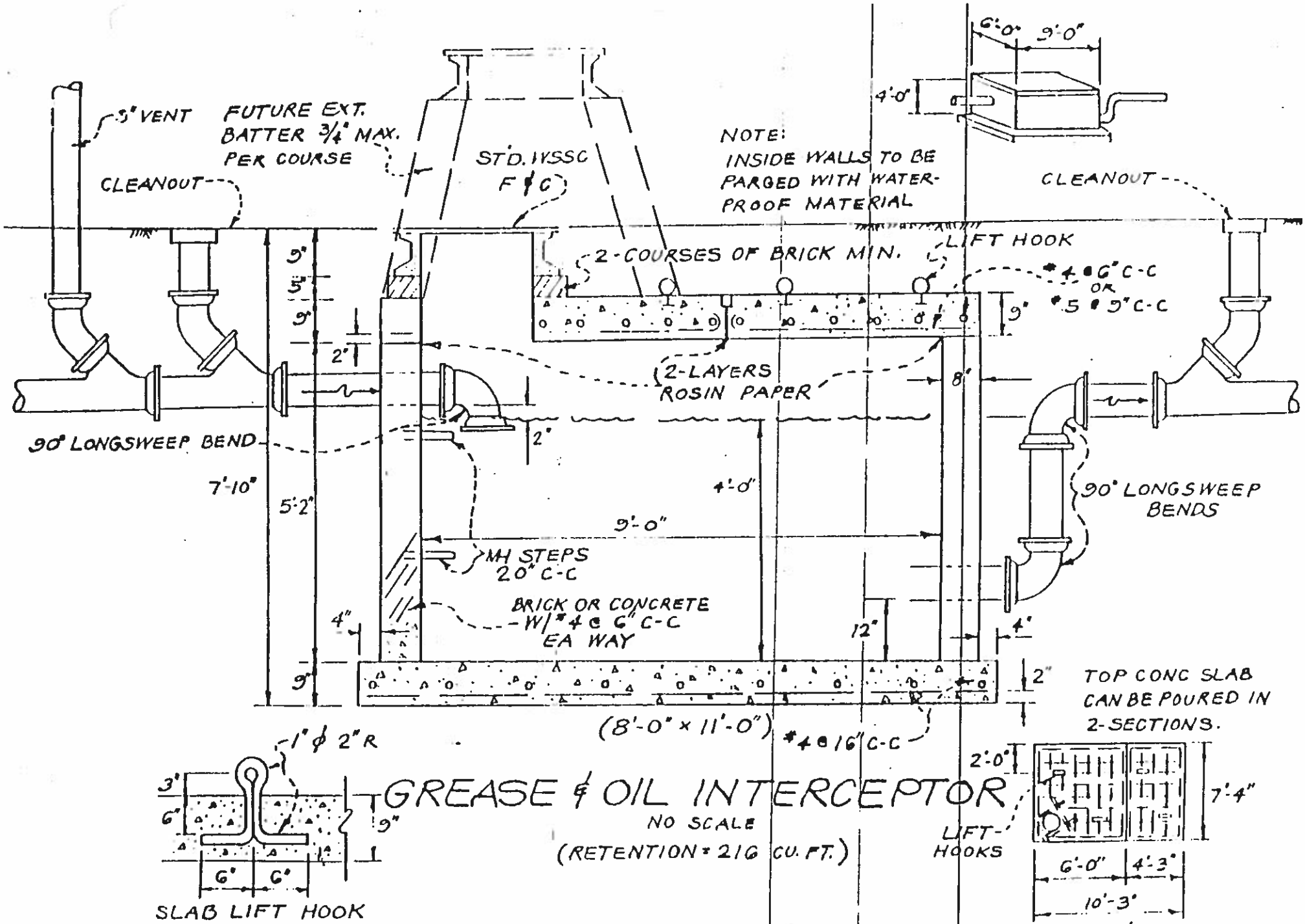
Legend:
✓ - Complete
INC-Incomplete/Incorrect
NA -Not Applicable

Your submission for plan approval has been reviewed. The review was made per the following minimum acceptable criteria checklist.

Review

1st	2nd	3rd	SEPARATOR ITEMS ONLY
_____	_____	_____	Location and drainage area(s)
_____	_____	_____	Entire structure reinforced concrete
_____	_____	_____	Plan view, cross-sections each direction, profile
_____	_____	_____	Bottom of elbow and top of slots 1 foot below 4 foot maximum depth, standing pool
_____	_____	_____	Dimensions and elevations
_____	_____	_____	Comps for storage required (40 c.f. per 0.1 Ac D.A. at weir elevation)
_____	_____	_____	Comps for passage of 10-year storm (1 foot minimum weir height)
_____	_____	_____	No flooding or hydraulic problems
_____	_____	_____	Disposal notes on plan
_____	_____	_____	Access to each chamber
_____	_____	_____	Ease of maintenance
_____	_____	_____	Maintenance Easement and Covenant
_____	_____	_____	Maintenance and Structural Certification on Plan
_____	_____	_____	Loadings for structural design, specified on plan (H-20 for paved areas)
_____	_____	_____	Inspector checkoff list/Sequence of construction

RECYCLED PAPER



GREASE & OIL INTERCEPTOR

NO SCALE

(RETENTION = 216 CU. FT.)

APPROVED BY: MICHAEL P. BOSWELL
SECTION HEAD, PLUMBING REGULATIONS
INSPECTION SECTION

DESIGN: HARRISON/NORRINGTON

Standards & Specifications for Infiltration Practices (1984)

Engineering Technologies
Associates, Inc.
Engineers • Planners • Surveyors

Michael L. Clar, P.E.

(301) 461-9929 Balt.
(301) 621-4690 Wash.

Standards and Specifications for INFILTRATION Practices

MARYLAND
DEPARTMENT OF NATURAL RESOURCES
WATER RESOURCES ADMINISTRATION
STORMWATER MANAGEMENT DIVISION

MARYLAND STANDARDS AND SPECIFICATIONS

FOR

STORMWATER MANAGEMENT

INFILTRATION PRACTICES

Stormwater Management Division
Water Resources Administration
Maryland Department of Natural Resources
Tawes State Office Building
Annapolis, MD 21401

February, 1984

Table of Contents

	Page
Table of Contents	ii
List of Figures	iii
List of Tables	vi
Notation	vii
Chapter	
1. Introduction	1-0
1.1 Background	1-1
1.2 Purpose and Scope	1-4
1.3 Organization and Use of Handbook	1-5
2. Planning Considerations	2-0
2.1 Introduction	2-1
2.2 Subsurface Conditions	2-2
2.3 Water Quality	2-17
2.4 Feasibility Tests	2-18
2.5 Construction and Maintenance	2-24
2.6 References	2-25
3. Standards and Specifications	3-0
3.1 Introduction	3-1
3.2 Infiltration Basin	3-2
3.3 Infiltration Trench	3-10
3.4 Dry Well	3-17
3.5 Porous Asphalt Pavement	3-24
3.6 Vegetated Swales with Check Dams	3-38
3.7 Vegetative Filter Strip	3-48
4. Hydrologic Design Methods	4-0
4.1 Introduction	4-1
4.2 Design of Infiltration Basin	4-6
4.3 Design of Infiltration Trenches	4-17
4.4 Design of Dry Wells	4-33
4.5 Design of Porous Asphalt Pavement	4-43
4.6 Design of Vegetated Swales	4-52
5. Case Studies	5-0

List of Figures

Number		Page
2-1	Typical Exploration Program for Infiltration Basin Design	2-4
2-2	Typical Exploration Program for Infiltration Trench Design	2-5
2-3	Schematic Cross Section Showing the General Pattern of Groundwater Flow Toward a Stream	2-6
2-4	Sketch Showing the Principle of Artesian Water Flow	2-8
2-5	Physiographic Provinces and Their Divisions in Maryland	2-9
2-6	Cross Section Showing Typical Soil Pattern in the Chester-Glenelg Association	2-10
2-7	Abandoned Gravel Pits are Commonly Used as Infiltration Basins	2-13
2-8	Recharge Pit Excavated Through Fine-Grained Material to Penetrate the Upper Part of an Aquifer	2-13
2-9	Where Land is Not Readily Available for Recharge Facilities, a Combination of Recharge Shafts and Pits Permits Achievement of Maximum Rates	2-14
2-10	Representative Pattern of Soils and Parent Material in the Muirkirk-Evesboro Soil Association in Anne Arundel County	2-14
2-11	Cross Section Showing Typical Pattern in the Sassafras-Woodston-Fallsington Association in Baltimore County	2-15
2-12	Cross Section of the Beltsville-Gravelly Land-Bourne Association Showing Topography, Important Soils, and Underlying Materials	2-16
2-13	USDA Textural Triangle	2-20
3-1	Two-Level Infiltration Basin	3-4
3-2	Retention Basin and Adjoining Infiltration Basin	3-4
3-3	Water-Containing Infiltration Basin Illustrating Stormwater Disposal Through the Sides of the Basin Above the Level of Accumulated Material of Low Hydraulic Conductivity	3-5

List of Figures (Continued)

Number		Page
3-4	Typical Section of Infiltration Trenches	3-11
3-5	Observation Well Detail	3-14
3-6	Typical Dry Well Cross Section	3-18
3-7	Examples of Storm Drain Catch Basins Used As Dry Wells	3-19
3-8	Porous Asphalt Paving Typical Section	3-25
3-9	Porous Asphalt Paving Drainage System	3-32
3-10	Typical Lot Grading Plan	3-39
3-11	Typical Road Cross Section Using Vegetated Swales	3-40
3-12	Properties of Typical Channel Cross Sections	3-44
3-13	Effective Buffer Length Determination for Trap Efficiencies (T_R) of 75, 95, and 99 percent	3-51
4-1	Peak Discharge (q_{ub}) in csm per inch of Runoff versus Time of Concentration (T_c) for 24-Hour Type II Storm Distribution	4-2
4-2	Schematic of Infiltration Basin	4-7
4-3 thru 4-8	Determination of Infiltration Basin Length	4-11 thru 4-16
4-9	Schematic of Infiltration Trench	4-18
4-10	Inlet to Infiltration Trench with Sediment Trap	4-19
4-11 thru 4-20	Determination of Infiltration Trench Surface Area	4-23 thru 4-32
4-21	Schematic of Dry Well	4-34
4-22 thru 4-26	Determination of Dry Well Surface Area	4-38 thru 4-42
4-27	Schematic of Porous Pavement Section	4-44

List of Figures (Continued)

Number		Page
4-28 thru 4-31	Determination of Porous Paving Reservoir Depth	4-48 thru 4-51
4-32	Schematic of a Vegetated Swale with Check Dam	4-53

List of Tables

Number		Page
2-1	Hydrologic Soil Properties Classified by Soil Texture	2-19
2-2	Maximum Allowable Depth of Storage or Two Criteria, Selected Maximum Ponding Times and Minimum Infiltration Rates	2-22
3-1	Design Scheme for Porous Paving	3-28
3-2	Minimum Thickness of Porous Paving for Various Loading Conditions	3-29
3-3	Open Graded Asphalt Concrete Formulation	3-35
3-4	Permissible Velocities for Vegetated Channels	3-43
3-5	Permanent Seeding and Seeding Dates	3-54
3-6	Maintenance Fertilization for Permanent Seedings	3-57

NOTATION

This list of notations is provided only as a guide to some of the notations used in this report. The exact definition and units are listed when the symbol is used. Since the same symbol can be used for different design methods, the exact definition should be obtained directly from the appropriate section of the report.

A = drainage area (mi^2)

A_b = top surface area of basin (ft^2)

A_B = bottom surface area of basin (ft^2)

A_c = area contributing runoff to infiltration structure (ft^2)

A_p = surface area of porous asphalt pavement (ft^2)

A_s = surface area of swale (ft^2)

A_t = surface area of trench (ft^2)

A_u = upland area contributing runoff to infiltration structure (ft^2)

A_w = surface area of dry well (ft^2)

ΔA = change in drainage area, usually a noncontributing area (mi^2)

CN = SCS runoff curve number

ΔCN = change in curve number

CN_c = curve number of area contributing runoff

C_w = effective water capacity of soil overlying dry well (in/in)

d_b = basin depth (ft)

d_{max} = maximum depth of infiltration structure (ft)

d_o = depth of soil overlying dry well (ft)

d_p = depth of porous asphalt paving stone subbase (ft)

d_s = depth of swale check dam (ft)

d_t = trench depth (ft)

d_w = dry well storage depth (ft)

f = minimum infiltration rate of soil (in/hr)

I_a = initial abstraction (inches)

L = top length of basin (ft)

L_B = bottom length of basin (ft)

L_t = length of trench (ft)

L_T = total length of swale (ft)

N_s = number of check dams along total length of swale

P = rainfall depth (inches)

Q = runoff depth from overlying area of dry well (ft)

Q_a = after development depth of runoff (inches)

Q_b = before development depth of runoff (inches)

Q_c = depth of runoff from contributing area (ft)

Q_s = depth of runoff controlled by vegetated swale (inches)

ΔQ_u = increase in upland runoff depth (ft)

ΔQ = change in runoff depth (inches)

q_a = after development peak discharge (cfs)

q_b = before development peak discharge (cfs)

q_p = peak discharge (cfs)

q_{ua} = after development unit peak discharge (cfs/mi^2/inch of runoff)

q_{ub} = before development unit peak discharge (cfs/mi^2/inch of runoff)

Δq = change in peak discharge (cfs)

R = ratio of the area of the contributing portion to the area of the porous pavement

S_s = bottom slope of swale (ft/ft)

T = time during which the infiltration structure fills with water (hrs.)

T_p = surface ponding time (hrs.)

T_s = subsurface storage time (hrs.)

t_c = time of concentration (hrs.)

V_r = void ratio

V_w = volume of water stored in infiltration structure (ft^3)

W = top width of basin (ft)

W_b = bottom width of swale storage (ft)

W_B = bottom width of basin (ft)

W_t = width of trench (ft)

Z = basin side slope ratio (h:v)

Z_1 and Z_2 = side slope ratio of swale cross section (h:v)

CHAPTER 1

INTRODUCTION

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

The process of urbanization has been observed to generate a number of detrimental changes to the hydrologic equilibrium of the land surface and the receiving fluvial estuarine environments. These changes include the following:

1. Increases in peak flow and total volume of stormwater runoff;
2. Accelerated stream channel erosion;
3. Decreases in low flow volumes in receiving streams;
4. Decreases in water quality and stream environment.

In the State of Maryland efforts to control these conditions have resulted in the development of statewide programs of erosion and sediment control, stormwater management (SWM) and floodplain management. Stormwater management efforts to date, however, have focused mainly on the control of the increased peak flows. Considerably less attention has been directed towards the control of the total annual volume of stormwater runoff, the corresponding problem of decreased low flow volumes in the receiving streams and water quality impacts.

As a result of this focus on peak flow conditions, the typical approach to stormwater control has favored the use of a stormwater detention basin. Other stormwater control measures such as infiltration have not gained wide acceptance because they typically are not perceived as being very effective in controlling the peak flow discharges.

There is an increasing statewide recognition that a sound and effective stormwater management plan should be a diversified and multiple purpose plan. This plan should address the full range of hydrologic consequences resulting from urban development instead of simply focusing on control of peak flow, without consideration of flow volume reduction, low flow augmentation, water quality control, and ecological protection.

The need to apply infiltration practices in conjunction with various flow attenuation practices and detention practices is clearly implied in the Stormwater Management Act (Natural Resources Article 8-11A). It states that "the primary goal of the state and local programs will be to maintain after development, as nearly as possible, the predevelopment runoff characteristics." It is the intent of this statement that a stormwater management plan take into account not only flow rate and volume, but water quality as well.

The incorporation of SWM infiltration practices into SWM plans has been considerably hindered by the absence of detailed standards and specifications that can guide the planner and designer in their application. In the absence of this type of guidance, the frequent questions related to the practicality, conditions and limitations of usage, and advantages and disadvantages of these practices have remained unanswered.

This document presents planning and design procedures, inspection, and maintenance responsibilities for the utilization of infiltration practices. It will require periodic modification as our experiences in the utilization of infiltration practices increase. The following sheet should be completed and returned to the Administration so that future modifications to the document may be sent directly to you.

Tape Here

Fold

Place
Stamp
Here

Water Resources Administration
Stormwater Management Division
Tawes State Office Building
Annapolis, Maryland 21401

Name _____

Title _____

Affiliation _____

Address _____

_____

_____

Zip Code _____

1.2 PURPOSE AND SCOPE

This handbook presents standards and specifications for the following SWM infiltration practices:

1. Infiltration basin
2. Infiltration trench
3. Dry well
4. Porous asphalt pavement
5. Vegetated swales with check dams
6. Vegetative filter

The purpose of these standards and specifications is to establish minimum criteria for the design, review, approval, installation and maintenance of SWM infiltration practices on land undergoing development. These standards and specifications were developed to assist the planner, engineer, developer and regulator in determining when and how to use these practices, their practicality, conditions and limitations of usage, and advantages and disadvantages of these practices.

It is intended that these standards and specifications will be used in the evaluation, selection and design of SWM infiltration practices for the State of Maryland. Innovative methods are encouraged, however, the approving agency shall forward copies of any innovative ideas to the Stormwater Management Division of the Maryland Water Resources Administration for the purpose of evaluation, approval and dissemination.

These standards and specifications were written to be generally applicable to all development and construction sites in Maryland. However, there may be many specific projects or sites not appropriately covered by these standards. It is intended that modifications to these standards and specifications may be made by the approving county agency with Water Resources Administration concurrence in order to improve or update them. The approving agency may also determine the applicablility of a given practice in a specific situation.

1.3 ORGANIZATION AND USE OF HANDBOOK

This handbook has been structured into five chapters. The standards and specifications for the six SWM infiltration practices listed above make up the contents of Chapter 3. The standards and specifications for each of the six practices presents the following information.

1. Description
2. Applicability
3. Planning Considerations
4. Design Criteria
5. Water Quality
6. Construction Specifications
7. Maintenance

Chapter 2 provides an overview of the major planning considerations associated with the use of the infiltration practices. These considerations include legal aspects, site evaluation procedures and construction and maintenance issues.

Chapter 4 presents hydrologic design methods which are based on the Soil Conservation Service's hydrologic models (TR-55 and TR-20) and principles. These methods were developed to provide suitable methods of quantifying the effects of infiltration control methods on surface runoff.

Chapter 5 presents a series of 6 case studies. The case studies illustrate the application of the design methods to the various infiltration practices for residential and commercial land uses.

CHAPTER 2

PLANNING CONSIDERATIONS

CHAPTER 2

PLANNING CONSIDERATIONS

2.1 INTRODUCTION

The planning, design, and construction of SWM infiltration systems must take a number of factors into consideration. These include regulatory requirements, subsurface conditions, water quality protection requirements, and construction and maintenance requirements.

This chapter provides general guidance on the use of these factors in evaluating the extent to which SWM infiltration practices can be used on a given site. It also describes a number of feasibility tests which shall be used in determining whether, and to what extent, SWM infiltration practices can be applied on a particular site.

2.2 SUBSURFACE CONDITIONS

Collection and analysis of soils, geologic, and hydrologic information are a critical component of the SWM planning and design process. The subsurface investigation must be conducted under the supervision of an engineer or scientist of appropriate qualifications. The investigation shall involve both a review of available literature from the U.S. Soil Conservation Service, Maryland Geological Services, and others; and a field investigation as part of the overall geotechnical site investigation.

The specific details of appropriate subsurface exploration techniques can be found in the following literature:

1. Soil Conservation Service, National Engineering Handbook, Section 8 - Engineering Geology
2. Soil Conservation Service, National Engineering Handbook, Section 18 - Ground Water
3. Soil Conservation Service, Technical Release 36 - Ground Water Recharge
4. Pettyjohn, 1981 - Introduction to Artificial Ground Water Recharge
5. Bianchi and Muckel, 1970 - Ground Water Recharge Hydrology
6. Schmidt and Clements, 1977 - Reuse of Municipal Wastewater for Ground Water Recharge
7. Cedergren, 1976 - Seepage, Drainage and Flow Nets
8. Davis and DeWiest, 1966 - Hydrogeology
9. Ferris, et al; 1962 - Theory of Aquifer Tests
10. Bental, 1963 - Methods of Collecting and Interpreting Ground Water Data
11. Todd, 1959 - Ground Water Hydrology
12. Wenzel, 1942 - Methods of Determining Permeability of Water Bearing Materials.

2.2.1. General Subsurface Exploration Guidelines

To effectively design a SWM infiltration practice, the following information shall be required:

(a) Textural character of the soil horizons and/or strata units within the subsoil profile

(b) Location of seasonal high groundwater table

(c) Depth to bedrock.

The first step in determining the site capabilities should be to consult the appropriate Soil Survey available for all counties in Maryland. The Soil Surveys may be obtained from the Soil Conservation Service or the local Soil Conservation District. The age of the Soil Survey for Baltimore City requires on-site investigation.

For larger land developments, soil information has traditionally been collected during the geotechnical site investigation in order to determine foundation conditions for structures and design earth structures such as fills and cuts. The standard method of conducting subsurface investigations is to drill holes and collect a 1 3/8 inch diameter soil sample, 1.5 feet long at 3 to 5 foot intervals in the boring using a split-spoon sampler. Solid augers are also used to collect large samples for compaction testing but do not provide an accurate picture of the soil profile.

Where feasible, the excavation of 8 to 10 foot deep test pits or trenches is the preferred method for mapping the stratigraphic profile and collecting samples of the various strata for gradation testing in the laboratory. For deeper depths and where considerable stratification is anticipated, boring with continuous split-spoon sampling is also a satisfactory exploration and sampling practice. The recommended minimum subsurface exploration depth is 5 feet below the anticipated design depth of the structure or to the static groundwater table, whichever occurs first.

An example of a typical subsurface exploration program for basin design and for trench design is shown in Figures 2-1 and 2-2, respectively. The finished grade for the basin example in Figure 2-1 and for the trench example in Figure 2-2 are less than four feet above the static water table in a sand and gravel unit.

The location of the seasonal high groundwater table can be determined by field observation of static water elevation in borings, changes in soil moisture content, and changes in soil color. It should be noted that the groundwater table elevation fluctuates not only on a seasonal basis but also on an annual basis in response to prolonged periods of wet and dry precipitation cycles. Thus, the field work should be supplemented with consultation of the counties' health and public works agencies to benefit from their long-term experience with local groundwater conditions.

Groundwater occurs under two types of conditions, water table and artesian. Water table conditions exist where the water-bearing materials that make up the groundwater reservoir are not overlain by impervious strata and water from precipitation may directly enter the reservoir by downward percolation. The upper surface of the saturated zone, which is under atmospheric pressure is called the water table or groundwater table. Its position is marked by the static water level and wells or borings. Figure 2-3 presents a schematic cross-section which shows the general pattern of flow under water table conditions. In nearly all cases, these conditions rather than artesian conditions, will influence the design of SWM infiltration practices.

Artesian conditions are formed where the water that moves along the water-bearing bed passes beneath relatively impervious stratum and is confined under pressure other than atmospheric. If an artesian reservoir is penetrated by a well, the water level in the artesian well will rise above the elevation of the confining stratum. The water is artesian whether or not it rises to or above

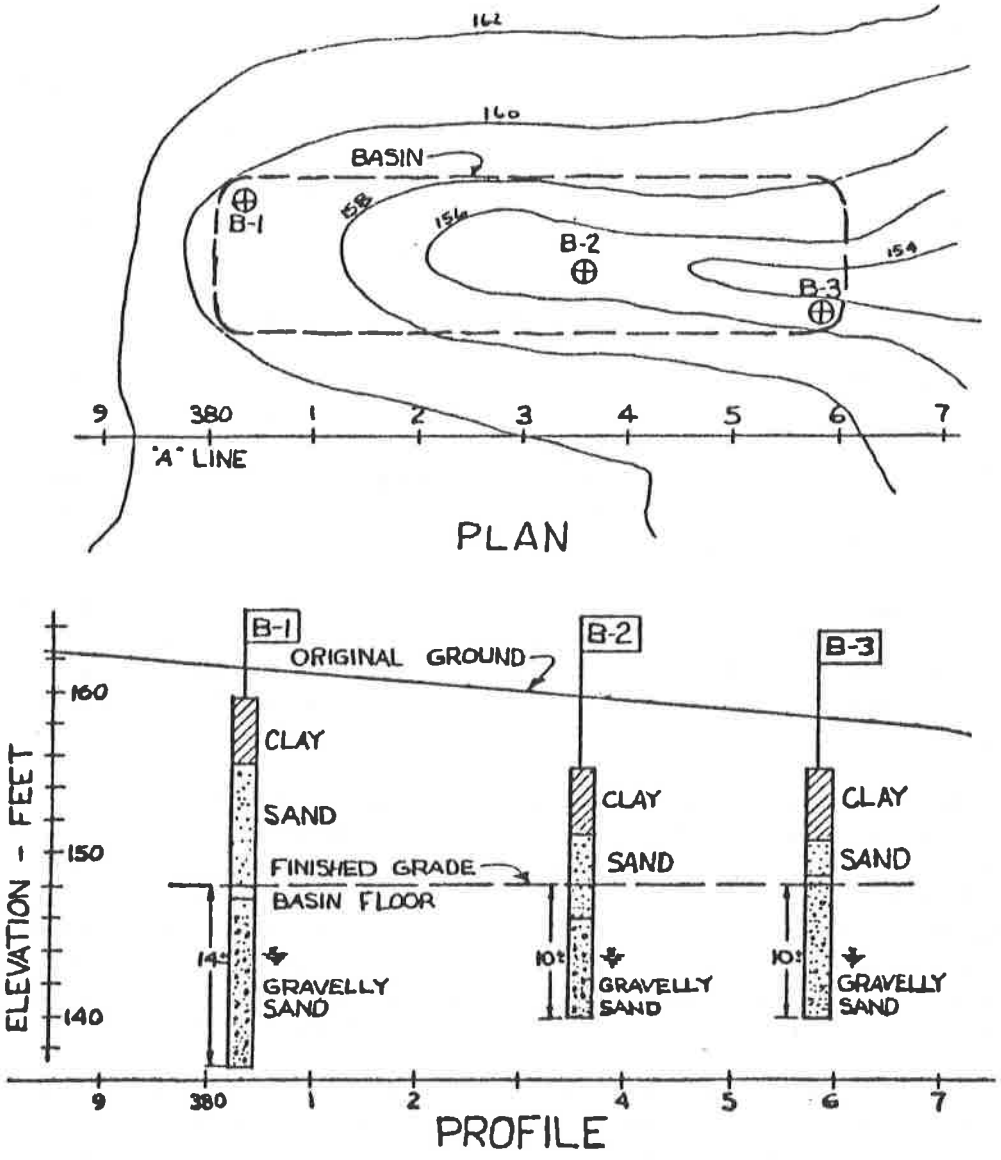


Figure 2-1. Typical Exploration Program for Infiltration Basin Design

Source: Hannon, 1980

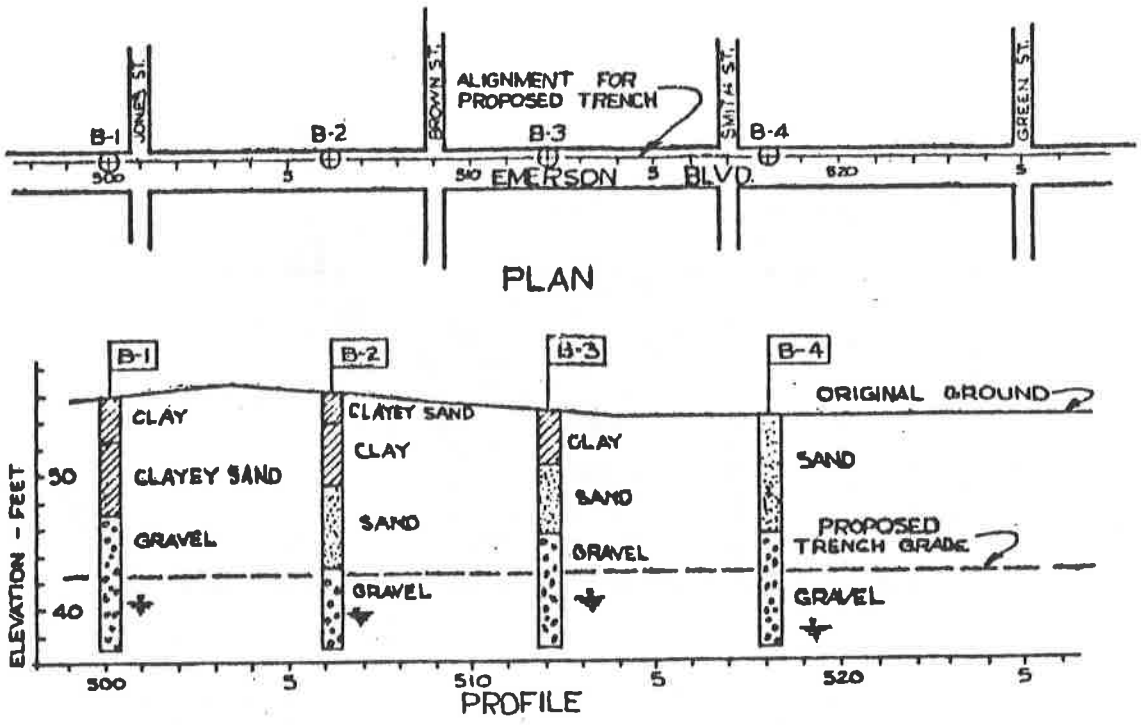


Figure 2-2. Typical Exploration Program for Infiltration Trench Design

Source: Hannon, 1980

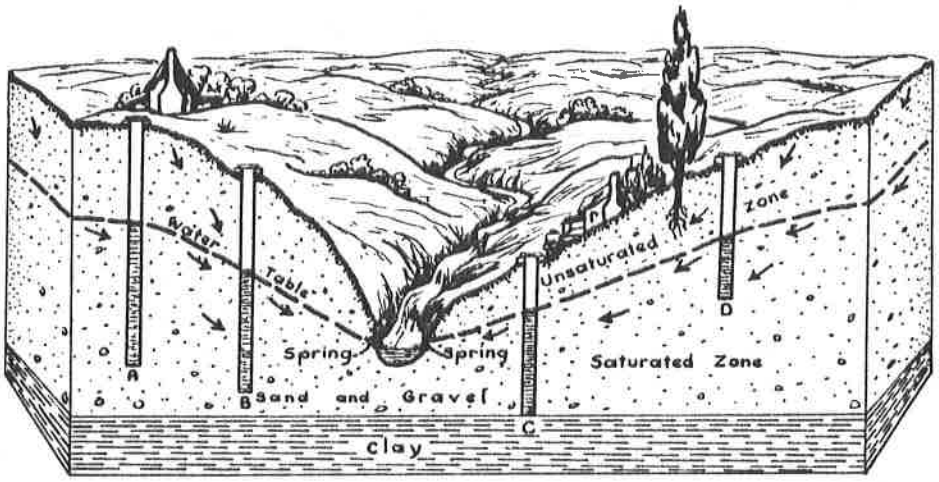


Figure 2-3. Schematic Cross Section Showing the General Pattern of Ground-Water Flow toward a Stream

Source: Vokes and Edwards, 1974

the land surface. The imaginary surface coinciding with the level to which the water rises in a well penetrating an artesian reservoir is called piezometric surface. A typical artesian situation is depicted in Figure 2-4.

2.2.2. Regional Conditions

The discussion that follows is a brief overview of some typical regional subsurface conditions and their influence or limitation on the use of infiltration practices.

2.2.2.1 Piedmont Region

The Maryland Piedmont region is subdivided into an eastern and a western division (see Figure 2-5). The eastern division extends in a north westerly direction from the Fall Line, which separates the Piedmont province from the Coastal Plain province. The eastern Piedmont division includes parts of Montgomery, Howard, Carroll, Baltimore and Harford counties.

Groundwater in the Piedmont province occurs primarily under water table conditions although some artesian conditions may be encountered locally. Most producing wells are located in the parent crystalline rocks at depths ranging from 20 to 750 feet with the majority of the wells being 50 or more feet deep.

As an example figure 2-6 presents a cross section showing a typical soil pattern in the Chester-Glenelg soil association which is an important soil association in both Montgomery and Baltimore counties. Although bedrock is generally reported at depths ranging from 5 to 10 feet below the surface, this is a highly weathered and permeable rock material. Typically the water table should be encountered at depths ranging from 10 to 20 feet or more. Consequently this type of condition should be well suited to the application of the entire range of infiltration practices. It should be noted, however, that localized lenses of clayey silts as well as hardpans resulting from agricultural use may be encountered which can inhibit surface infiltration. The soils investigation should identify the presence of these materials and care should be taken to design infiltration practices to penetrate these confining layers and access the lower more permeable materials.

The western division of the piedmont includes part of Montgomery, Frederick and Carroll counties. Groundwater in this western division also occurs primarily under water table conditions. One notable difference between the two divisions is the presence of extensive limestone formations in the western division. These limestone formations, which underlie most of the area around Frederick and also occur, although to a much lesser extent, in both divisions of the Piedmont, are often excellent water bearing formations. Stormwater management detention basins built on soils overlying these formations have been observed to provide a considerable amount of infiltration. These limestone derived soils are very permeable and well suited for infiltration practices. Caution, however, should be exercised if deep infiltration basins are to be used. To preclude the possibility of groundwater contamination, it is advisable to line the bottom of deep basins with one to two feet of sandy material to filter out the pollutants contained in the surface runoff.

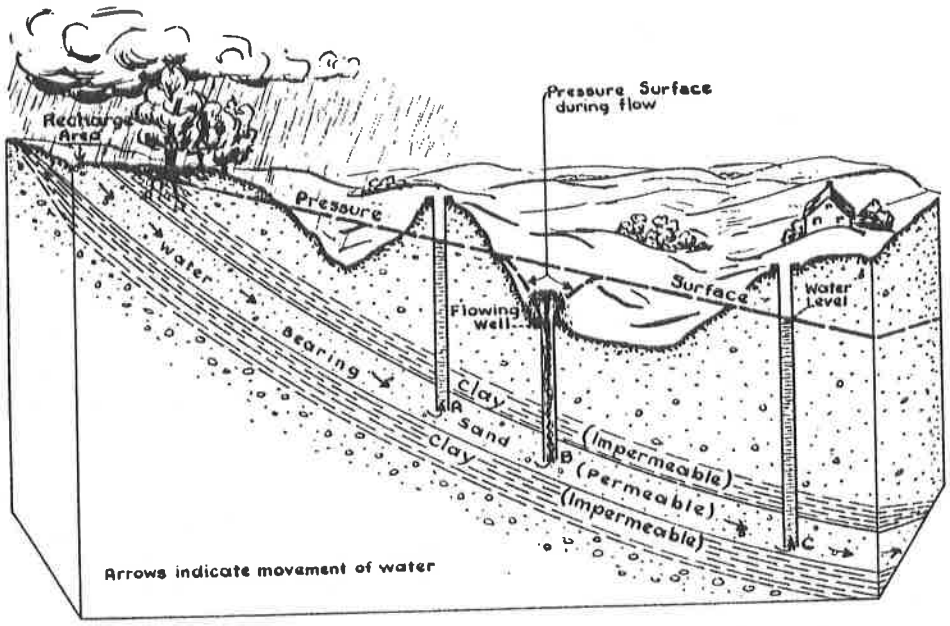


Figure 2-4. Sketch Showing the Principle of Artesian Water Flow

Source: Vokes and Edwards, 1974

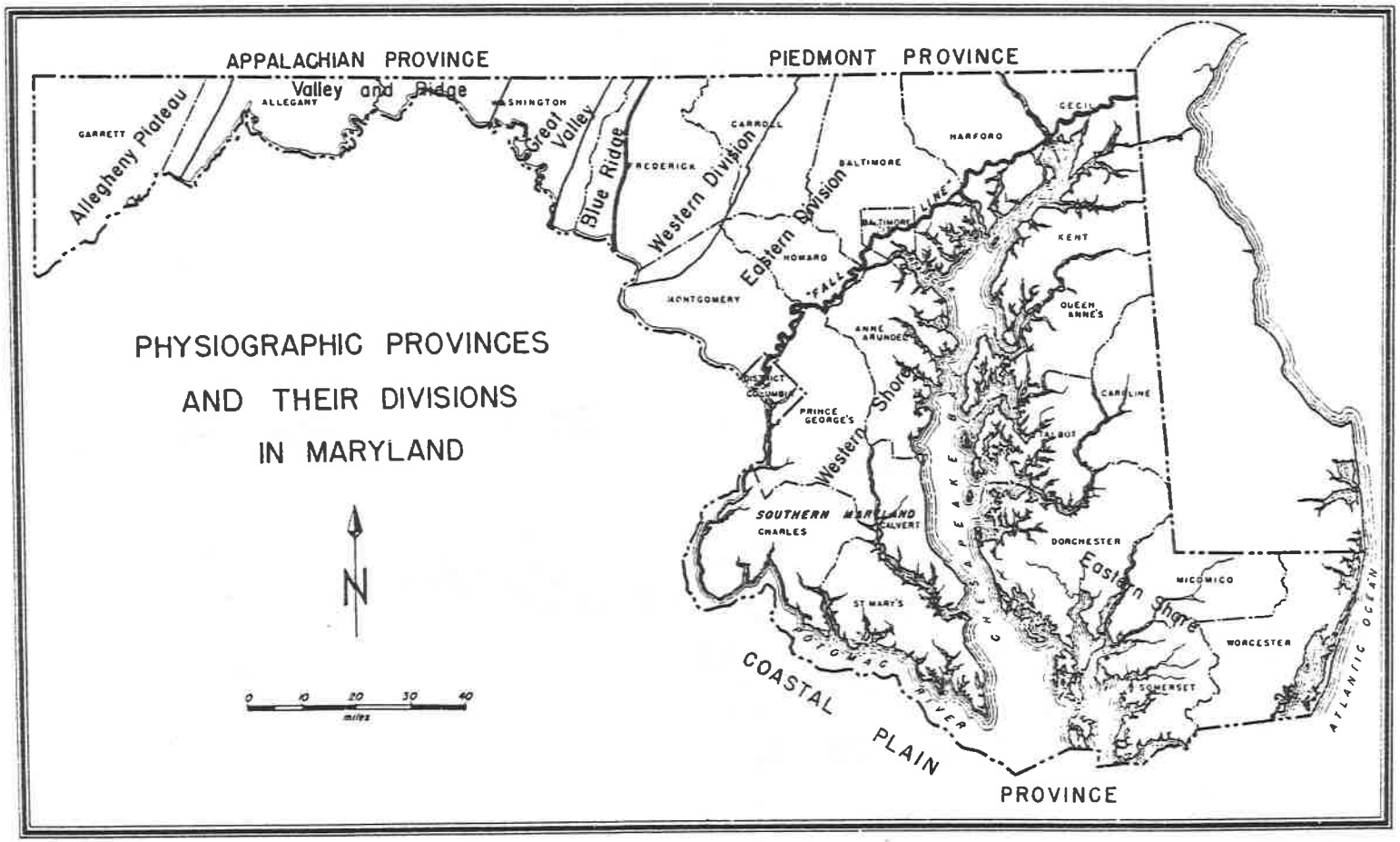


Figure 2-5. Physiographic Provinces and their Divisions in Maryland

Source: Vokes and Edwards, 1974

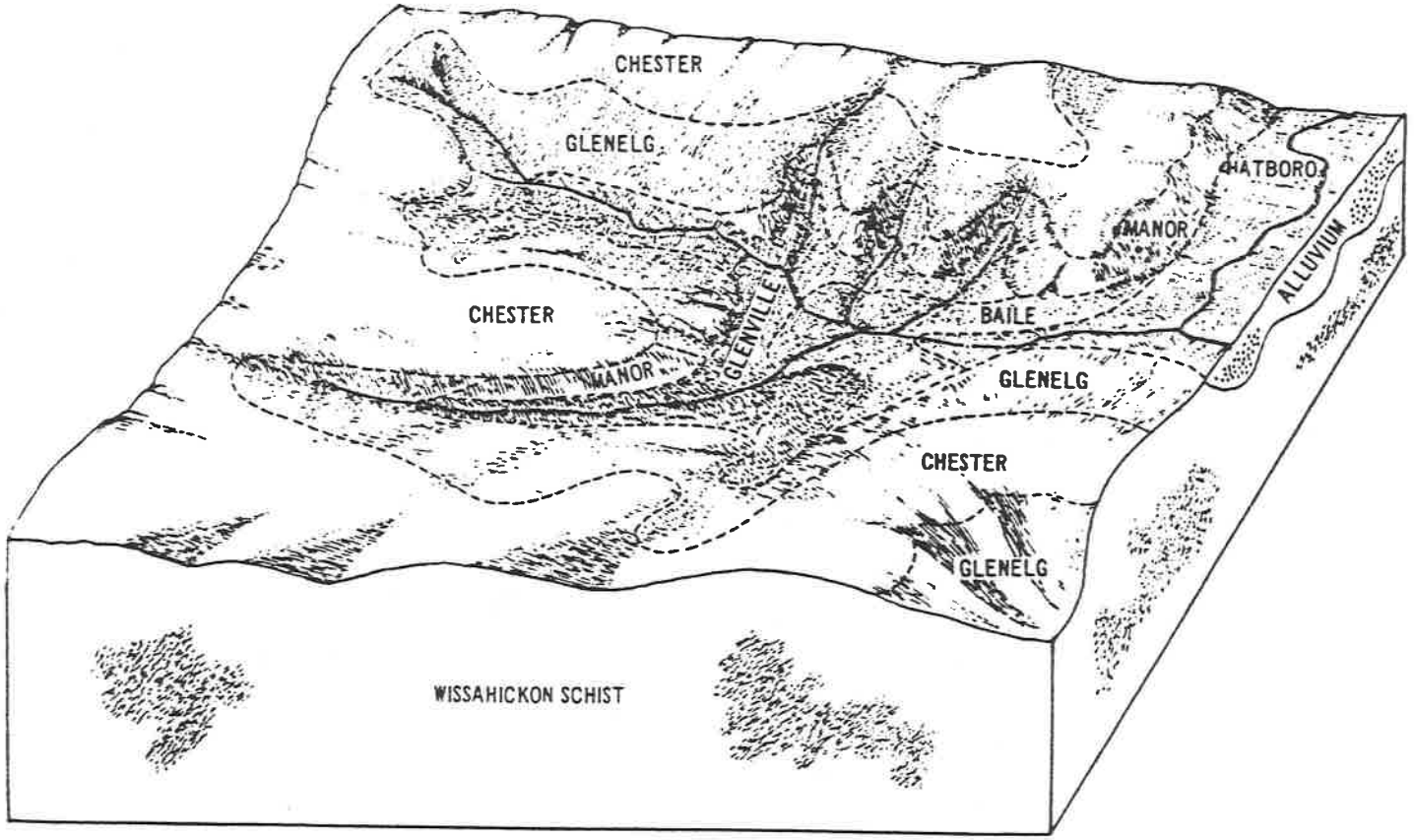


Figure 2-6. Cross Section Showing Typical Soil Pattern in the Chester-Glenelg Association

Source: Soil Survey, Baltimore County, Maryland

2.2.2.2. Coastal Plain - Western Shore

The western shore of the Coastal Plain includes all of Prince George's, Anne Arundel, Charles, Calvert, and St. Mary's counties as well as the lower parts of Baltimore, Montgomery, and Harford counties. Many of these areas and in particular Prince George's, Anne Arundel, and Baltimore counties are undergoing extensive urbanization.

Groundwater in the coastal plain province occurs under both water table and artesian conditions. The topmost surficial materials consist of a thin Pleistocene formation. This formation is made up of a series of gravels with minor amounts of sandy and silty materials which occur in terraces that gradually flatten out from west to east. These materials contain water under water table conditions. The lower strata down dip from their outcrops near the Fall Line and have their water in the sands between the clay beds, and hence under artesian conditions. Shallow dug wells yield water from the surficial deposits; deeper wells penetrate the sands where the water is under artesian conditions. The water level in water table wells fluctuates with the rate of recharge. It goes through an annual cycle, rising during the late fall to early spring and falling from late spring to early fall. In periods of drought, the yield of water table wells declines and even fails completely. As a result the water table aquifer is no longer an important source of ground water. The water level in artesian wells is not subject to such variations and the yield of artesian wells is generally not affected by droughts. Consequently most new well development is conducted in the artesian aquifers.

There are large and numerous deposits of sand and gravel materials throughout the western shore of the coastal plain. In some cases this material is covered by 10-15 feet of silt loam soil that contains a hardpan layer. This is a frequent occurence south of Washington, D.C. These sand and gravel deposits and in particular abandoned gravel pits as illustrated in Figure 2-7 are ideally suited for infiltration practices. The soils investigations in the coastal plain region should not overlook the presence of these materials although they may occur at considerable depth. Figures 2-8 and 2-9 present strategies for locating an infiltration basin through a layer of low permeability to access more permeable subsoils.

As another example figure 2-10 presents a representative pattern of soils and parent material of the Muirkirk-Evesboro association in Anne Arundel County. The use of infiltration practices on the soils of this association could be restricted by the clay lenses that occur between the sand formations. In applying the infiltration practices on these soils it is important to penetrate through the clay lenses and into the sands overlying the Patapsco clay to maximize the opportunity for infiltration as illustrated in Figures 2-8 and 2-9.

Figure 2-11 presents a representative cross section of the Sassafras-Woodston-Fallsington association in Baltimore County. This cross section suggests that the Sassafras and Galestown soil series might be suited for shallow infiltration trenches. The Woodston and Fort Mott series might be suited for vegetated swales. The other soil series appear limited by high water table conditions.

Figure 2-12 presents a cross section of the Beltsville-Gravelly Land-Bourne association in Charles County. As the illustration indicates, infiltration practices used on the Beltsville, Bourne, Exum and Wickham soil

series should be designed to penetrate the inhibiting fragipan as well as the silty mantle which have poor permeability. The bottom of the infiltration structures should be located in the gravelly pleistocene deposits. The Gravelly Land Series would also be condusive to infiltration; however, the steepness of the slope would make a careful seepage analysis manadatory.

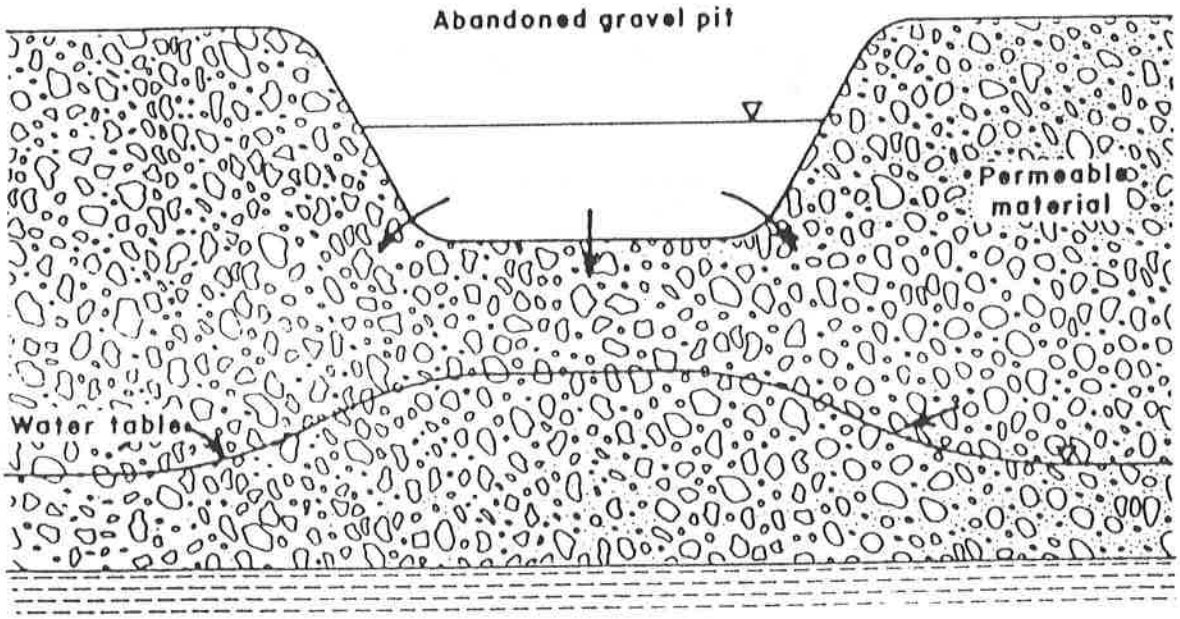


Figure 2-7. Abandoned Gravel Pits are Commonly Used as Infiltration Basins

Source: Pettyjohn, 1981

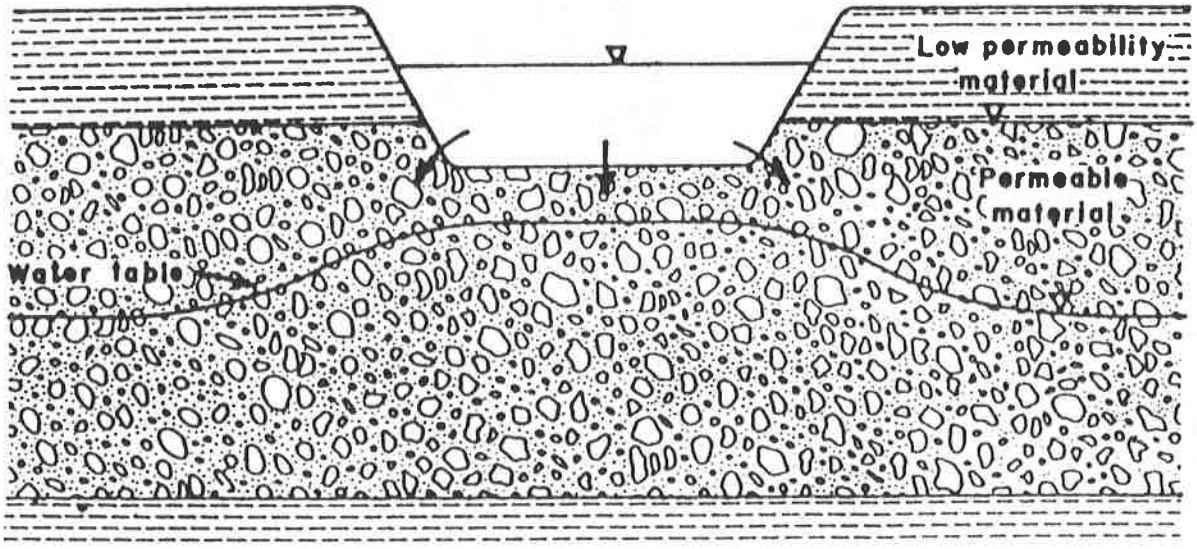


Figure 2-8. Recharge Pit Excavated Through Fine-Grained Material To Penetrate The Upper Part Of An Aquifer.

Source: Pettyjohn, 1981

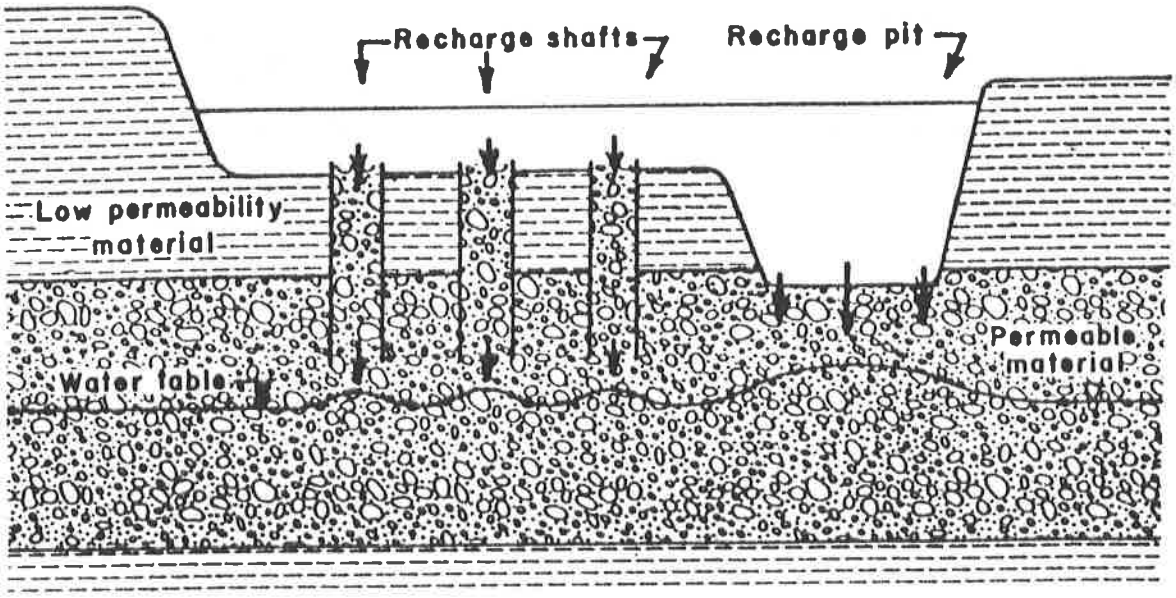


Figure 2-9. Where Land is Not Readily Available for Recharge Facilities, a Combination of Recharge Shafts and Pits Permits Achievement of Maximum Rates

Source: Pettyjohn, 1981

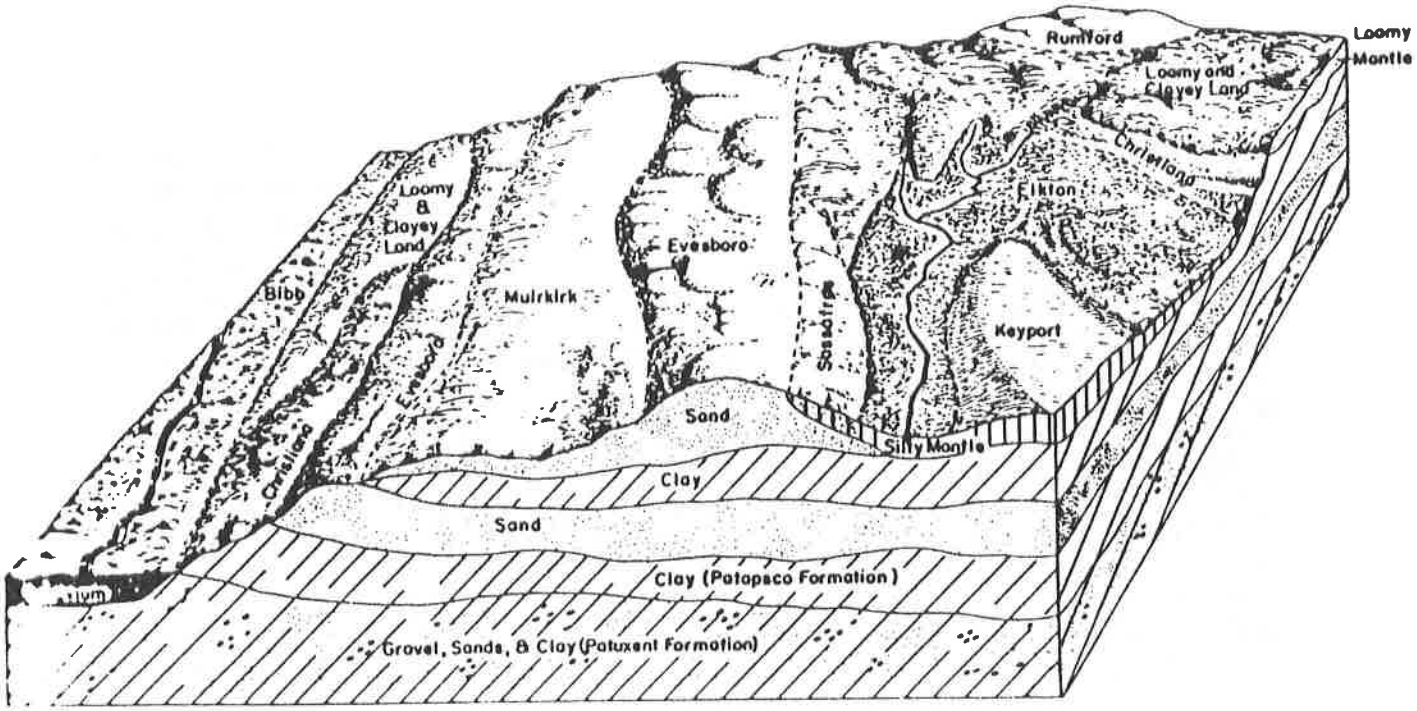


Figure 2-10. Representative Pattern of Soils and Parent Material in the Muirkirk-Evesboro Soil Association in Anne Arundel County

Source: Soil Survey, Anne Arundel County, Maryland

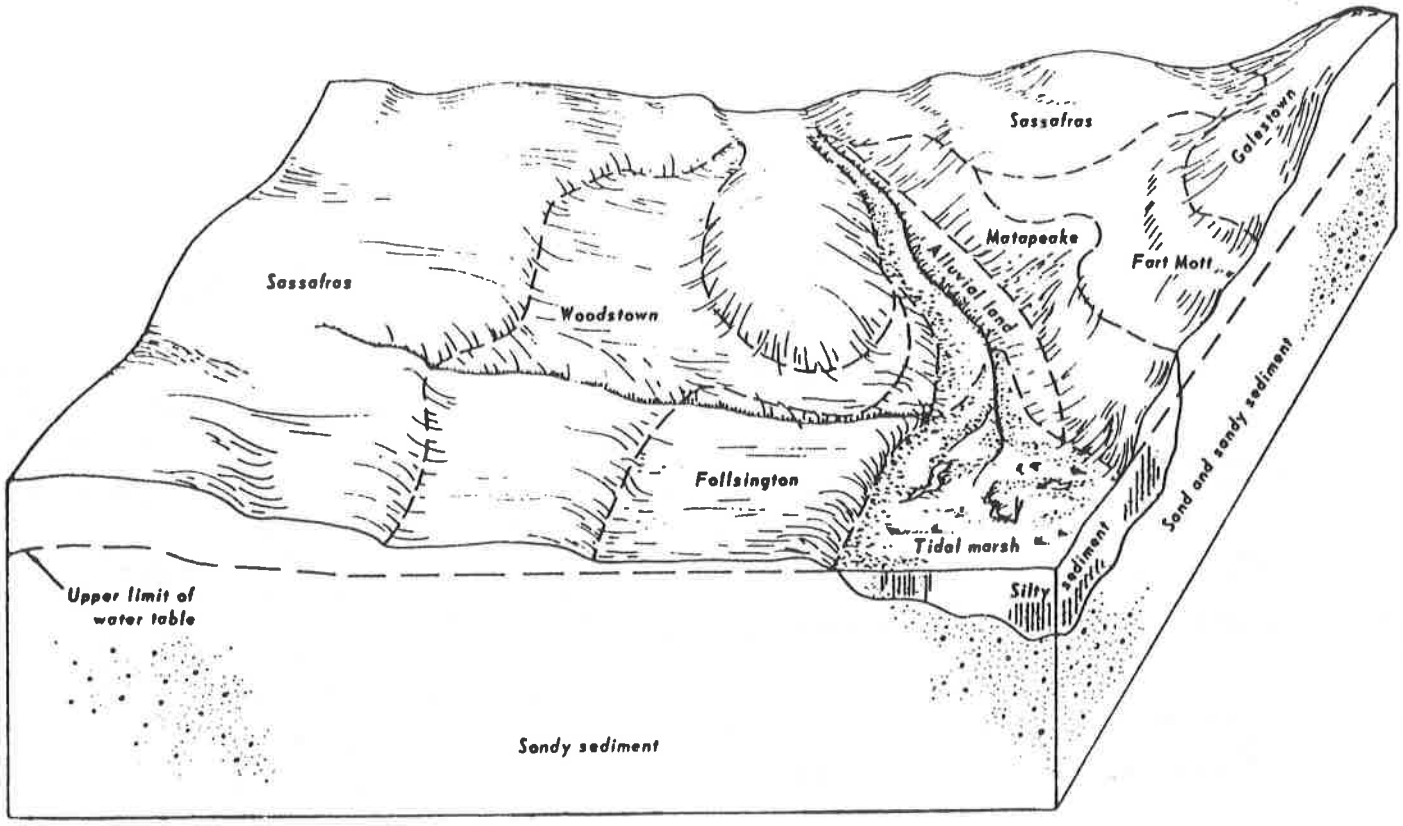


Figure 2-11. Cross Section Showing Typical Pattern in the Sassafras-Woodstown-Fallsington association in Baltimore County

Source: Soil Survey, Baltimore County, Maryland

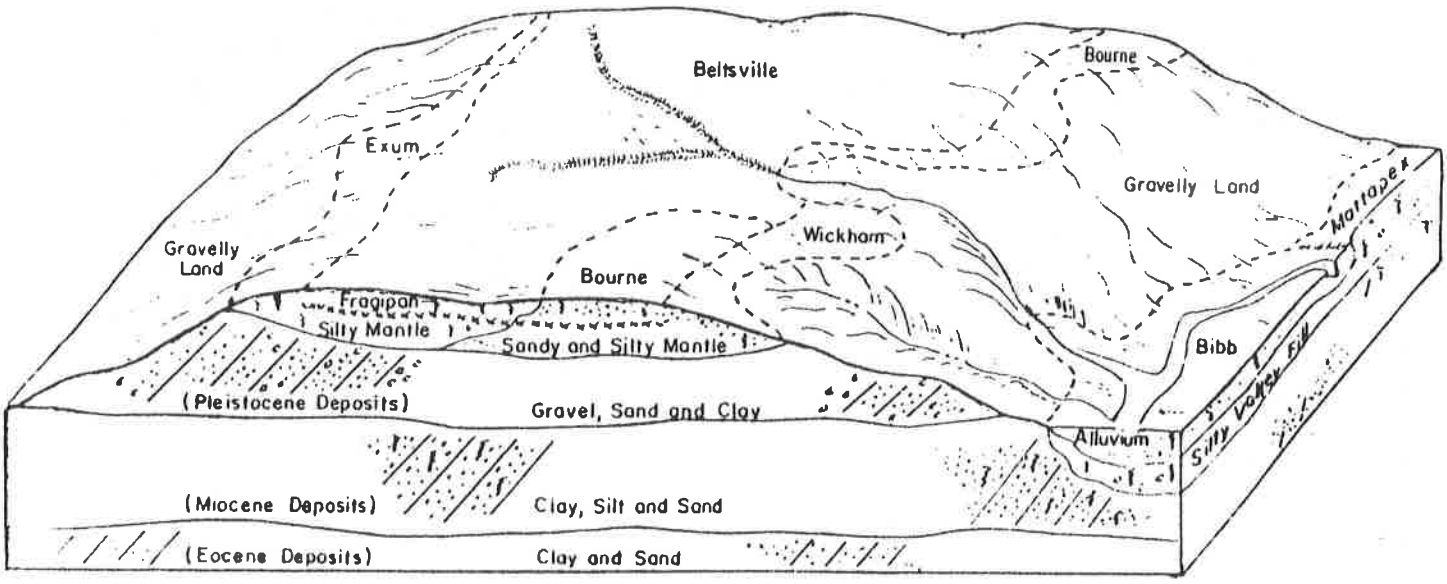


Figure 2-12. Cross Section of the Beltsville-Gravelly Land-Bourne association Showing Topography, Important Soils, and Underlying Material

Source: Soil Survey, Charles County, Maryland

2.3 WATER QUALITY

Urban stormwater runoff has been identified as a serious source of pollution to receiving waters. The major pollutants associated with urban runoff include, 1) organic matter, 2) nitrogen, 3) phosphorus, 4) heavy metals including copper, lead, nickel, cobalt and zinc, 5) sediment, 6) bacteria and 7) temperature.

There exists considerable concern that the use of infiltration practices for SWM may result in widespread contamination of the soil and groundwater. Land application of wastewater is not a new concept. The use of the soil as a filtering mechanism for the disposal of secondary effluent has been thoroughly researched and evaluated for many years.

The water quality advantages gained by the use of infiltration practices may far outweigh the potential disadvantages. It is important, however, to provide a minimum distance between the bottom of the infiltration practice and the seasonal high water table. However, the Environmental Protection Agency has criteria for onsite wastewater treatment and disposal systems, which calls for a two to four foot distance between the bottom of the system and the water table. (EPA, 1980).

Where possible infiltration practices shall be located to intercept the initial runoff from the entire developing area. This is necessary to provide overall site water quality benefits. Obviously, infiltration practices accepting runoff from only a portion of a development will still result in degraded downstream water quality.

2.4 FEASIBILITY TESTS

A number of feasibility requirements can be tested to determine whether a SWM infiltration practice may be constructed on a specific site and to what extent it may be applied. These feasibility tests include:

1. Soil textural classes with minimum infiltration rates that permit adequate percolation of stored runoff.

2. Maximum allowable ponding or storage time within the structure.

3. Available depth between the bottom of the infiltration practice and the seasonal high groundwater table or depth to bedrock.

4. The topographic character of the site including the slope, nature of the soil (natural or fill), and proximity of building foundations and water supply wells.

The usage of infiltration practices will depend upon a careful site investigation to determine the conditions in which the feasibility tests will indicate positive results. Each of the above feasibility conditions are to be investigated and each are equally important in ensuring the proper functioning of the proposed infiltration practice. Should a site investigation reveal that any one of the feasibility tests is not adequate, the implementation of infiltration practices should not be pursued. Alternate feasibility criteria may be permitted in only those conditions in which the local jurisdictions can justify and ensure proper application.

2.4.1. Soil Textures

The hydrologic design methods presented in Chapter 4 are based on the utilization of two hydrologic soil properties, the effective water capacity (C_w) and the minimum infiltration rate (f) of the specific soil textural groups, as shown in Table 2-1. The effective water capacity of a soil is the fraction of the void spaces available for water storage, measured in terms of inches per inch. The minimum infiltration rate is the final rate that water passes through the soil profile during saturated conditions, measured in terms of inches per hour. The hydrologic soil properties are obtained by identifying the soil textures by a gradation test for each of the changes in soil profile. The soil textures presented in Table 2-1 correspond to the soil textures of the U.S. Dept. of Agriculture (USDA) Textural Triangle presented in Figure 2-13.

The data presented in Table 2-1 are based on the analysis of over 5,000 soil samples under carefully controlled procedures by the USDA. The use of the soil properties established in Table 2-1 for design and review procedures will offer two advantages. First, it will provide for consistency of results in the design procedures. Second, it will eliminate the need for the laborious and costly process of conducting field and laboratory infiltration and permeability tests.

Based on the soil textural classes and the corresponding minimum infiltration rates, a restriction is established to eliminate unsuitable soil conditions. Soil textures with minimum infiltration rates of 0.17 inches per hour or less are not suitable for usage with infiltration practices. These include soils that have a 30 percent clay content, making these soils

TABLE 2-1. HYDROLOGIC SOIL PROPERTIES CLASSIFIED BY SOIL TEXTURE*

Texture Class	Effective Water Capacity (C_w) (inch per inch)	Minimum Infiltration Rate (f) (inches per hour)	Hydrologic Soil Grouping
Sand	0.35	8.27	A
Loamy Sand	0.31	2.41	A
Sandy Loam	0.25	1.02	B
Loam	0.19	.52	B
Silt Loam	0.17	.27	C
Sandy Clay Loam	0.14	.17	C
Clay Loam	0.14	.09	D
Silty Clay Loam	0.11	.06	D
Sandy Clay	0.09	.05	D
Silty Clay	0.09	.04	D
Clay	0.08	.02	D

* Source: Rawls, Brakensiek and Saxton, 1982

Textural Triangle U.S.D.A.

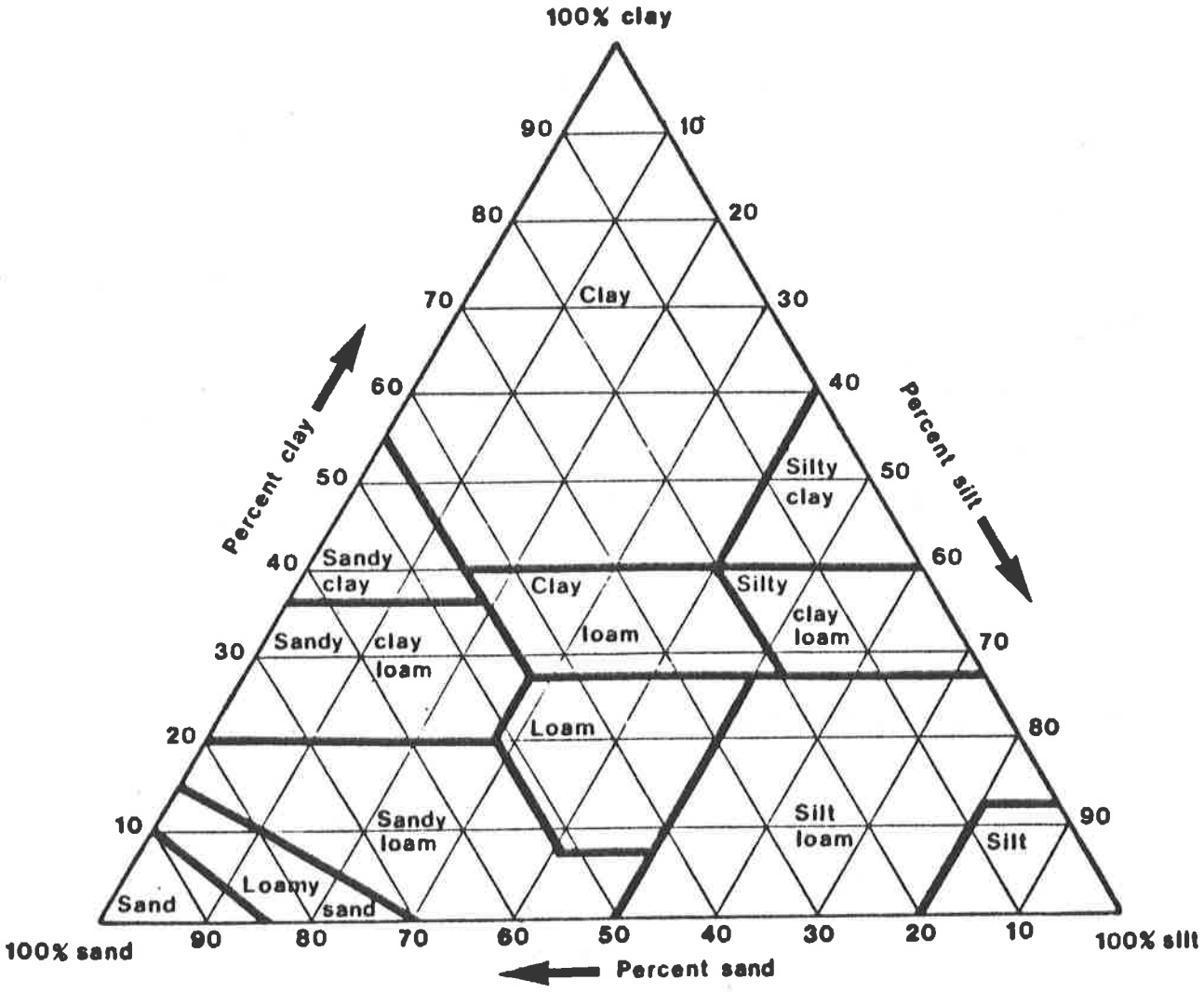


Figure 2-13. U.S.D.A. Textural Triangle

susceptible to frost heaving and structurally unstable, in addition to having a poor capacity to percolate runoff. Soil textures that are recommended for infiltration systems include those soils with minimum infiltration rates of 0.27 inches per hour or greater, which include silt loam, loam, sandy loam, loamy sand, and sand.

2.4.2. Maximum Allowable Ponding or Storage Time

The feasibility criteria for using SWM infiltration systems can also be based upon the concept of a maximum allowable ponding time (T_p) for surface storage or a maximum allowable storage time (T_s) within a subsurface stone aggregate reservoir. The concept will vary depending upon the storage mechanism of each practice which will govern the available storage within the structure. The established maximum ponding and storage time is a 3 day or 72 hour period in which stored runoff within the structure should be completely drained. The maximum ponding time for vegetated swales is 24 hours. The use of the maximum allowable time frame in conjunction with a specific soil minimum infiltration rate (f) will dictate the maximum allowable design depth (d_{max}) of the structure. The maximum depth of an infiltration basin and a vegetated swale may be defined as:

$$d_{max} = fT_p \qquad (2\text{-}1)$$

The maximum depth of an infiltration trench, dry well, and porous asphalt pavement subbase will depend upon the void ratio (V_r) of the stone aggregate reservoir and may be defined as:

$$d_{max} = \frac{fT_s}{V_r} \qquad (2\text{-}2)$$

The maximum allowable design depths for various soil textures and ponding or storage times are given in Table 2-2 for the criteria in Equations 2-1 and 2-2. The portion of the table that is shaded represents soil infiltration rates that are unacceptable. The maximum design depths will obviously become greater as the minimum infiltration rates of a soil texture class becomes greater. The depth of the structure required for design will depend upon the site characteristics and the level of control. The values of d_{max} in Table 2-2 represent only the upper allowable range for design depths which may be less where other limitations exist (i.e., distance to groundwater).

2.4.3. Depth to High Groundwater Table and Bedrock

An additional feasibility criterion of a SWM infiltration structure consists of determining the safe distance between the bottom of the structure and the location of the seasonal high groundwater table. This distance is also important in protecting against the flooding of the structure due to the rise of the water table, rendering the structure ineffective. The U.S. Environmental Protection Agency's (EPA) criteria for onsite wastewater treatment and disposal systems specifies that a 2 to 4 foot distance be provided between the bottom of the waste disposal system and the water table or bedrock (EPA, 1980). Thus, it is recommended that infiltration structures be located only in areas where the bottom of the structure will be 2 to 4 feet above the seasonally high groundwater table and/or bedrock.

TABLE 2-2. MAXIMUM ALLOWABLE DEPTHS (INCHES) OF STORAGE FOR TWO CRITERIA, SELECTED MAXIMUM PONDING OR STORAGE TIMES (T_p OR T_s IN HOURS), MINIMUM INFILTRATION RATES (INCHES/HOUR)

Criterion	T_p or T_s (hrs)	SOIL TEXTURE/F (INCHES/HOUR)										
		Sand	Loamy Sand	Sandy Loam	Loam	Silt Loam	Sandy Clay Loam	Clay Loam	Silty Clay Loam	Sandy Clay	Silty Clay	Clay
		8.27	2.41	1.02	.52	.27	.17	.09	.06	.05	.04	.02
fT_p	24	198	58	24	13	6	4					
	48	397	116	49	25	13	8	4	3			
	72	595	174	73	37	19	12	6	4	4	3	1
fT_s/V_r for (V_r = 0.4)	24	496	145	61	31	16	10	5	4	3	2	1
	48	992	290	122	62	32	20	11	7	6	6	2
	72	1489	434	183	93	49	31	16	11	9	7	4

Note: T_p = Maximum allowable ponding time

T_s = Maximum allowable storage time

V_r = Voids ratio

▨ These values represent unfeasible solutions

Data on the application of secondary effluent to land disposal systems suggests that a 2 to 3 foot depth is generally sufficient to remove most pollutants (COG, 1980). Experience on Maryland's Eastern Shore, where high water table conditions are common, indicates that septic systems can be successfuly designed and built with less distance than generally recommended by rules of thumb. In addition, the use of vegetated swales on the Eastern Shore is a common drainage technique which has been used successfully to convey runoff, although during high water table conditions they become saturated. Thus, the use of swales as a SWM infiltration practice may still be encouraged in cases where the distance to the water table is on the order of 1 to 2 feet.

2.4.4. Topographic Conditions

The topographic conditions of the site represent feasibility factors that need to be examined prior to incorporating infiltration systems on specific sites. These include the slope, nature of the soil (natural or fill), and the proximity of building foundations and water supply wells. If local health authorities document existing problems regarding water supply well pollution resulting from infiltration practices, infiltration shall not be utilized.

The use of a particular practice will place a restriction on the allowable slope. The use of porous asphalt pavement and vegetated swales, for example, requires a relatively level or gently sloping area not in excess of 5 percent (20h:1v). All other infiltration practices shall be located in areas in which the slope does not exceed 20 percent (5h:1v). Application of infiltration practices on a steep grade increases the chance of water seepage from the subgrade to the lower areas of the site and reduces the amount which infiltrates.

Developments occurring on sloping and rolling sites often require the use of extensive cut and fill operations. The use of SWM infiltration systems on fill material is not recommended due to the possibility of creating an unstable subgrade. Fill areas can be very susceptible to slope failure due to slippage along the interface of the in-situ and fill material. This condition could be aggravated if the fill material is allowed to become saturated by using infiltration practices.

The proximity of building foundations should be at least 10 feet up gradient from infiltration systems to prevent the possibility of flooding basements. Additionally, the location of infiltration practices shall be a minimum of 100 feet from any water supply well where the runoff is from commercial or industrial impervious parking areas.

2.4.5. Other Considerations

In addition to the feasibility criteria presented above, there are a number of other factors to be considered in evaluating the use of infiltration practices. One of these is the possibility of conflict with existing local regulations. A number of localities have regulations which require the use of curb and gutter for all subdivision development. Unless this requirement is changed, it will cause a conflict with the use of vegetated swales. Some localities have regulations which prevent the connection of roof drains to dry wells. Also, some localities have requirements that all structures have a positive drain outlet. These requirements seriously limit the use of infiltration practices.

2.5 CONSTRUCTION AND MAINTENANCE

2.5.1. Construction

Regardless of the type of infiltration practice to be constructed, careful consideration must be given in advance of construction to the effects of the work sequence, techniques, and equipment employed on the future maintenance of the practice. Serious maintenance problems can be averted, or in large part, mitigated, by the adoption of relatively simple measures during construction.

Previous experience with infiltration practices in Maryland has shown that SWM infiltration practices must not be constructed until the drainage areas contributing to the structure have been adequately stabilized. When this precaution has not been taken, the infiltration structure has often become clogged with sediment from the construction operations upland and thus failed to operate from the outset.

Specific construction methods and specifications are provided in Chapter 3 of this handbook for each individual SWM infiltration practice.

2.5.2. Maintenance

The maintenance requirements of SWM practices are an important aspect which are often not addressed in the planning and design of these structures. Infiltration basins, vegetated swales, and vegetative buffers can be visually inspected and easily maintained. The wearing surface of porous asphalt paving can also be visually inspected and maintained, but the subsurface storage area cannot. Likewise, infiltration trenches and dry wells, once installed, are very difficult to inspect and maintain. Consequently, these latter practices should be designed using inlet structures, sediment and grease traps and vegetated filters which will protect the integrity of the practice, ensure a long functional life, and provide readily accessible structures for maintenance.

Specific maintenance specifications and recommendations are provided for each individual SWM infiltration practice in Chapter 3 of this handbook.

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CHAPTER 3

STANDARDS AND SPECIFICATIONS

CHAPTER 3

STANDARDS AND SPECIFICATIONS

3.1 INTRODUCTION

This chapter presents detailed standards and specifications for the following six stormwater management infiltration structures:

1. Infiltration basin
2. Infiltration trench
3. Dry well
4. Porous asphalt pavement
5. Vegetated swale with check dams
6. Vegetated buffer

The standards and specifications for each of the above six structures contains information on the following topics:

1. Description
2. Applicability
3. Planning Considerations
4. Design Criteria
5. Water Quality
6. Construction Specifications
7. Maintenance

3.2 INFILTRATION BASIN

(IB)

3.2.1. Description

An infiltration basin is a water impoundment made by constructing a dam or an embankment or by excavating a pit or a dugout in or down to relatively permeable soils. The purpose of the basin is to temporarily store the surface runoff for a selected design storm and to maintain or increase ground water recharge by infiltration through the bed and sides of the basin.

3.2.2. Applicability

An infiltration basin will generally be used in the same manner as a detention basin. The infiltration basin will typically be constructed in drainage areas of 5 to 50 acres. An infiltration basin may be constructed jointly with a detention basin by raising the outlet pipe.

3.2.3. Planning Considerations

An infiltration basin has relatively large surface area requirements in comparison to either an infiltration trench or a dry well. Whereas a trench or a dry well is generally associated with small drainage areas of 1 acre or less, infiltration basins are better suited to control larger drainage areas generally ranging from 5 to 50 acres in size.

A typical infiltration basin will range from 3 to 12 feet in depth. The seasonally high groundwater table should be located at least 2 to 4 feet below the bottom of the basin. Similarly, bedrock should also be located at least 2 to 4 feet below the bottom of the basin.

The permeability or final infiltration rate of the various soil types will determine how rapidly the stormwater ponded in the basin at the end of the storm will be infiltrated into the ground. Table 2-2 provides the maximum allowable depth of ponding for the various soil textures for a range of allowable ponding times. The table indicates that for soil textural classes with final infiltration rates (f) of 0.52 in/hr and larger allow for the design of basins with a ponding depth of approximately 3 feet and deeper, provided that the criteria for depth to high water table and bedrock are satisfied.

The soil textural class with an f value of 0.27 inches per hour (silt loam) may have some limited suitability for a very shallow infiltration basin. This shallow basin will of course control a smaller drainage area than the deeper basins and thus will require more surface area to provide an equivalent level of control. Due to the high cost of land being converted to urban uses, the designer or developer will generally seek to minimize land costs by using fewer, smaller, and deeper basins. This constraint will make soils with infiltration rates less than 0.27 inches per hour unsuitable for use of infiltration basins. The infiltration capacities of soils which allows them to infiltrate 36 inches of stored runoff over a 3 day period makes them well suited for an infiltration basin.

3.2.4. Design Criteria

The design of infiltration basins will follow the criteria of the Maryland SCS Standard and Specification 378-Ponds dated July, 1981 or subsequent revisions for embankment design, in conjunction with an adequate, non-erosive outlet channel, and the additional criteria set forth below.

3.2.4.1. Design Storm

All hydrologic and hydraulic calculations shall be based on the design storm criteria provided in the Maryland SWM Regulations (COMAR 08.05.05).

3.2.4.2. Ponding Time

All infiltration basins shall be designed to completely drain stored runoff within 3 days following the occurrence of a storm event. Thus an allowable maximum ponding time (T_p) of 72 hours shall be used.

3.2.4.3. Water Table, Bedrock, and Groundwater Conditions

Infiltration basins should be located only in areas where the bottom of the basin will be at least 2 to 4 feet above the seasonally high groundwater table or bedrock at all times. Also infiltration basins shall be located at least 100 feet horizontally away from any water supply well.

Concerns related to the development of a groundwater mound below the infiltration facility as well as the potential for polluting downgradient groundwater supplies often arise when infiltration facilities are considered. The data base evaluated in the preparation of these specifications indicates that due to the intermittent nature of precipitation patterns and the associated operation of infiltration practices, groundwater mounding has not been observed to be a problem. Also, the data base indicates that groundwater pollution has not been observed to be a problem.

3.2.4.4. Runoff Filtering

Grease, oil, floatable organic materials, and settleable solids should be removed from runoff water before it enters the infiltration basin. These materials can take up storage capacity and reduce infiltration rates.

Runoff filtering devices such as vegetative filters (see Section 3.7), sediment traps, and grease traps can be used to remove objectionable materials. In addition, modified basin designs such as illustrated in Figures 3-1 and 3-2 can be used to enhance and prolong the infiltration capacity of the basin bottom. Even when the basin bed becomes clogged by layers of accumulated sediment, infiltration can still be achieved through the sides of the basins, as shown in Figure 3-3, provided that the side materials are relatively permeable.

When a runoff filtering system or structure is included in the design, the maintenance requirements and schedule of the filter structure must be included.

3.2.4.5. Principal Spillway for Combination Structure

The bottom elevation of the low-stage orifice should be designed to

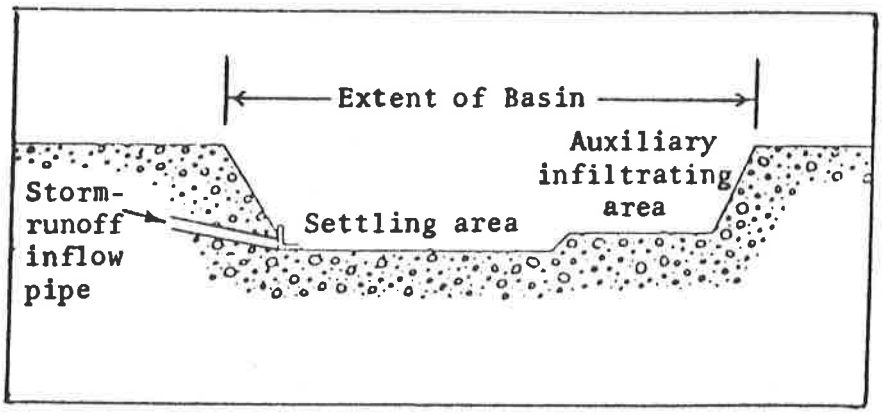


Figure 3-1. Two-level Infiltration Basin.

Source: Aronson and Seaburn, 1969

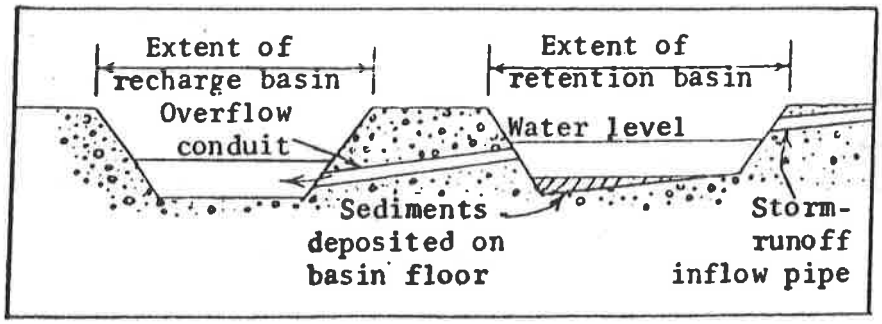


Figure 3-2. Retention Basin and the Adjoining Infiltration Basin.

Modified After Aronson and Seaburn, 1969

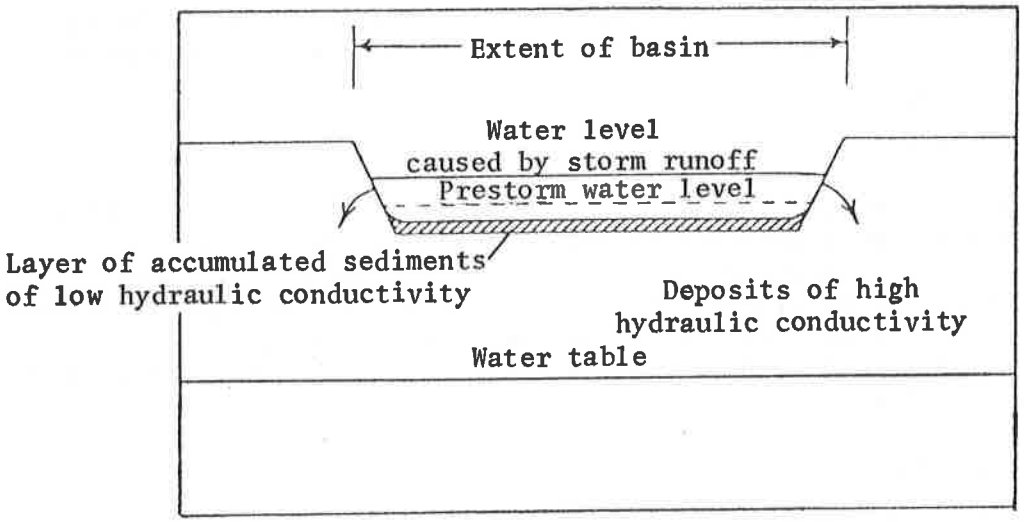


Figure 3-3. Water-containing Infiltration Basin illustrating Stormwater Disposal through the Sides of the Basin above the Level of Accumulated Material of Low Hydraulic Conductivity.

Source: Aronson and Seaburn, 1969

coincide with the 3 day infiltration capacity of the basin. All other aspects of the principal spillway design will follow the guidelines provided in the Maryland SCS Standards and Specifications 378-Ponds dated July, 1981 or subsequent revisions. Level spreaders should be utilized for stormwater inflow into the basin to reduce erosion.

3.2.4.6. Emergency Spillway

An emergency spillway shall be provided for all basins created by an embankment. All excavated basins shall have a nonerosive outlet channel. The emergency spillway design shall comply with the requirements of the Maryland SCS Standards and Specifications 378-Ponds dated July, 1981 or subsequent revisions.

3.2.4.7. Vegetation

The embankment, emergency spillway, spoil and borrow areas, and other disturbed areas shall be stabilized and planted in accordance with the appropriate vegetative measure standards in the Maryland Standards and Specifications for Soil Erosion and Sediment Control. The emergency spillway is often the most critical area. Additionally, a grass strip or other vegetative buffer at least 20 feet wide shall be provided around the basin to protect against erosion.

3.2.4.8. Fencing

The embankment and basin shall be fenced where and when deemed necessary by the land developer or local jurisdiction to provide public safety or protection of vegetation.

3.2.4.9. Hydrologic Design Method

A hydrologic design method based on SCS TR-55 procedures is provided in Chapter 4, Hydrologic Design Methods.

3.2.5. Water Quality

The effectiveness of this practice for runoff and pollution control is dependent upon the size and design of the infiltration facility. If a basin is designed to collect and infiltrate the storm runoff over a given drainage area, the practice should be effective for both runoff control and pollution abatement for storms up to and including the design storm.

3.2.6. Construction Specifications

The construction of all infiltration basins should comply with the criteria set forth in the Maryand SCS Standards and Specifications 378-Ponds dated July, 1981 or subsequent revisions and the additional criteria provided below.

3.2.6.1. Schedule

The sequence of various phases of basin construction shall be coordinated with the overall project construction schedule. A program should schedule

rough excavation of the basin with the rough grading phase of the project to permit use of the material as fill in earthwork areas. The partially excavated basin could serve as a sedimentation basin in order to assist in erosion and sediment control during construction. However, basins near final stages of excavation should never be used prematurely for runoff disposal. Drainage from untreated, freshly constructed slopes within the watershed area would load the newly formed basin with a heavy concentration of fine sediment. This could seriously impair the natural infiltration characteristics of the basin floor. Final grade of an infiltration basin shall not be attained until after its use as a sediment control basin is completed.

Specifications for basin construction should state: (1) the earliest point in progress when storm drainage may be directed to the basin, and (2) the means by which this delay in use is to be accomplished. Due to the wide variety of conditions encountered among projects, each should be separately evaluated in order to postpone use as long as is reasonably possible.

3.2.6.2. Excavation

Initial basin excavation should be carried to within 1 foot of the final elevation of the basin floor. Final excavation to the finished grade should be deferred until all disturbed areas on the watershed have been stabilized or protected. The final phase excavation should remove all accumulated sediment. Relatively light tracked equipment is recommended for this operation to avoid compaction of the basin floor. After the final grading is completed, the basin floor should be deeply tilled by means of rotary tillers or disc harrows to provide a well-aerated, highly porous surface texture.

3.2.6.3. Lining Material

Infiltration basins may be lined with a 6- to 12-inch layer of filter material such as coarse sand to help prevent the buildup of impervious deposits on the soil surface. The filter layer can be replaced or cleaned when it becomes clogged. When a 6-inch layer of coarse organic material is specified for discing (such as hulls, leaves, stems, etc.) or spading into the basin floor to increase the permeability of the soils, the basin floor should be soaked or inundated for a brief period, then allowed to dry subsequent to this operation. This induces the organic material to decay rapidly, loosening the upper soil layer.

Establishing dense vegetation on the basin side slopes and floor is recommended. A dense vegetative stand will not only prevent erosion and sloughing, but will also provide a natural means of maintaining relatively high infiltration rates. Erosion protection of inflow points to the basin shall also be provided. Removal of accumulated sediment is a problem only at the basin floor. Little maintenance is normally required to maintain the infiltration capacity of slope areas.

Selection of suitable vegetative materials for the side slope and all other areas to be stabilized with vegetation and application of required fertilizer and mulches shall be done in accordance with the Maryland Standards and Specifications for Soil Erosion and Sediment Control. Local Extension Agencies should also be consulted.

3.2.7. Maintenance

3.2.7.1. Inspection Schedule

Drainage systems must be inspected on a routine basis to ensure that they are functioning properly. Inspections can be on a semiannual basis but should always be conducted following major storms.

3.2.7.2. Sediment Control Effect on Vegetated Basins

Cleanout frequency of infiltration basins will depend on whether they are vegetated or nonvegetated and will be a function of their storage capacity, recharge characteristics, volume of inflow, and sediment load. Infiltration basins should be inspected at least once a year. Sedimentation basins and traps may require more frequent inspection and cleanout.

Grass bottoms on infiltration basins seldom need replacement since grass serves as a good filter material. This is particularly true of Kentucky 31 Tall Fescue, which is extremely hardy and can withstand several days of submergence. If silty water is allowed to trickle through the turf, most of the suspended material is strained out within a few yards of surface travel. Well established turf on a basin floor will grow up through sediment deposits, forming a porous turf and preventing the formation of an impermeable layer. Grass filtration would work well with long, narrow, shoulder-type (swales, ditches, etc.) depressions where highway runoff flows down a grassy slope between the roadway and the basin. Kentucky 31 Tall Fescue demands very little attention and looks attractive when trimmed. Grass planted on basin side slopes will also prevent erosion.

3.2.7.3. Sediment Removal From Nonvegetated Basin

(a) Technique. Remove sediment only when the basin floor is completely dry, after the silt layer has mud-cracked and separated from the basin floor. Equipment maneuverability and precise blade control are essential in small areas and can greatly reduce the quantity of material to be removed.

(b) Frequency. All sediment must be removed prior to tilling operations. As tilling is required periodically and at least once annually, the frequency of sediment removal will be reduced to small operations on a regular basis.

3.2.7.4. Tilling of Nonvegetated Basin Floor

In all cases, tilling must be preceded by thorough removal of surface sediment as previously above.

(a) Purposes. It is necessary to restore the natural infiltration capacity by overcoming the effects of surface compaction, and to control weed growth on the basin floor.

(b) Technique. Rotary tillers or disc harrows will normally serve this purpose. Light tractors should be employed for these operations. In the event that heavy equipment has caused deeper than normal compaction of the surface, these operations should be preceded by deep plowing. In its final condition after tilling, the basin floor should be level, smooth, and free of ridges and furrows to ease future removal of sediment and minimize the material to

be removed during future cleaning operations. A levelling drag, towed behind the equipment on the last pass, will accomplish this.

(c) Frequency. In the spring, the basin surface is usually quite porous due to the effects of frost and subsequent thawing. The infiltration capacity diminishes rapidly thereafter. To enhance infiltration capacity, tilling should be thorough once each season, from late June through September. To control vegetative growth, an additional light tillage may be advisable during the growing season. Precautions must be observed, however, to avoid any possibility of working sediment accumulations into the basin floor as a part of light cultivation for the purpose of weed control. It is therefore stressed again that any cultivation or tilling operation be preceded in all cases by careful sediment removal.

3.2.7.5. Side Slope Maintenance

(a) Purpose. To promote a dense turf with extensive root growth, thereby enhancing infiltration through the slope surface and prevent weeds from gradually taking over the slope areas.

(b) Frequency. Grasses of the fescue family are recommended for seeding primarily due to their adaptability to dry sandy soils, drought resistance, hardiness, and ability to withstand brief inundations. The use of fescues will also permit long intervals between mowings. This is important due to the relatively steep slopes which make mowing difficult. Mowing twice a year, once in June and again in September, is generally satisfactory. Refertilization with 10-6-4 ratio fertilizer at a rate of 500 lb per acre (11 lb per 1000 sq ft) may be required the second year after seeding.

3.2.8. References

1. Becker, B.C., M.L. Clar, R.R. Kautzman, Approaches to Stormwater Management, prepared by Hittman Associates, Inc., for the Office of Water Research, USDI, November, 1973.

2. Tourbier, J.T., R. Westmacott, A Handbook of Measures to Protect Water Resources in Land Development, Urban Land Institute, Washington, DC, 1981.

3. Anonymous, Controlling Storm Water Runoff in Developing Areas: Selected Best Management Practices, Metropolitan Washington Council of Governments, July 1979.

4. Hannon, J.B., Underground Disposal of Storm Water Runoff, Design Guidelines Manual, prepared by the California Department of Transportation in cooperation with the Federal Highway Administration, U.S. Department of Transportation, February 1980.

5. Weaver, R.J., Recharge Basins for Disposal of Highway Storm Drainage, Research Report 69-2, Engineering Research and Development Bureau, New York State Department of Transportation, Albany, NY, March 1971.

6. Aronson, D.A. and G.E. Seaburn, Appraisal of Operating Efficiency of Recharge Basins on Long Island, New York in 1969, U.S. Geological Survey Water Supply Paper 2001-D, 1974.

3.3 INFILTRATION TRENCH

(IT)

3.3.1. Description

An infiltration trench consists of a shallow excavated trench, generally 2 to 10 feet in depth backfilled with a coarse stone aggregate, allowing for temporary storage of storm runoff in the voids between the aggregate material. Stored runoff then gradually infiltrates into the surrounding soil. Figure 3-4 provides a typical section of infiltration trenches.

The surface of the trench will consist of stone, gabion, sand, or a grassed covered area with a surface inlet.

3.3.2. Applicability

An infiltration trench will generally be used on relatively small drainage areas. This practice can be used on residential lots, commercial areas, parking lots and open space areas. A trench may also be installed under a swale to increase the storage of the infiltration system.

3.3.3. Planning Considerations

3.3.3.1. Soil Permeability

The permeability or final infiltration rate of the various soil textural classifications will be a limiting factor in the selection of infiltration trenches by itself. The infiltration rate becomes a factor when combined with other considerations such as 1) minimum construction depth, 2) maximum allowable storage time, and 3) surface area requirements for a specified level of control. Soil textural classes with infiltration rates greater or equal to 0.27 inches per hour can be considered for use of infiltration trenches.

3.3.3.2. Depth of Trench

An infiltration trench is projected to range from 2 to 10 feet in stone reservoir depth. A trench with a grassed covered surface will consist of at least one foot of overlying soil above the aggregate reservoir. This 3 foot depth of aggregate is felt to represent the shallowest infiltration trench likely to be built. In general, the design engineer will seek to make the trench as deep as possible to minimize the surface area of the trench.

The final infiltration rate of the soil below the infiltration trench will dictate the maximum allowable trench depth. The maximum storage time of 3 days is to be used to determine the maximum storage depth of the trench.

3.3.3.3. Water Table, Bedrock, and Groundwater Conditions

The seasonally high ground water table as well as bedrock should be located at least 2 to 4 feet below the bottom of the trench at all times. Therefore these two parameters may often determine the maximum allowable depth for the trench. Also infiltration trenches shall be located at least 100 feet horizontally away from any water supply well.

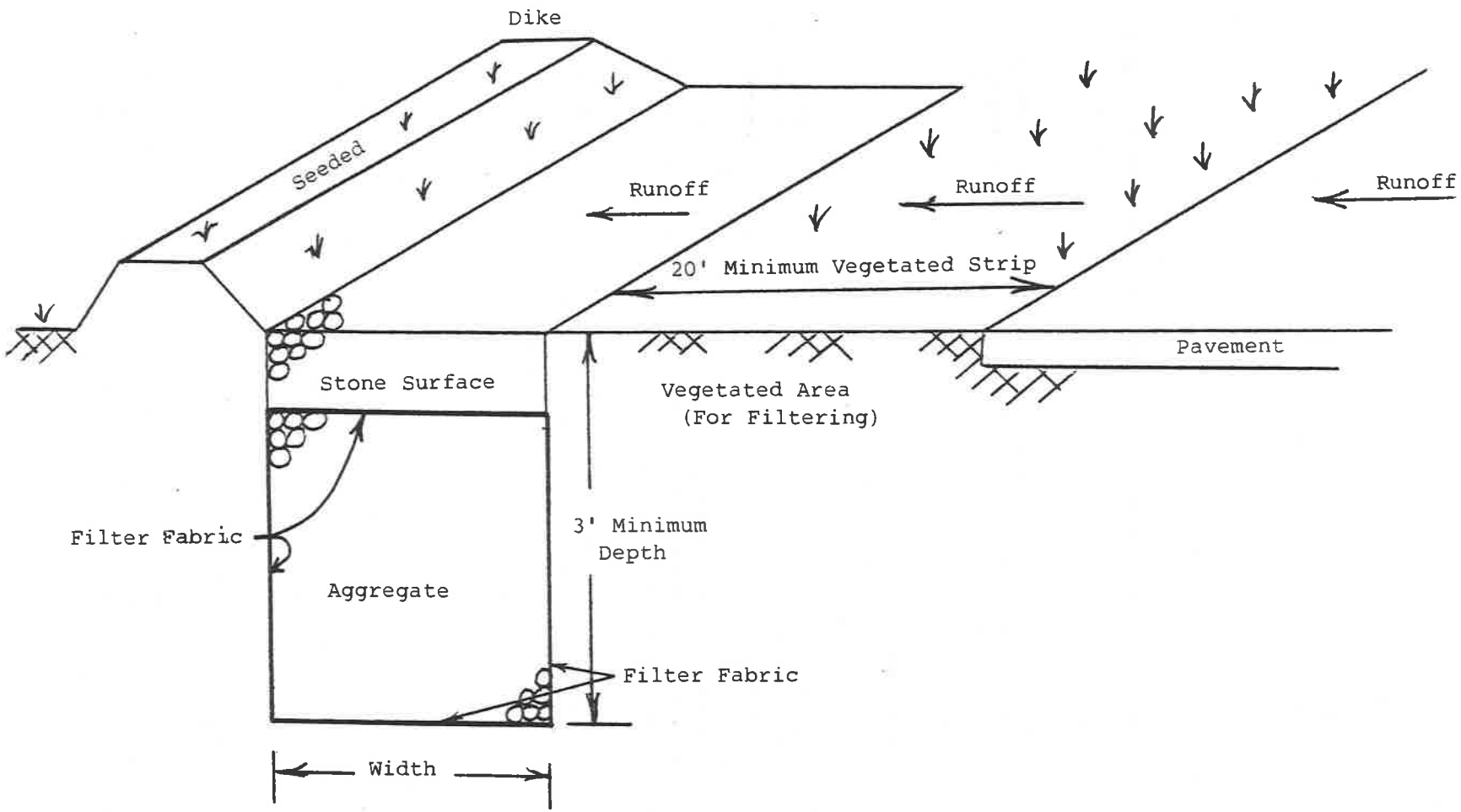


Figure 3-4. Typical Section of Infiltration Trenches
Modified after Frederick Co., MD. (1979)

3.3.4. Design Criteria

3.3.4.1. Design Storm

All hydrologic and hydraulic calculations shall be based on the design storm criteria provided in the Maryland SWM Regulations.

3.3.4.2. Storage Time

All infiltration trenches shall be designed to be empty within 3 days. Thus the maximum allowable storage time (T_s) of 72 hours shall be used.

3.3.4.3. Backfill Material

The aggregate material for the infiltration trench shall consist of a clean aggregate with a maximum diameter of 3" and a minimum diameter of 1-1/2". The aggregate should be graded such that there will be few aggregates smaller than the selected size. Void space for these aggregates are assumed to be between the range of 30 to 40 percent.

The aggregate fill material shall be completely surrounded as shown in Figure 3-4 with an engineering filter fabric. In the case of an aggregate surface, filter fabric should surround all of the aggregate fill material except for the top one foot.

3.3.4.4. Runoff Filtering

At all times, grease, oil, floatable organic materials, and settleable solids should be removed from runoff water before it enters the infiltration facility. These materials can take up storage capacity and reduce infiltration rates. Runoff filtering devices such as grass filter strips and sediment traps can be used to remove objectionable materials. The design and construction of vegetated filter strips is described in Section 3.7 of this chapter. All trenches with surface inlets shall be designed to capture sediment before discharging into the stone aggregates.

The use of infiltration trenches in combination with swales with check dams is recommended. In this situation the trench should be constructed below the swale. The pool created by the check dam will increase the volume of runoff infiltrated into the trench.

3.3.4.5. Overflow Channel

In general, because of the small drainage areas controlled by the infiltration trench, an emergency spillway is not necessary. In all cases, though, the overland flow path of surface runoff exceeding the capacity of the trench should be evaluated to preclude the development of uncontrolled, erosive concentrated flow. A non-erosive overflow channel leading to a stabilized watercourse shall be provided.

3.3.4.6. Seepage Analysis and Control

An analysis shall be made to determine any possible adverse effects of seepage zones when there are nearby building foundations, basements, roads parking lots, or sloping sites. Developments on sloping sites often require the use of extensive cut and fill operations. The use of infiltration trenches

on fill sites with steep slopes is not permitted. Fill areas can be very susceptible to slope failure due to slippage along the interface of the in-situ and fill material. This condition could be further aggravated if the fill material is allowed to saturate using infiltration practices. The methods for seepage analysis and estimation of infiltration rates using Darcy's law and flow nets can be used to conduct the seepage analysis.

When infiltration trenches are used in residential areas, special care must be taken to prevent seepage from the trenches causing wet basements. Infiltration trenches 3 or more feet deep shall be located at least 10 feet down gradient from foundation walls.

3.3.4.7. Hydrologic Design Methods

A hydrologic design method based on SCS procedures is provided in Chapter 4.

3.3.4.8. Observation Well

An observation well shall be installed in every infiltration trench. The observation well will serve two primary functions: 1) it will indicate how quickly the trench dewaters following a storm and 2) it will provide a method of observing how quickly the trench fills up with sediments.

The observation well should consist of perforated PVC pipe, 4 to 6 inches in diameter. It should be located in the center of the structure and be constructed flush with the ground elevation of the trench as shown in Figure 3-5. The top of the well shall be capped to discourage vandalism and tampering.

3.3.5. Water Quality

The effectiveness of this practice for runoff and pollution control is dependent upon the size and design of the infiltration facility. If a trench or a series of trenches are designed to collect and infiltrate the total volume of runoff for a design storm over a given drainage area, the practice will be effective for both runoff control and pollution abatement for storms up to and including the design storm.

3.3.6. Construction Specifications

3.3.6.1. Timing

An infiltration trench shall not be constructed or placed in service until all of the contributing drainage area has been stabilized and approved by the responsible inspector.

3.3.6.2. Trench Preparation

Excavate the trench to the design dimensions. Excavated materials shall be placed away from the trench sides to enhance trench wall stability. Large tree roots must be trimmed flush with the trench sides in order to prevent fabric puncturing or tearing during subsequent installation procedures. The side walls of the trench shall be roughened where sheared and sealed by heavy equipment.

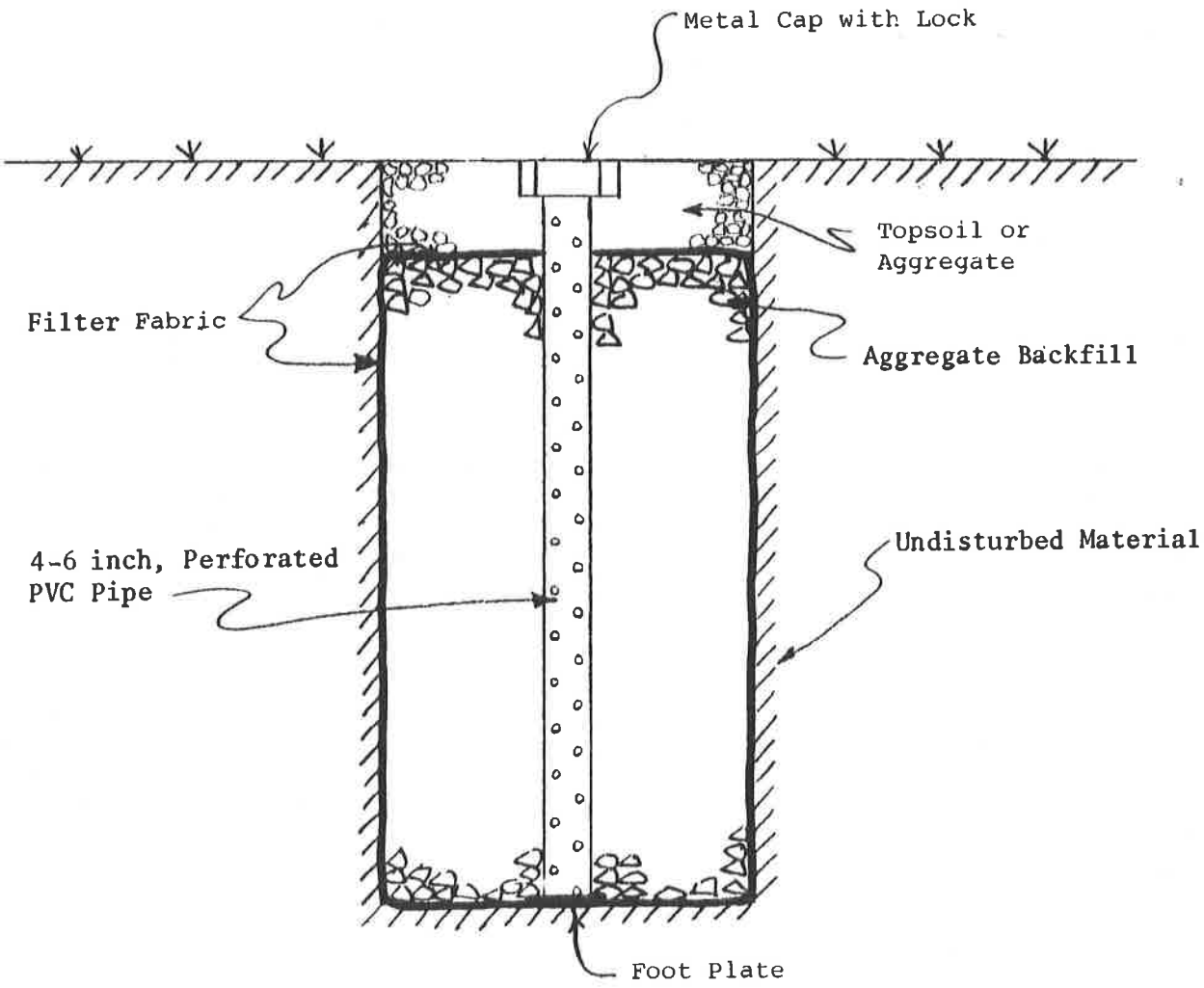


Figure 3-5. Observation Well Detail

3.5.4.6. Factor of Safety in Design

Some pavement designers have suggested that because open graded mixes are not as strong as dense graded mixes, the pavement thicknesses suggested in Table 3-2 might be insufficient and need to be increased. However, with normal and proper construction practices, sufficient subgrade compaction should be achieved so that with a well-drained subgrade, a minimum CBR of 6 or 7 could be used quite safely. These higher CBR values permit pavements to be considerably thinner, so it is assumed that there is an adequate safety built into the specifications given in Table 3-2. Further refinement of these designs is anticipated as a result of increased use of these materials.

3.5.4.7. Calculation of Void Space

Void space should be calculated according to the testing procedure recommended in Federal Highway Administration Report No. FHWA-RD-74-2, Design of Open-Graded Asphalt Friction Courses (Smith, Rice, and Spelman, 1974). The volume of the sample should be measured mechanically rather than calculated from a water displacement method because a great deal of water is absorbed.

3.5.4.8. Aggregate Gradation

The gradation required to obtain a porous asphaltic concrete pavement is of the "open" graded type as contrasted to the "dense" graded type which is capable of close packing. The following aggregate specification is recommended:

U.S. Sieve Series Size	Opening (mm)	Specification: Percent Passing by Weight
1/2 in.	12.70	100
3/8 in.	9.51	95-100
#4	4.76	30- 50
#8	2.38	5- 15
#200*	0.074	2- 5

*Aggregate should be uniformly graded between the #8 and #200 sieves.

Open graded mixes, due to their relatively high permeability to air and water, provided good resistance and durability to freeze/thaw conditions and to asphalt film oxidation.

3.5.4.9. Type and Quality of Aggregate

The aggregates selected for porous pavement construction should meet requirements of the standard specification for "Crushed Stone, Crushed Slag, and Crushed Gravel for Dry- or Water-Bound Macadam Base and Surface Courses of Pavements," ASTM D 693-77, with two exceptions. First, the gradation test must be of the open graded type described here. Second, a soundness test is required, as specified in ASTM D 692-79, Coarse Aggregate for Bituminous Paving Mixtures," to determine if the aggregate is susceptible to disintegration by water.

3.5.4.10. Asphalt Cement Grade in Mix

The suggested viscosity grade of asphalt cement to be used is AC-20 of

TABLE 3-2.

MINIMUM THICKNESS OF POROUS PAVING FOR VARIOUS LOADING CONDITIONS

Traffic Group	General Character	CBR 15 - plus	CBR 10 -	CBR 6 - 9	CBR 5 - less*	EAL
1	Light Traffic	5"	7"	9"		5 - less
2	Medium Light (Max. 1000 VPD)	6"	8"	11"		6 - 20
3	Medium (Max. 3000 VPD)	7"	9"	12"		21 - 75

* Studies indicated that for all traffic areas (1,2,3) with a CBR of 5 or less, the subgrade was improved to CBR 6 with crushed stone 2" size

VPD = vehicles per day
EAL = equivalent axle load (18 Kips) average daily

Source: Thelen, 1978.

TABLE 3-1. DESIGN SCHEME FOR POROUS PAVING*

We Must Know:	So We Can Calculate:	So We Can Decide on:	So We can Write Specifications on:
Soil Strength Frost Conditions Traffic Load	Conventional Thickness Requirements	Base Course Thickness	Material Design Installation Maintenance
Soil Permeability Maximum Storm Intensity & Frequency Allowable Runoff	Required Reservoir Capacity		
Slope Area Underground Drainage Surroundings Allowable Risk Allowable Cost	Design Options: Basic with Variations Off-site Drainage, etc.	Optimum Design	
Availability Cost of Materials Equipment & Labor Contractors	Cost and Times of Various Options	Economical & Feasible Design	

*Source: Thelen and Howe, 1978

(8) Prepare specifications for materials, product installation, and maintenance and test.

The logic of the design steps listed above is shown in Table 3-1.

3.5.4.1. Design Storm

All hydrologic and hydraulic calculations shall be based on the design storm criteria provided in the Maryland SWM Regulations.

3.5.4.2. Soil Borings

Test soil borings should be taken to determine the character and permeability of the soil. The ability of the soil to percolate the water passing through the pavement will determine the thickness of the base reservoir required. In some cases where the infiltration rate is moderate, an alternate approach may be applicable for the removal of water from the base reservoir to the water table, such auxiliary drainage as described in Section 3.5.4.14.

3.5.4.3. Storage Time

All porous paving installations shall be designed to drain the runoff stored in the reservoir course within 72 hours after the rainfall event. Table 2-2 provides values of the maximum depth of storage associated with the various soil textures.

3.5.4.4. Frost Heave

Soils capable of resisting frost heaving have been defined by a triangular chart, Asphalt Institute Publication MS-15 (1966); essentially the total clay and silt content of the subgrade soil must be less than 40 percent by weight. If a soil with a high susceptibility to frost heaving is being considered, for example a silt loam, the reservoir base course must extend below the frost line to allow for adequate drainage. In most cases, this depth below the frost line will exceed the depth of storage required to control the runoff volume from the site.

3.5.4.5. Pavement Design

The design of porous asphalt pavements equivalent to conventionally constructed pavements will depend primarily on the load-bearing capacity of the subgrade, the expected traffic volume, and the storage capacity of reservoir and base. Specifications of the Franklin Institute Research Laboratories have been used to design the porous asphalt pavement roadways illustrated in Table 3-2.

The traffic intensity will be a factor in the design depth requirement of the porous pavement. The traffic intensity is defined by the average daily Equivalent Axle Load (EAL), based on the equivalent of 18,000 pounds (18 Kips) axle load in the design lane. In most cases, the application of porous asphaltic pavement will be restricted to light traffic and parking lots. Thus, a minimum pavement thickness, from the top of the pavement to the subgrade soil, will generally be 9 inches to handle traffic intensity.

3.5.3. Planning Considerations

3.5.3.1. Soil Permeability

Areas considered suitable for porous asphalt paving should be located primarily in hydrologic soil groups "A" and "B" as indicated in Table 2-1. These soils, which include sand, loamy sand, sandy loam and loam, have minimum infiltration rates greater than 0.5 inches per hour.

Porous asphalt can also be located in some "C" soils, but they may need to be engineered with auxiliary drainage. The soils will only include a silt loam textural class having a minimum infiltration rate of 0.27 inches per hour. It is not recommended that porous asphalt paving be used over type "D" soil.

3.5.3.2. Ground Water, Bedrock, and Groundwater Conditions

The seasonally high groundwater table and bedrock shall be located at least 2 to 4 feet below the bottom of the reservoir base course. Also porous asphalt paving shall be located at least 100 feet horizontally away from any water supply well.

3.5.4. Design Criteria

The nature of each individual site will determine the design of the porous asphalt paving to be placed on it. A thorough prior examination of the site is of primary importance to the proper functioning of the porous pavement. Each case is different depending upon site and particularly soil and climate conditions, the wear expected on the surface itself, and the objectives of the particular use of the porous surface. An overview of the steps to be taken is provided below:

(1) Examine the site to determine its drainage. Walk over it and the surrounding area; examine the topographic and soil maps; and take soil cores and examine the horizons.

(2) Examine the various soils to determine their permeability. Run gradation tests of the soil cores to determine textural classification and use values in Table 2-1 to obtain infiltration rates.

(3) Determine the load bearing capability of the soil by lab test or categorically from soil maps. Design a pavement to carry the load and meet frost conditions. For each possible design, calculate the required base course thickness, considering grades.

(4) Determine the design storm volume.

(5) Evaluate the level of control provided by the porous asphalt paving.

(6) Consider ways to augment percolation or flow of water from the base course, if soil percolation is slow.

(7) Compare the most attractive options for probable cost, and complete the design using the most favorable one.

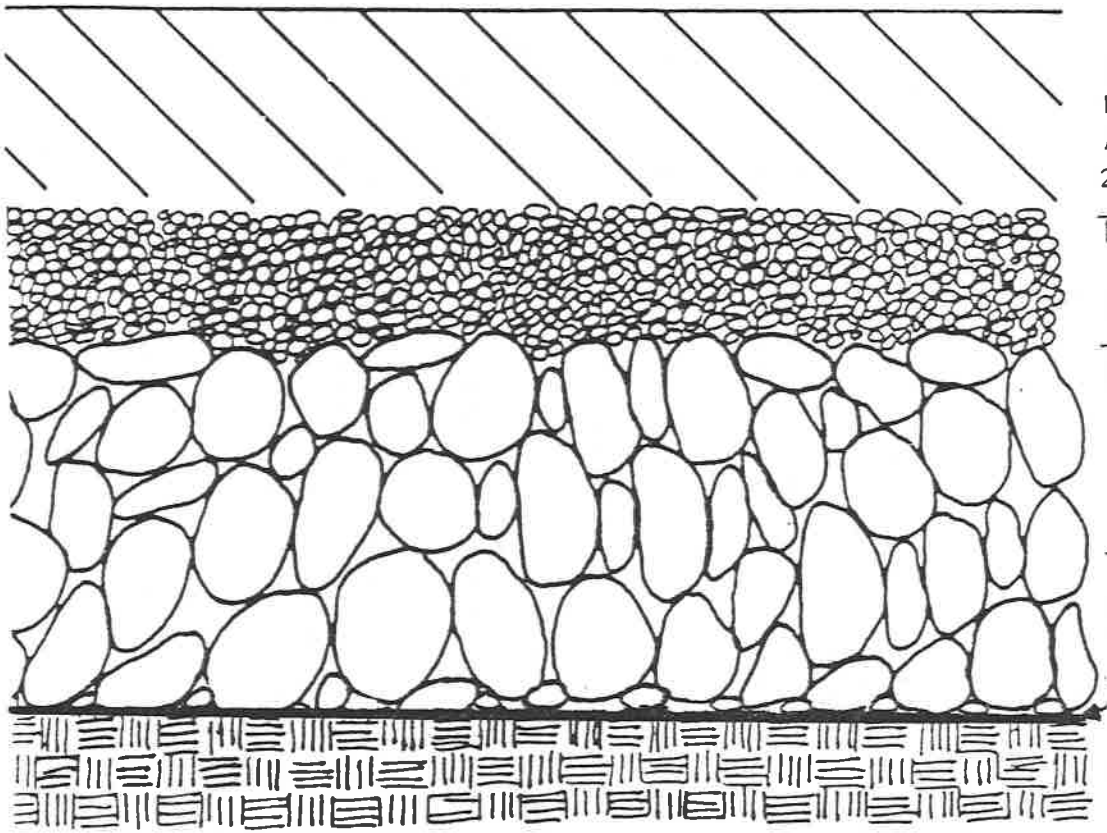


FIGURE 3-8

POROUS ASPHALT PAVING TYPICAL SECTION

Modified after Diniz, 1980 and City of Rockville, Maryland, 1982

3.5 POROUS ASPHALT PAVEMENT

(PA)

3.5.1. Description

Porous asphalt refers to a porous asphaltic paving material and a high void aggregate base that allows for rapid infiltration and temporary storage of runoff and rain falling on paved surfaces. In general porous pavement is composed of four layers as described below (Diniz, 1980).

(1) Minimally compacted subbase consisting of undisturbed existing soil. Auxiliary drainage structures (French drains, pipe drains, etc.) may also be required for soils with slower infiltration rates.

(2) Reservoir base course consisting of 1 to 2 inch diameter stone aggregate. The thickness of this reservoir layer is determined from runoff storage needs and frost depth considerations underlain by filter fabric.

(3) Two inches of 1/2-inch aggregate to stabilize the reservoir base course surface.

(4) Porous asphalt concrete surface course with a thickness that is based on bearing strength and pavement design requirements. In most applications, 2-1/2 to 4 inches have been found to be sufficient.

In addition, a layer of engineering filter fabric shall be placed between the soil and the reservoir base course, as shown in the typical porous asphalt pavement cross section presented in Figure 3-8.

Porous asphalt paving is used to recharge groundwater supplies and reduce stormwater runoff and water pollution from paved, low-volume traffic areas by providing a bearing surface having adequate strength to accommodate vehicles while allowing infiltration of surface water and filtration of pollutants.

3.5.2. Applicability

This practice is applicable as a substitute for conventional asphalt pavement on parking areas and low-traffic volume roads provided that the grades, subsoil drainage characteristics and groundwater table conditions are suitable for such use. In general the grades shall be very gentle to flat, subsoil shall have at least moderate permeability ($f \geq 0.27$ in/hr) and the depth to the water table or bedrock shall be 2 to 4 feet.

Possible areas for use of this paving material include (VSWCB, 1979):

(1) Parking lots, especially fringe or overflow parking areas;

(2) Parking aprons, taxiways, and runway shoulders at airports;

(3) Emergency stopping and parking lanes and vehicle cross-overs on divided highways; and

(4) Low-traffic volume roads.

most convenient time during construction to ensure fabric conformity to the excavation sides. Soil piping, fabric clogging, and possible surface subsidence will be avoided by this remedial process.

3.4.6.8. Unstable Excavation Sides

Vertically excavated trench walls may be difficult to maintain in areas where the soil moisture is high or where soft cohesive or cohesionless soils predominate. These conditions may require laying back of the side slopes to maintain stability; trapezoidal rather than rectangular cross sections may result.

3.4.6.9. Foundation Protection

Dry wells 3 or more feet deep shall be located at least 10 feet down gradient from foundation walls.

3.4.6.10. Observation Well

An observation well, as described in subsection 3.4.4.8 and Figure 3-5, will be provided. The depth of the well, at the time of installation, will be clearly marked on the well cap.

3.4.7. Maintenance

Dry wells shall be designed to minimize maintenance. However, it is recognized that all infiltration facilities are subject to clogging by sediment, oil, grease, grit and other debris. In addition, the performance and longevity of these structures is not well documented. Consequently, a monitoring observation well is required for all infiltration structures.

The observation well should be monitored periodically. For the first year after completion of construction, the well should be monitored on a quarterly basis and after every large storm. It is recommended that a log book be maintained indicating the rate at which the facility dewaters after large storms and the depth of the well for each observation. Once the performance characteristics of the structure have been verified, the monitoring schedule can be reduced to an annual basis, unless the performance data indicate that a more frequent schedule is required.

3.4.8. References

1. Becker, B.C., M.L. Clar, and R.R. Kautzman, Approaches to Stormwater Management, prepared by Hittman Associates, Inc. for the Office of Water Resources Research, USDI, November, 1973.

2. Sullivan, R.H., editor, Urban Stormwater Management, Special Report No. 49, American Public Works Association, Chicago, Illinois, 1981.

3. Anonymous, Controlling Stormwater Runoff in Developing Areas: Selected Best Management Practices, Metropolitan Washington Council of Governments, July, 1979.

4. Design Guidelines for Subsurface Drainage Structures, MIRAFI, Inc., P.O. Box 240967, Charlotte, NC 28224.

3.4.6. Construction Specifications

3.4.6.1. Timing

A dry well shall not be constructed or placed in service until all of the contributing drainage area has been stabilized and approved by the responsible inspector.

3.4.6.2. Dry Well Preparation

Excavate the dry well to the design dimensions. Excavated materials shall be placed away from the excavated sides to enhance wall stability. Large tree roots shall be trimmed flush with the sides in order to prevent fabric puncturing or tearing during subsequent installation procedures. The side walls of the dry well shall be roughened where sheared and sealed by heavy equipment

3.4.6.3. Fabric Laydown

The filter fabric roll shall be cut to the proper width prior to installation. The cut width must include sufficient material to conform to well perimeter irregularities and for a 6-inch minimum top overlap. Place the fabric roll over the well and unroll a sufficient length to allow placement of the fabric down into the well. Stones or other anchoring objects should be placed on the fabric at the edge of the well to keep the lined well open during windy periods. When overlaps are required between rolls, the upstream roll shall lap a minimum of 2 feet over the downstream roll in order to provide a shingled effect. The overlap ensures fabric continuity or the fabric conforms to the excavation surface during aggregate placement and compaction.

3.4.6.4. Aggregate Placement and Compaction

Drainage aggregate shall be placed in lifts and compacted using plate compactors. As a rule of thumb, a maximum loose lift thickness of 12 inches is recommended. The compaction process ensures fabric conformity to the excavation sides, thereby reducing the potential for soil piping and fabric clogging.

3.4.6.5. Overlapping and Covering

Following aggregate placement, the fabric previously weighted by stones should be folded over the aggregate to form a 6" minimum longitudinal lap. The desired fill soil should be placed over the lap at sufficient intervals to maintain the lap during subsequent backfilling.

3.4.6.6. Contamination

Care shall be exercised to prevent natural or fill soils from intermixing with the drainage aggregate. All contaminated aggregate shall be removed and replaced with uncontaminated aggregate.

3.4.6.7. Voids Behind Fabric

Voids can be created between the fabric and excavation sides and should be avoided. Removing boulders or other obstacles from the trench walls is one source of such voids. Natural soils should be placed in these voids at the

In all cases, however, the overland flow path of surface runoff exceeding the capacity of the well shall be evaluated to preclude the development of uncontrolled, erosive concentrated flow. An overflow system leading to a stabilized channel or watercourse including measures to provide non-erosive flow conditions along its length and at the outfall shall be provided. An overflow orifice shall be installed in the inflow pipe above the dry well surface area to allow drainage in extreme events as shown in Figure 3-6.

3.4.4.6. Seepage Analysis and Control

A foundation analysis shall be made to determine any possible adverse effects of seepage zones on nearby building foundations, roads, parking lots, and other structures. This is particularly important on a steeply sloping site. Developments on sloping sites often require the use of extensive cut and fill operations. The use of dry wells on large or steeply sloping fill sites is not recommended. Fill areas can be very susceptible to slope failure due to slippage along the interface of the in-situ and fill material. This condition could be further aggravated if the fill material is saturated by using infiltration practices. The methods for seepage analysis and estimation of infiltration rates using Darcy's law and flow nets can be used to conduct the seepage analysis.

When dry wells are used in residential areas, special care must be taken to prevent seepage from the dry wells creating wet basements. Dry wells 3 or more feet deep should be located at least 10 feet down gradient from foundation walls.

3.4.4.7. Hydrologic Design Methods

A hydrologic design method based on SCS procedures is provided in Chapter 4.

3.4.4.8. Observation Well

An observation well shall be installed in every dry well. The observation well will serve two primary functions: 1) it will indicate how quickly the trench dewaters following a storm, and 2) it will provide a method of observing how quickly the dry well fills up with silt and thus requires maintenance cleanout.

The observation well should consist of perforated PVC pipe, 4 inches in diameter. It should be located in the center of the structure and be constructed flush with the ground elevation of the structure as shown in Figure 3-5. The top of the well shall be capped to discourage vandalism and tampering. The depth of the well at the time of installation should be clearly marked on the well cap.

3.4.5. Water Quality

The effectiveness of this practice for runoff and pollution control is dependent upon the size and design of the structure. If a dry well is designed to collect and infiltrate the total volume of runoff for a design storm over a given drainage area, the practice theoretically should be effective for both runoff control and pollution abatement for storms up to and including the design storm (COG, 1979).

The maximum depth of dry wells will generally be determined by a number of factors. These include: 1) the soil textural characteristics and 2) the depth to the water table or bedrock.

3.4.3.3. Water Table, Bedrock, and Groundwater Conditions

The bottom of the dry well shall be located at least 2 to 4 feet above the seasonally high groundwater table as well as bedrock. Therefore, these two parameters will often determine the maximum allowable depth for the well. Also dry wells shall be located at least 100 feet horizontally away from any water supply well.

3.4.4. Design Criteria

3.4.4.1. Design Storm

All hydrologic and hydraulic calculations shall be based on the design storm criteria provided in the Maryland SWM Regulations.

3.4.4.2. Storage Time

All dry wells shall be designed to be empty within 3 days from the beginning of the storm. Thus an allowable storage time (T_s) of 72 hours shall be used.

3.4.4.3. Backfill Material

The aggregate fill material for the infiltration trench shall consist of a clean aggregate with a maximum diameter of 3" and a minimum diameter of 1-1/2". The aggregate should be poorly graded with few stones smaller than the selected size. Void space for these aggregates are assumed to be between the ranges of 30 to 40 percent.

Any stone aggregate shall be completely surrounded with an engineering filter fabric as shown in Figure 3-6.

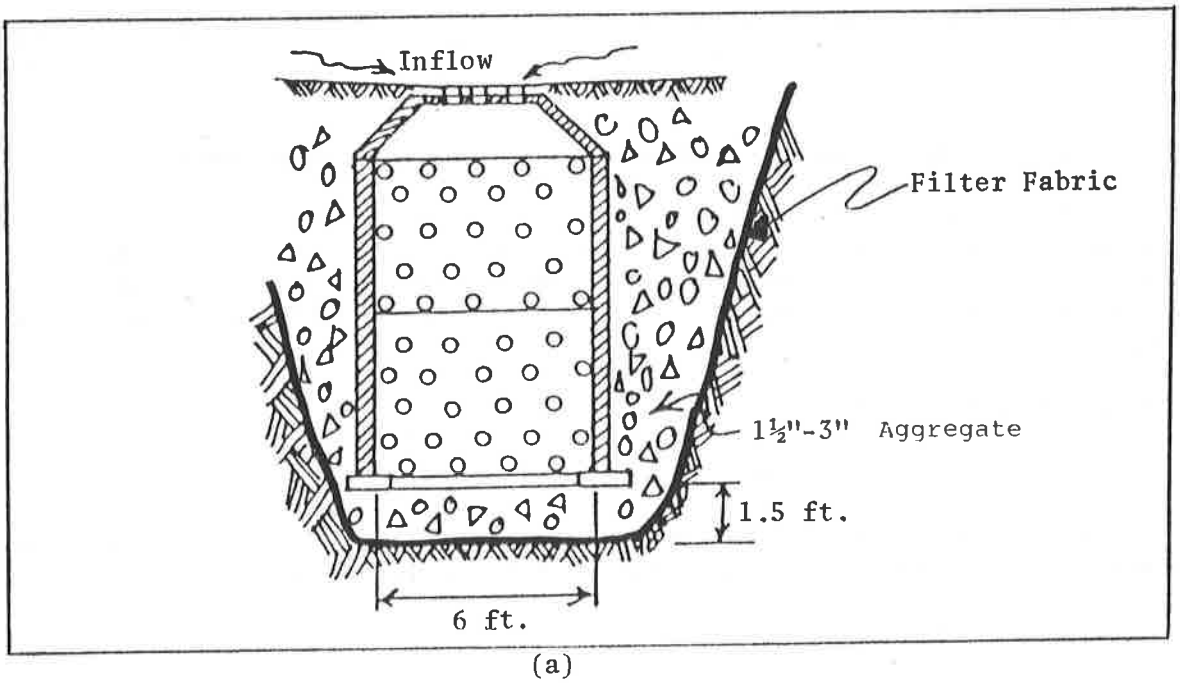
3.4.4.4. Runoff Filtering

At all times grease, oil, floatable organic materials, and settleable solids should be removed from runoff water before it enters the dry well. These materials can take up storage capacity in addition to reducing infiltration rates. Screens should be placed at the top of the roof leader to prevent leaves from entering the dry well.

When a runoff filtering system or structure is included in the design, the maintenance requirements shall be included.

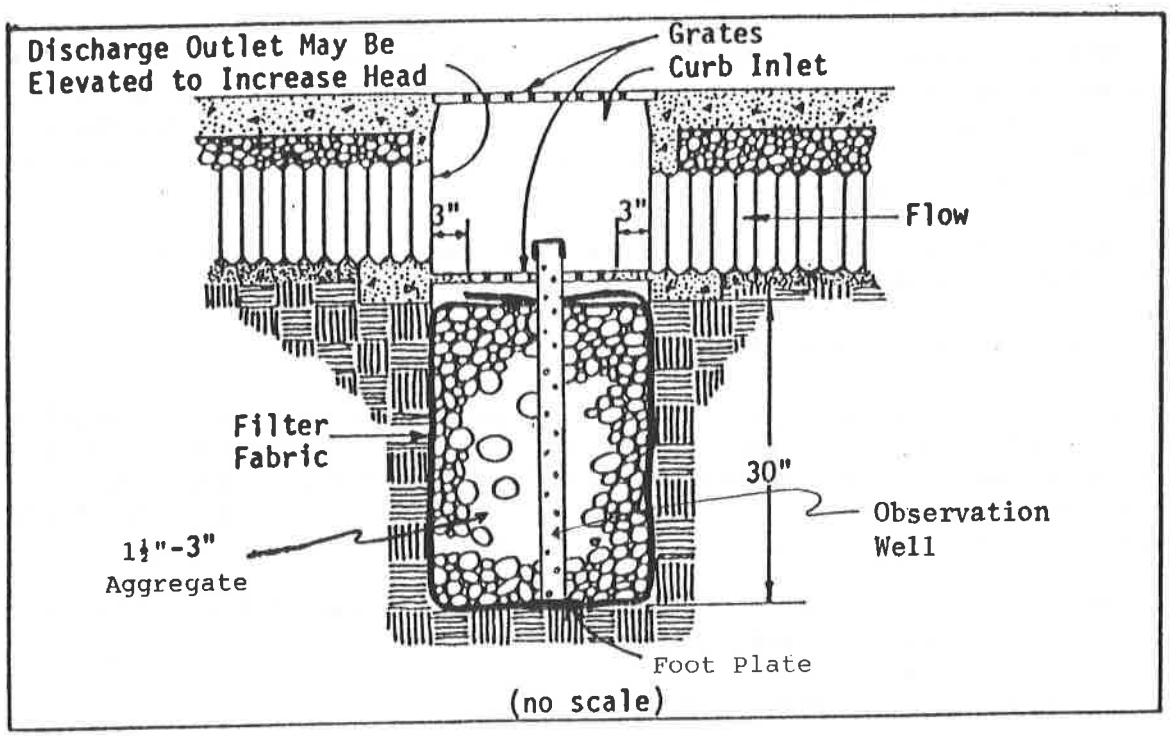
3.4.4.5. Outflow Structures

Other than overflow provisions outflow structures are generally not used with infiltration systems. Some counties, however, have been requiring the use of a positive drain or discharge pipe from such structures. This practice is not acceptable, though, because it converts the infiltration structure into a detention structure, unless the positive drain is located such that a volume of storage is provided below the positive drain invert.



(a)

Source: Modified from Sullivan (1981)



(b)

Source: COG (1979)

Figure 3-7. Examples of Storm Drain Catch Basins Used as Dry Wells

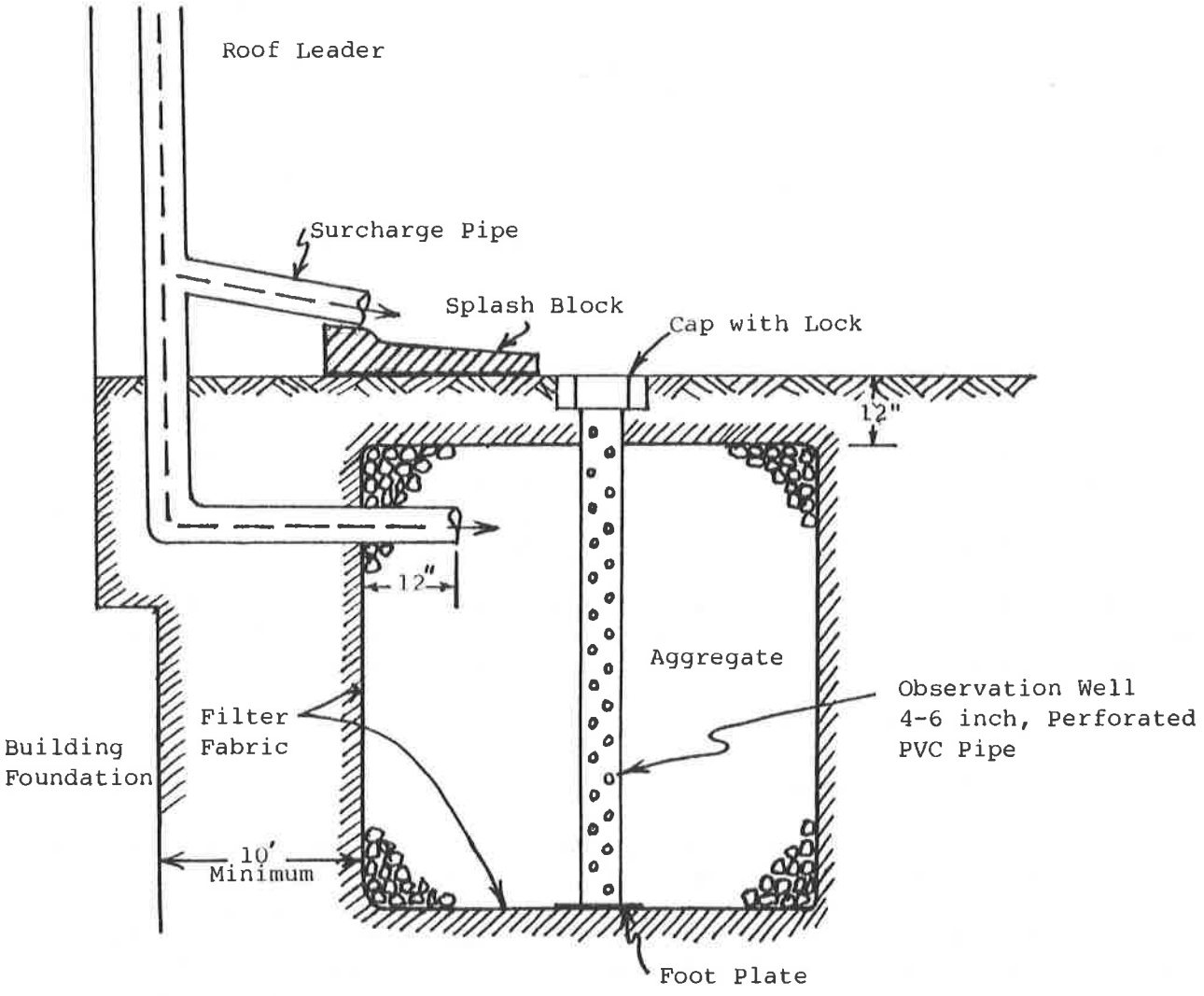


Figure 3-6. Typical Dry Well Cross Section

3.4 DRY WELL

(DW)

3.4.1. Description

A dry well consists of a small excavated pit backfilled with aggregate. The dry well is similar to the infiltration trench previously described but differs in two ways. The dry well is generally a much smaller structure particularly with respect to the surface area dimensions. The depth of the well will generally range from 3 to 12 feet. An important difference between the dry well and the trench is the inflow mechanism. Inflow to the dry well will occur by means of an inflow pipe and through surface infiltration. As previously described, the infiltration trench can only accept inflow through surface or inlet inflow. A typical dry well cross section is presented in Figure 3-6.

3.4.2. Applicability

A dry well will generally be used to capture and store runoff from roof top areas of less than one acre in surface area. This practice can be used to store runoff from residential, commercial, industrial and institutional roof tops. A secondary application can be found in those instances where storm drain catch basins can be built as open-bottomed structures to provide for infiltration of stormwater as shown in Figure 3-7.

For both areas of application, the site conditions must include soils that are suitable for infiltration with sufficient depth available between the bottom of the well and the top of the groundwater table.

3.4.3. Planning Considerations

3.4.3.1. Soil Permeability

The permeability or final infiltration rate of the various soil textural classifications will be a limiting factor in the selection of dry wells. The infiltration rate becomes a factor when combined with other considerations such as: 1) minimum construction depth, 2) maximum allowable storage time, and 3) surface area requirements for a specified level of control. Soil textural classes with infiltration rates greater or equal to 0.27 inches per hour are acceptable for use of dry wells.

3.4.3.2. Depth of Well

A dry well is expected to range from 3 to 12 feet in depth. In all cases the top foot of the well will consist of a soil filter medium. Thus, a 3 foot deep well would consist of 1 foot of soil filter media and 2 feet of aggregate storage area. This 3 foot depth is felt to represent the shallowest dry well likely to be built. In general, the developer and design engineer will seek to make the dry well as deep as possible to obtain the maximum area of control possible. Table 2-2 indicates that a silt loam soil texture with an f value of 0.27 inches per hour can drain a 4-foot deep storage area in a 72-hour period.

3.3.6.10. Traffic Control

Heavy equipment and traffic shall be restricted from travelling over the infiltration areas to minimize compaction of the soil.

3.3.6.11. Observation Well

An observation well, as described in subsection 3.3.4.8 and Figure 3-5 shall be provided. The depth of the well at the time of installation will be clearly marked on the well cap.

3.3.7. Maintenance

Infiltration trenches shall be designed to minimize maintenance. However, it is recognized that all infiltration facilities are subject to clogging by sediment, oil, grease, grit and other debris. In addition, the performance and longevity of these structures is not well documented. Consequently, a monitoring observation well is required for all infiltration structures.

The observation well shall be monitored periodically. For the first year after completion of construction, the well should be monitored on a quarterly basis and after every large storm. It is recommended that a log book be maintained indicating the rate at which the facility dewaters after large storms and the depth of the well for each observation. Once the performance characteristics of the structure have been verified, the monitoring schedule can be reduced to an annual basis, unless the performance data indicate that a more frequent schedule is required.

Sediment build-up in the top foot of stone aggregates or the surface inlet should be monitored on the same schedule as the observation well. A monitoring well in the top foot of stone aggregate will be required when the trench has a stone surface. Sediment deposited shall not be allowed to build up to the point where it will reduce the rate of infiltration into the trench.

3.3.8. References

1. Stormwater Management Design Manual for Frederick Co., Maryland, 1979.

2. Anonymous, Controlling Stormwater Runoff in Developing Areas: Selected Best Management Practices, Metropolitan Washington Council of Governments, July, 1979.

3. Percolation Pits; Their Design, Construction, Use and Maintenance for Stormwater Disposal, Ground Water Recharge, and Surface Water Quality Protection in Adams County, Colorado, Adams County Planning Department.

3.3.6.3. Fabric Laydown

The filter fabric roll must be cut to the proper width prior to installation. The cut width must include sufficient material to conform to trench perimeter irregularities and for a 6-inch minimum top overlap. Place the fabric roll over the trench and unroll a sufficient length to allow placement of the fabric down into the trench. Stones or other anchoring objects should be placed on the fabric at the edge of the trench to keep the lined trench open during windy periods. When overlaps are required between rolls, the upstream roll should lap a minimum of 2 feet over the downstream roll in order to provide a shingled effect. The overlap ensures fabric continuity or to ensure that the fabric conforms to the excavation surface during aggregate placement and compaction.

3.3.6.4. Stone Aggregate Placement and Compaction

The stone aggregate should be placed in lifts and compacted using plate compactors. As a rule of thumb, a maximum loose lift thickness of 12 inches is recommended. The compaction process ensures fabric conformity to the excavation sides, thereby reducing the potential for soil piping, fabric clogging, and settlement problems.

3.3.6.5. Overlapping and Covering

Following the stone aggregate placement, the filter fabric shall be folded over the stone aggregate to form a 6" minimum longitudinal lap. The desired fill soil or stone aggregate shall be placed over the lap at sufficient intervals to maintain the lap during subsequent backfilling.

3.3.6.6. Contamination

Care shall be exercised to prevent natural or fill soils from intermixing with the stone aggregate. All contaminated stone aggregate shall be removed and replaced with uncontaminated stone aggregate.

3.3.6.7. Voids Behind Fabric

Voids can be created between the fabric and excavation sides and shall be avoided. Removing boulders or other obstacles from the trench walls is one source of such voids. Natural soils should be placed in these voids at the most convenient time during construction to ensure fabric conformity to the excavation sides. Soil piping, fabric clogging, and possible surface subsidence will be avoided by this remedial process.

3.3.6.8. Unstable Excavation Sides

Vertically excavated walls may be difficult to maintain in areas where the soil moisture is high or where soft cohesive or cohesionless soils predominate. These conditions may require laying back of the side slopes to maintain stability; trapezoidal rather than rectangular cross sections may result.

3.3.6.9. Vegetative Buffer

A vegetative buffer of at least 20 feet (wider, if possible) shall be used to intercept surface runoff from all impervious areas.

3.7 VEGETATIVE FILTER STRIP

(VFS)

3.7.1. Description

A vegetative filter strip or buffer area is an area of vegetative cover through which runoff may flow before it leaves the site. As the water containing sediment and other pollutants flows through the filter strip, some of the sediment and pollutants are removed by filtering, absorption, and gravity sedimentation as the flow velocity is reduced.

3.7.2. Applicability

Vegetative filter strips can be used by themselves or in conjunction with other stormwater management measures. A vegetative filter can provide the following benefits (Clar, 1981):

(1) Serves as an effective method of reducing sediment yield by protecting the soil from rainfall impact energy.

(2) Reduces runoff by reducing overland flow velocities, increasing the time of concentration and increasing infiltration.

(3) Removes suspended sediment in overland flow by filtering, absorption, and gravity sedimentation as the flow velocity is reduced.

Vegetative filter strips should be considered for use in the following locations:

(1) Surrounding stormwater management infiltration structures, to reduce the sediment load delivered to the structure.

(2) Adjacent to all watercourses (waterways, diversions) and water bodies (streams, ponds and lakes).

(3) Along the tops and toes of slopes.

(4) At the outlets of stormwater management structures.

3.7.3. Planning Considerations

Almost any stand of vegetative cover will remove some sediment from water flowing through it. These filter strips can occur naturally or be man-made. The type of vegetation used can be very broad. Best performance is associated with dense stands of turf-forming grasses.

The most common, naturally-occurring filter strips are those vegetative stands associated with floodplains or found adjacent to natural swales and watercourses. In some cases, preservation of these areas is all that is required for them to continue to function as filter strips. As these filter strips are expected to perform for several months or more, a top dressing of fertilizer is recommended to improve the stand. In areas where natural vegetation is of poor quality or nonexistent, it is possible to establish a man-made vegetative filter (Albrecht and Barfield, 1981).

5. Searcy, J.K., Design of Roadside Drainage Channels, Hydraulic Design Series No. 4, U.S. Bureau of Public Roads, U.S. Government Printing Office, Washington, DC 20402.

6. Stormwater Management Design Manual, for Frederick County, Maryland, 1979.

3.6.6. Maintenance

(a) Grass Lined Channels. During the initial establishment of grass-lined channels, any repairs and grass establishment shall be done immediately. After grass has become established, the channel shall be checked periodically to determine if the grass is staying in place. Any mowing of the channel should not damage the grass. Permanent channels shall be mowed periodically to maintain their capacity.

Grassed waterways shall be inspected periodically, especially after large storms, to determine whether there are erosion problems that need to be controlled, to remove accumulated debris, and to check the condition of the vegetation.

(b) Other Linings. Earth or riprap lined channels shall be checked periodically to ensure that scouring is not occuring at the soil surface or beneath the riprap layer. The channel shall also be checked for slumping of the side slopes and to determine if any stones particularly in channel bends or constrictions have been dislodged by the flow.

(c) Sediment Deposition. If the channel is below a high sediment-producing area, sediment should be trapped using vegetative buffers or sediment traps before it enters the channel. If sediment is deposited in grass-lined channels, it shall be removed promptly to prevent damage to the grass. Sediment deposited in riprap and earth channels shall be removed when it reduces the capacity of the channel.

(d) Homeowner Responsibilities. In residential subdivisions, swale maintenance, such as grass cutting and debris removal is usually the responsibility of the homeowner. More education may be necessary to inform the property owner of these responsibilities and of the need to discourage the off-road parking along swale areas, especially during wet periods when the swale grasses and underlying soils are most vulnerable to damage. Also education is necessary so that the homeowner does not remove the check dams. Such activities can alter the drainage configuration of the swale area and kill the vegetation that stabilizes it and provides natural treatment of runoff.

3.6.7. References

1. Becker, B.C., M.L. Clar, R.R. Kautzman, "Approaches to Stormwater Management," prepared by Hittman Associates, Columbia, MD, for the Office of Water Resources Research, U.S. Department of the Interior, Washington, DC, 1973.

2. Post, Buckley, Schuh and Jernigan, Inc., "Evaluation of Two Best Management Practices: A Grassy Swale and a Retention/Detention Pond," prepared for the Brevard County Water Resources Department and County Board of Commissioners, Brevard County, Florida, January 1982.

3. Stormwater Workshop: Best Management Practices, Regional Planning Council, Baltimore, MD, 1981.

4. Anonymous, "Controlling Stormwater Runoff in Developing Areas: Selected Best Management Practices," Metropolitan Washington Council of Governments, July 1979.

(b) Parabolic Channels. Parabolic channels are often used where the quantity of water to be handled is larger and where space is available for a wide, shallow channel with low velocity flow. Riprap should be used where higher velocities are expected and where some dissipation of energy (velocity) is desired. Combinations of grass and riprap are also useful where there is continuous low flow in the channel.

(c) Trapezoidal Channels. Trapezoidal channels are often used where the quantity of water to be carried is large and conditions require that it be carried at a relatively high velocity.

A cross-section of a 60-foot-side road right-of-way is shown in Figure 3-11. This cross-section illustrates the common use of center crown sloping at a rate of one-quarter inch per foot toward a swale on each side of the street. Sidewalks can be placed along the swales' banks where hydraulic capacities permit gentle slopes.

In general, swales adjacent to a roadway should have a section with a side slope not steeper than 2:1 (horizontal to vertical) and should preferably have a rounded bottom.

3.6.4.7. Channel Linings

(a) Grass. The grass type used shall be appropriate for the site conditions, i.e., drainage tolerance, shade tolerance, maintenance requirements, etc. The vegetation should have a dense root system and be water tolerant. Refer to Vegetative Practices in Maryland Standards and Specifications for Soil Erosion and Sediment Control.

(b) Riprap. Riprap shall meet the design criteria set forth in the Riprap Standard in the Maryland Standards and Specifications for Soil Erosion and Sediment Control.

3.6.4.8. Outlets

Every swale or waterway shall have a stable outlet. This outlet may be another waterway, a stabilized open channel, etc. In all cases, the outlet shall discharge in such a manner as not to cause erosion. Outlets shall be constructed and stabilized before operating the waterway.

Outlet conditions for all channels are very important especially at the transition from a man-made lining such as concrete to a vegetative lining. Appropriate measures shall be taken to dissipate the energy of the flow to prevent scour of the receiving channel. Refer to Outlet Protection Standard in the Maryland Standards and Specifications for Soil Erosion and Sediment Control.

3.6.5. Construction Specifications

The construction specifications provided in the Standards and Specifications for Grassed Waterway of the Maryland Standards and Specifications for Soil Erosion and Sediment Control, shall be used for this practice.

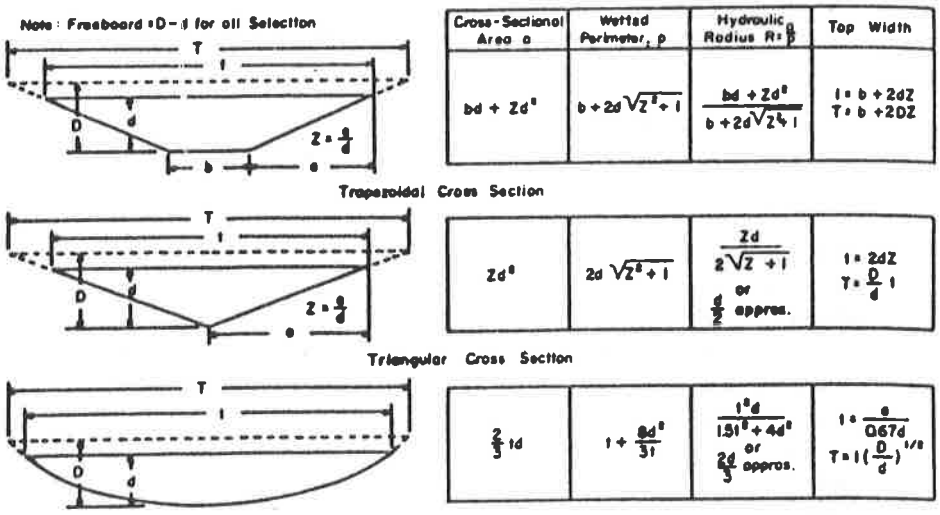


Figure 3-12. Properties of Typical Channel Cross Sections

TABLE 3-4. PERMISSIBLE VELOCITIES FOR VEGETATED CHANNELS*

No.	Cover [6/]	Slope Range (Percent)	Permissible Velocity: Erosion[2/] Resistant Soils <K. 3 fps	Permissible Velocity: Easily[2/] Eroded Soils> K- .3 fps
1.	Bermudagrass, Midland and Coastal, Tufcote[1/]	0-5	6.0	5.0
		5-10	5.0	4.0
		over 10	4.0	3.0
2.	Kentucky 31 Tall Fescue, Kentucky Bluegrass	0-5	5.0	4.0
		5-10	4.0	3.0
		over 10	3.0	2.0
3.	Grass-legume mixture	0-5[3/]	4.0	3.0
		5-10	3.0	2.0
4.	Red Fescue Redtop Lespedeza, sericea Alfalfa	0-5[4/]	3.5	2.5
5.	Annuals[5/] Common Lespedeza Sundangrass Small grain Ryegrass	0-5[5/]	3.0	2.0
6.	Rock riprap section for temp. const.	5-10	8.0	6.5
		over 10	7.0	6.0

1/ Common bermudagrass is a restricted noxious weed in Maryland

2/ Soil erodibility factor (K), <= Less than, > = more than

3/ Do not use on slopes steeper than 10 percent, except for vegetated side slopes in combination with stone or concrete or highly resistant vegetative center sections.

4/ Do not use on slopes steeper than 5 percent except for side slopes in a combination channel as in 3/ above.

5/ Annuals - used on mild slopes or as temporary protection until permanent covers are established. Use on slopes steeper than 5 percent is not recommended.

6/ Good, dense vegetative cover is assumed.

* Source: Maryland Standards and Specifications for Soil Erosion and Sediment Control, 1983.

presented in Table 3-4.

3.6.4.4. Capacity

The swale must have sufficient capacity to pass the peak discharge rate of the design storm above the check dam.

The channel above the check dams shall be designed in accordance with the Manning Formula, unless more detailed design procedures (backwater programs, for example) are required by the approving agency. The Manning Formula is:

$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$$

where: Q = flow rate, in cubic feet per second (cfs)

n = roughness coefficient

R = hydraulic radius (feet)

S = hydraulic gradient (ft/ft)

A = cross sectional area (ft^2)

3.6.4.5. Side Slope

The maximum side slopes shall be governed by the soil condition, type of flow, amount of flow and channel lining. In general, the side slopes shall not exceed the following criteria:

Seeded grasses	3 (horizontal) : 1 (vertical)
Sod	3:1
Riprap	2:1
Gabion baskets	can be vertical*
9" Gabion mats	1 1/2:1

*Special designs to be stepped or placed at 1:6 for heights over 5'.

3.6.4.6. Cross Sections

Channel cross sections may be vee-shaped, parabolic, or trapezoidal. Properties of typical channel cross-sections are shown in Figure 3-12.

(a) Vee-Shaped (Triangular) Ditches. Vee-shaped ditches are generally used where the quantity of water to be handled is relatively small, such as along roadsides. A grass or sod lining will suffice where velocities in the ditch are low. For steeper slopes where high velocities are encountered, a riprap lining may be necessary.

3.6.3.3. Water Table, Bedrock and Groundwater Considerations

The seasonally high ground water table or bedrock should be at least 1 to 2 feet below the bottom of the swale. Local officials may require greater depths to the groundwater table where proposed developments are expected to have large pollutant loads. It can be observed that one of the advantages of swales is that they allow the use of infiltration methods in permeable soils with relatively high water tables.

3.6.3.4. Other Considerations

In planning future street drainage systems, officials should weigh heavily the offsite advantages of using vegetated swales instead of curb and gutter systems. The following considerations should also be taken into account:

(1) Vegetated swales are generally less expensive to install than curb and gutter systems.

(2) Roadside swales keep flow away from the street surface during rainstorms, reducing the potential for hydroplaning of auto tires and wet brake linings.

(3) Vegetated swales require more maintenance than curb and gutter systems (mowing, seeding, debris removal, etc.)

(4) Roadside swales are subject to damage due to snow plowing and off street parking.

(5) Streets with swales may require more right-of-way and are less compatible with sidewalk systems.

(6) Roadside swales become less feasible as the number of driveway entrances requiring culverts increases.

(7) Roadside swales can be used in conjunction with infiltration trenches and basins to further attenuate runoff and improve its quality.

(8) Swales are not usable in all cases where poorly drained soils, extreme slope conditions, or the lack of positive outfalls exists.

3.6.4. Design Criteria

3.6.4.1. Design Storm

All hydrologic and hydraulic calculations shall be based on the design storm criteria provided in the Maryland SWM Regulations.

3.6.4.2. Ponding Time

The maximum allowable ponding time (T_p) in swales is 24 hours.

3.6.4.3. Velocity

Swales must be designed so that the velocity of flow expected from the design storm will not exceed the permissible velocity for the type of vegetative lining used. Permissible velocities for grass-lined channels are

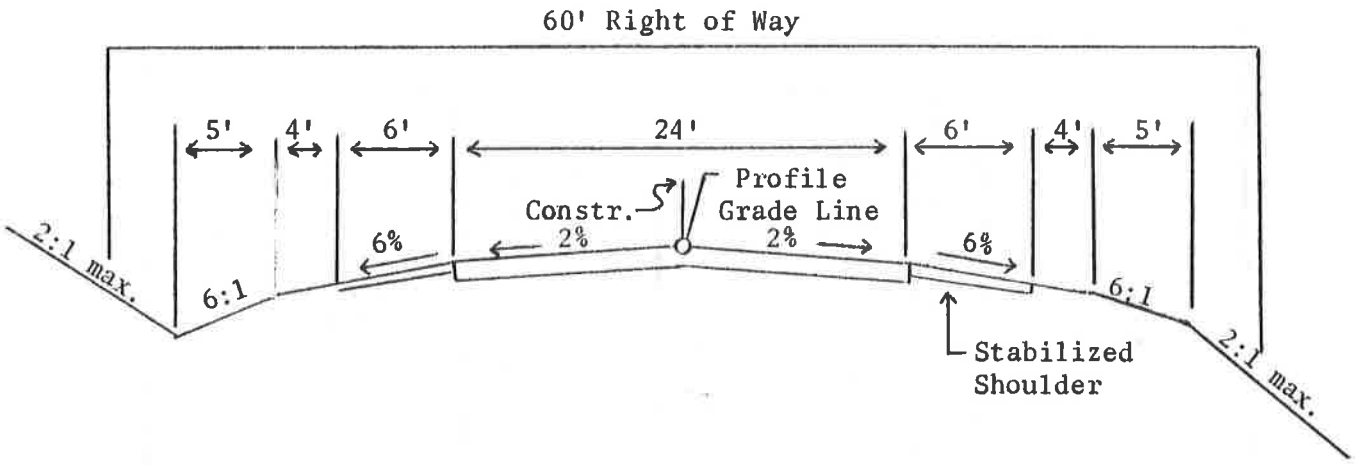


Figure 3-11. Typical Road Cross Section Using Vegetated Swales

Source: RPC 1980

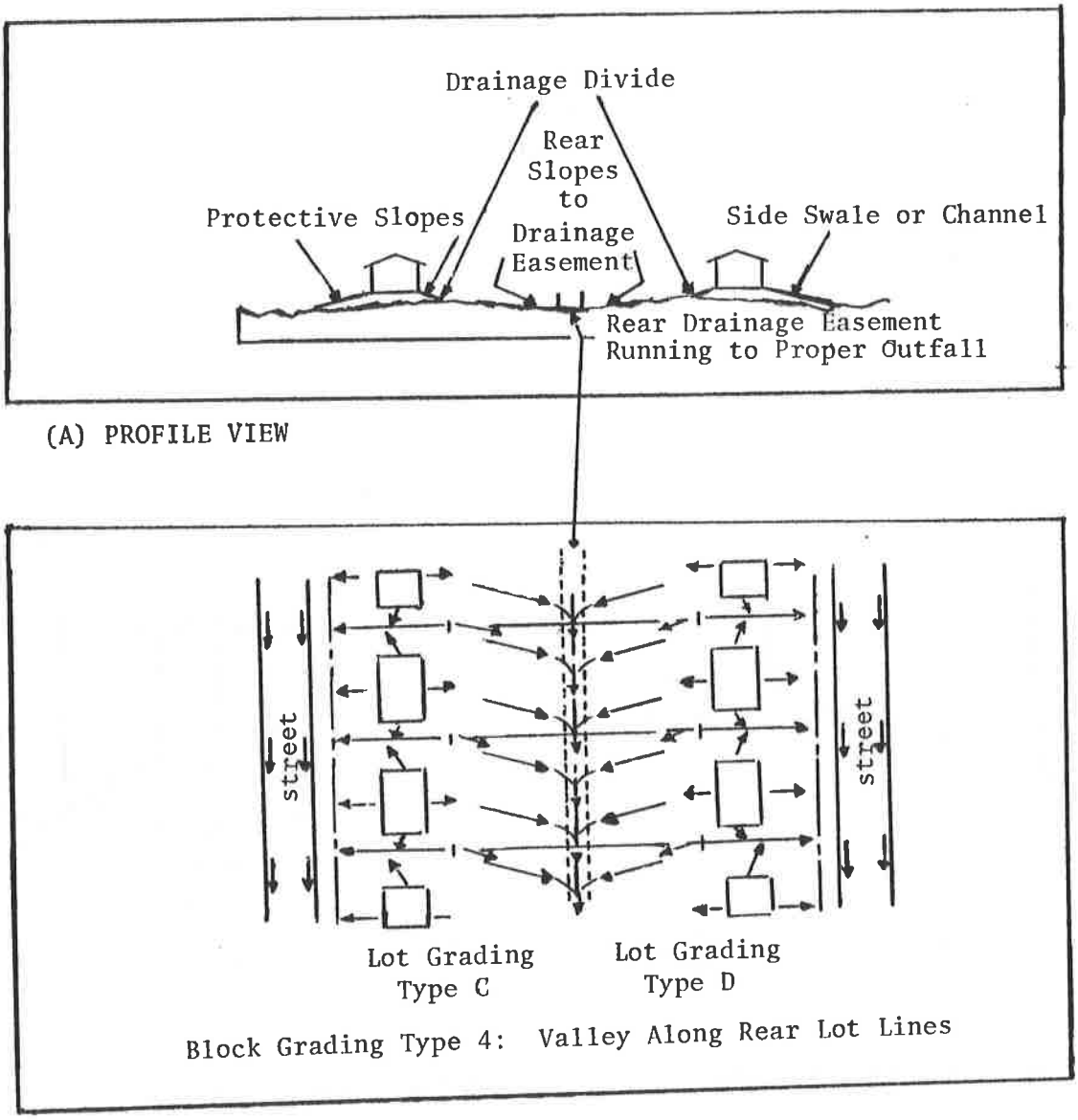


Figure 3-10. Typical Lot Grading Plan

3.6 VEGETATED SWALES WITH CHECK DAMS

(VS)

3.6.1. Description

This practice consists of vegetated swales with check dams (see diagram in Chapter 4) to retard or impound concentrated runoff to induce infiltration. This is achieved by directing concentrated flows of surface runoff through vegetated drainage swales or channels where gentle channel slopes and dense vegetative cover provide for a nonerosive flow velocity. The combination of low velocities and vegetative cover also provide an opportunity for nutrients and other pollutants to be filtered or settle out. The check dams, creating small infiltration pools, will generally consist of earthen fill 6 to 24 inches in height.

3.6.2. Applicability

Swales are most applicable in residential and institutional areas of low to moderate density where the percentage of impervious cover is relatively small. This practice requires that subdivision and site designs respect natural drainage patterns in lieu of elaborate storm drain systems.

Swales are usually located in a drainage easement at the side or back of residential lots as shown in Figure 3-10. Swales can also be used along the edge of roadways as a substitute for curb and gutter. This application, which is normally used in rural right-of-way road section is illustrated in Figure 3-11.

Swales with check dams can be used in combination with infiltration trenches when the trench is constructed below the vegetated swales. The pool created by the check dam increases the volume of runoff infiltrated into the trench, while the vegetated swale helps to filter out suspended solids and other runoff pollutants. The infiltration trench in turn will increase the opportunity for runoff to infiltrate into the underlying soil.

3.6.3. Planning Considerations

3.6.3.1. Soil Permeability

The permeability or final infiltration rate of the soil as provided in Table 2-1, will limit the utilization of swales for ponding and infiltration of stormwater runoff. The maximum allowable ponding time for swale ponds is 24 hours. Table 2-2 relates the ponding time criterion to soil texture and maximum allowable depth of ponding. Based on the data presented in Table 2-2, it is recommended that impoundments not be constructed in swales on soils with f values less than 0.27 inches per hour.

3.6.3.2. Swale Gradient

The use of small check dams to create impoundments in swales is limited to gradients of 5 percent or less. Although check dams can be constructed on steeper slopes, the volume of runoff stored behind the check dams on steeper slopes will be too small to be of much value. Therefore swales proposed on gradients steeper than 5% shall not be used for stormwater management

2. Virginia State Water Control Board, "Best Management Practices Handbook: Urban," Planning Bulletin 321, Richmond, Virginia, 1979.

3. Thelen, E. and L.F. Howe, Porous Pavement, The Franklin Institute Press, Philadelphia, PA, 1978.

4. Thelen, E. et al., Investigation of Porous Pavements for Urban Runoff Control, prepared by the Franklin Institute Research Laboratories for the U.S. Environmental Protection Agency, NTIS PB-227-5, Springfield, VA, 1972.

5. Smith, R.W., J.M. Rice and S.R. Spelman, "Design of Open Graded Asphalt Friction Courses," Federal Highway Administration, U.S. Department of Transportation, FHWA-RD-74-2, 1974.

3.5.5.6. Workmanship

(1) Work shall be done expertly throughout and without staining or damage to other permanent work.

(2) Make transition between existing and new paving work neat and flush.

(3) Finished paving shall be even, without pockets, and graded to elevations shown.

(4) Iron smoothly to grade, all minor surface projections and edges adjoining other materials.

3.5.5.7. Certification

An appropriate professional, registered in the State of Maryland, shall certify that these specifications were complied with.

3.5.6. Maintenance

The surface of porous asphalt pavement must be cleaned regularly to avoid its becoming clogged by fine material. This cleaning is best accomplished through use of a vacuum cleaning street sweeper. Outside of regular cleaning, porous pavement requires no more maintenance than conventional pavement. In times of heavy snowfall it must be recognized that application of abrasive material should be closely monitored to avoid clogging problems once the snow and ice has melted. No method of maintenance has been satisfactory on fully clogged pavements, and only a superficially clogged section showing a water infiltration rate of 0.1 inches per second compared to a normal water penetration of 0.38 inches per second can be restored to normal operation. The best method for cleaning is brush and vacuum sweeping followed by high pressure water washing of the pavement. Vacuum cleaning alone, once the pavement is clogged, has been found ineffective. The oils in the asphalt bind dirt, and only an abrading and washing technique can be effective in the removal of such dirt. Clogging to a depth of 0.5 inch is sufficient to prevent water penetration.

3.5.6.1. Traffic Control

Experience has shown the need for close control of contractor vehicles on newly installed areas of porous asphalt pavement. Damage to pavement porosity results chiefly from abuse during the early life of the pavement. Normally, paving is done while heavy construction or earth moving is continuing in an area. The pavement is thus subjected to mud and dirt from contractor vehicles for up to several months, and the continual passage of these vehicles compacts the dirt into the pores. Only if caked mud is cleaned from vehicle wheels and the pavement is cleaned daily by sweeping and high-pressure water washing can porosity be retained. Clogging can be further minimized by proper use of curbing to prevent surrounding soils from washing onto the pavement surface.

3.5.7. References

1. Diniz, E.V., Porous Pavement: Phase I - Design and Operational Criteria, U.S.E.P.A., EPA-600/2-80-135, Cincinnati, August, 1980.

TABLE 3-3.

POROUS (OPEN-GRADED) ASPHALT CONCRETE FORMULATION*

Material	Screen	Weight, %	Volume, %	Probable Particle Data		
				Width, mm	Weight, g	No. in 100g of Asphalt Concrete
Aggregate	Through 1/2	2.2	2.2	10.7	1.667	1.7
	Through 1/8	59.6	46.3	8.0	.697	85.5
	Through #1	17.0	13.3	4.0	.087	195.4
Sub-total-- Coarse Aggregate		79.4	61.8			282.6
	Through #6	2.8	2.2	2.0	.0109	255.6
	Through #16	10.4	8.0	1.0	.00136	7647.
	Through 200	1.9	1.5	.06	.000294	6462.
Asphalt		5.5	10.5			
Air		0	16.0			
		100.0	100.0			

*Source: City of Rockville, Maryland (1982).

3.5.5.3. Aggregate Base Course

(1) All stone used shall be clean, washed, crushed stone, meeting local highway department specifications.

(2) Aggregate shall be of two sizes: the reservoir base course shall be to depth as noted on drawings of aggregate (maximum of 2", minimum of 1"), and a 2-inch deep top course of 1/2" aggregate (maximum of 5/8", minimum 3/8").

(3) Aggregate base course shall be laid over a dry subgrade covered with engineering filter fabric to a depth shown in drawings, in lifts to lay naturally compacted. The stone base course shall be compacted lightly. Keep the base course clean from debris, and sediment.

3.5.5.4. Porous Asphalt Surface Course

(1) The surface course shall be laid directly over the 1/2" aggregate base course and shall be laid in one lift.

(2) The laying temperature shall be between 230° and 260°, with minimum air temperature of 50°F, to make sure that the surface does not cool prior to compaction.

(3) Compaction of surface course shall be done while the surface is cool enough to resist a 10-ton roller. One or two passes by the roller is all that is required for proper compaction. More rolling could cause a reduction in the surface course porosity.

(4) Mixing plant shall certify the aggregate mix and abrasion loss factor and the asphalt content in the mix. The asphaltic mix shall be tested for its resistance to stripping by water using ASTM D 1664. If the estimated coating area is not above 95 percent, anti-stripping agents shall be added to the asphalt.

(5) Transporting of mix to site shall be in clean vehicle with smooth dump beds that have been sprayed with a non-petroleum release agent. The mix shall be covered during transportation to control cooling.

(6) Mix of asphalt shall be 5.5 to 6 percent of weight of dry aggregate.

(7) Asphalt grade shall meet AASHTO Specification M-20 for 85 to 100 penetration road asphalt as a binder in the northern United States, 65 to 80 in the middle states (Maryland), and 50 to 65 in the South.

(8) Aggregate grading shall be as specified in Table 3-3.

3.5.5.5. Protection

After final rolling, no vehicular traffic of any kind shall be permitted on the pavement until cooling and hardening has taken place, and in no case less than 6 hours (preferably a day or two).

upon the nature of the subgrade soil. Again this system could be expanded to provide more water holding capacity (see Figure 3-9d).

(c) Two-Layers Systems. With this type system a subbase is provided as a filter medium. The coarse open rock drain layer (base) is protected by a suitable filter layer (subbase) such as clean concrete sand. This system should provide excellent resistance to clogging and excellent drainage capacity even after numerous years of service. The system is shown in Figure 3-9e.

(d) V-Trench Water Removal to Pond. A positive method of removal of water contained in a French Drain type system is to use the base material as a drain for transport to a relatively shallow V-trench at a low point in the cross section of the roadway. If a heavy volume of water is expected, it may be advisable to obtain greater drain capacity by construction of a two-layer system. If an appreciable gradient is involved, a cross drain should be placed at the downhill end of the cut. This will intercept any water flowing longitudinally which if not drained could saturate the fills and cause slumping of the fill slopes. The V-trench shown in Figure 3-9f could be emptied into a storage pond or other suitable drainage system. The profile of a road showing cross drains that empty into the V-trench is shown in Figure 3-9g.

(e) Pipe Drains. Subgrade soils which are for all practical purposes impervious to water would necessitate the use of pipe drains. The pipe is generally perforated with 1/4- to 3/8-inch diameter holes, placed in two or more double rows 90° to 120° apart running lengthwise on the bottom half of the pipe. Materials of construction include aluminum alloys, asbestos cement, bituminized fiber, cast iron, clay, concrete and plastic. They are available in sizes ranging from 4 inches to 120 inches and larger in diameter. The sizes and type pipe to be used would be determined by the conditions set for drainage. Such a system is shown in Figure 3-9 a, b, and h.

3.5.5. Construction Methods and Specifications
(Adapted from the Construction Specifications of the City of Rockville, MD)

3.5.5.1. Stabilization

To preclude premature clogging and/or failure of this practice, porous asphalt paving structures shall not be placed into service until all of the surface drainage areas contributing to the pavement have been effectively stabilized in accordance with Maryland Standards and Specifications for Soil Erosion and Sediment Control.

3.5.5.2. Subgrade Preparation

(1) Alter and refine the grades as necessary to bring subgrade to required grades and sections as shown in the drawings.

(2) The type of equipment used in subgrade preparation construction shall not cause undue subgrade compaction. (Use tracked equipment or oversized rubber tire equipment - DO NOT use standard rubber tired equipment.) Traffic over subgrade shall be kept at a minimum. Where fill is required, it shall be compacted to a density equal to the undisturbed subgrade, and inherent soft spots corrected.

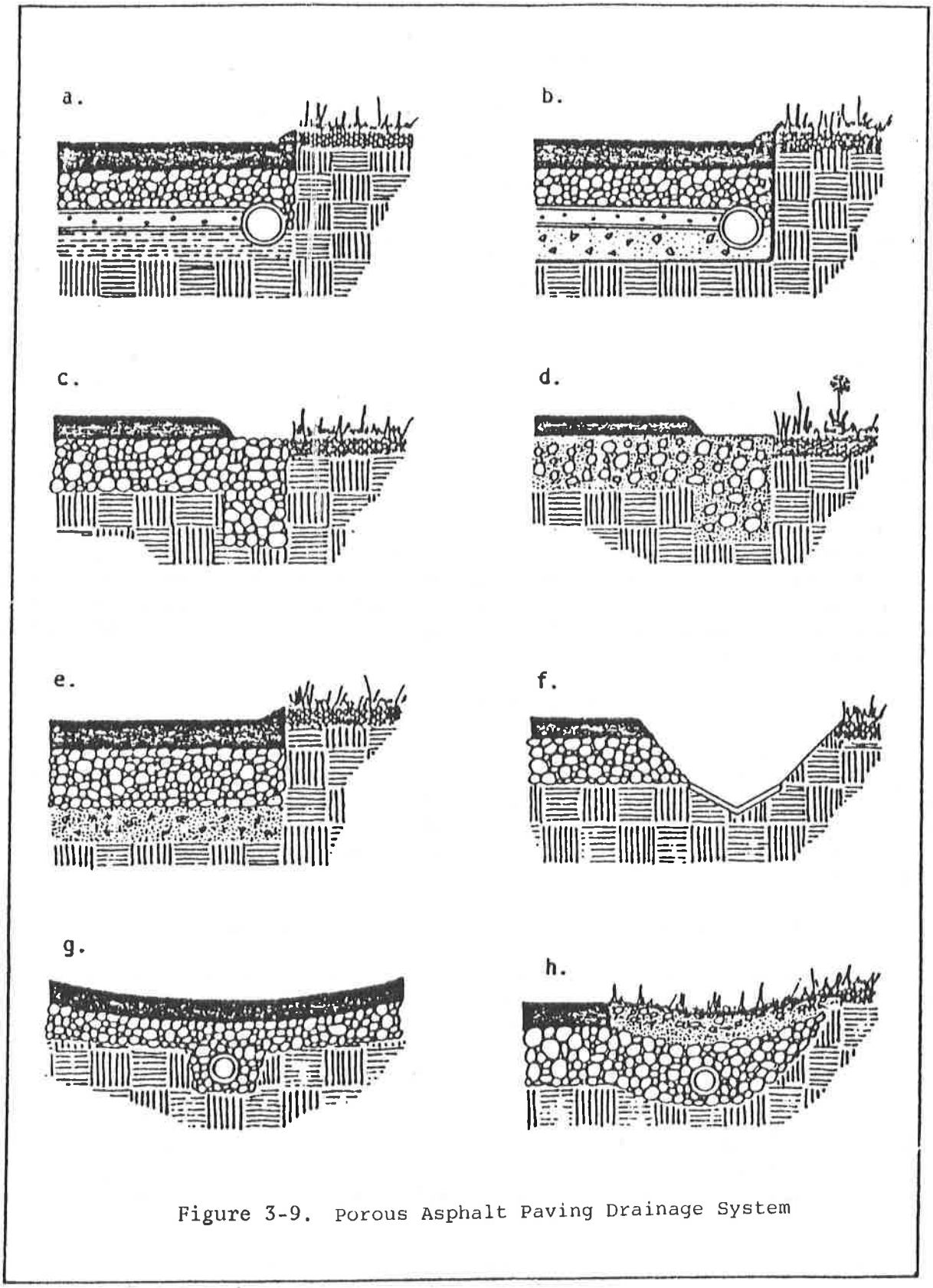


Figure 3-9. Porous Asphalt Paving Drainage System

Source: Thelen, 1972.

AASHO M-226-73 I. This grade is to be considered a tentative starting point because test results obtained from the design process may indicate an advantage or a necessity to alter the asphalt grade.

3.5.4.11. Mixing Temperature

To ensure that the individual aggregate particles are completely surrounded by asphalt, and that the asphalt is tightly bound to each particle, temperature of mixing at the hot mix plant shall be rigidly controlled. Too low a mixing temperature will result in inadequate asphalt binding and coverage of the aggregate, while too high a mixing temperature will allow asphalt to drain from the mix, resulting in a lower asphalt content and decreased strength. Suitable mixing temperatures range from 230 to 260 degrees Fahrenheit, but the lower end of that range (230° to 240° F) is recommended.

3.5.4.12. Asphalt Content in Mix

For road paving durability and to prevent too rapid hardening of the asphalt, it is desirable to have the highest asphalt content possible in the mix. Too much asphalt would separate out under traffic, so that maximum asphalt content is generally limited by that factor. Experience has shown that 5.5 percent by weight is the minimum recommended asphalt content. Asphalt content should be determined according to the testing procedure recommended in Federal Highway Administration Report No. FHWA-RD-74-2, already cited. The Marshall Design method for determining mix content is not recommended. Using a 5.5 percent asphalt content and the Asphalt Institute's recommended 4-inch minimum surface course, a 0.6-inch rainfall reservoir capacity is obtained with an infiltration rate of 176 inches per hour.

3.5.4.13. Hydrologic Design Method

A hydrologic design method based on SCS TR-55 procedures is provided in Chapter 4. It should be noted that when porous asphalt paving is designed without a positive drain the design situation is analogous to an infiltration trench. The porous paving may be designed as a subsurface detention system as described in Section 3.5.4.14, with hydrologic soil groups that have a slow infiltration rate.

3.5.4.14. Other Applications of Porous Asphalt Paving

On sites where the subgrade soil infiltration rate is slow, porous asphalt paving has been used to provide subsurface detention of stormwater runoff. There are a number of available drainage designs capable of adequately removing the water remaining in the reservoir base course. Several of these are illustrated in Figure 3-9 and described below:

(a) French Drain. This system utilizes coarse open-graded rock in relatively deep pits or trenches. This type of drain can be expanded out at the lateral edges of a roadway to provide a deeper system with more water holding capacity, so that the water has more time to percolate through a less permeable subgrade. Such a system is shown in Figure 3-9c.

(b) Sand Drain. This system is similar to the French Drain, but the coarse open-graded rock also contains enough fines to prevent intrusion of adjacent soil which may tend to clog the drain. This clogging is dependent

3.7.3.1. Flow

The vegetative filter should be used to control overland sheet flow only. If the filter will be subject to any concentrated flows, such as low points in parking lots or grass areas, then a level spreader or reverse bench should be used to establish sheet flow.

3.7.3.2. Selecting the Type of Vegetation

The selection of vegetative materials ranges from using existing vegetation to specifying a vegetation mix tailored to suit the characteristics of the site. The Maryland Standards and Specifications for Soil Erosion and Sediment Control should be used as a guide in selecting the vegetation type.

3.7.3.3. Slope Characteristics

The effectiveness of vegetative filters as sediment control devices decreases with increasing slope. Their effectiveness has not been established on slopes greater than 17 percent (Albrecht and Barfield, 1981).

3.7.3.4. Runoff

When filter strips are used in treating sediment-laden runoff, the following shall be considered:

(1) Good drainage to ensure satisfactory performance.

(2) A level spreader at the inlet to ensure uniform distribution of flow.

(3) Dry periods between flows to reestablish an aerobic soil provile.

(4) An adequate filter area and length of flow to provide the desired treatment.

(5) Slopes less than five percent are more effective; steeper slopes require a greater area and length of flow to achieve the same effectiveness.

(6) Provisions for mowing and removing undesirable vegetation to maintain the effectiveness of the filter area.

3.7.4. Design Criteria

3.7.4.1. Length of Filter Strip

The minimum length of filter strip used in conjunction with all other stormwater management infiltration structures shall be 20 feet.

Additional guidelines to assist the designer in calculating the trap efficiency of an existing vegetative buffer strip, or the length of vegetation filter required to provide a specific trap efficiency are provided below.

3.7.4.2. Graphical Solution

A solution for computing the sediment trap efficiency of a vegetative

buffer strip can be represented graphically (Wong and McCuen, 1982). Figure 3-13 shows the relationship between trap efficiency and the length and slope of the filter strip, as well as the roughness coefficient of the vegetation. The required length of a buffer strip is very sensitive to variation in the trap efficiency as it approaches 100 percent, indicating that a small incremental increase in the trap efficiency requires a considerable addition in the buffer length. The curves also suggest that a significant trap efficiency (up to 75 percent) may be achieved at relatively short buffer lengths. Figure 3-13 assumes a coarse silt material.

The trap efficiency for other soil textures may also be determined using Figure 3-13. The settling velocity of sediment particles manifests the appropriate trap efficiencies that are attainable using filter strips for a particular particle size. In general, the greater the settling velocity, the higher the trap efficiency per length of filter strip. For example, the ratio of the settling velocities for a coarse silt and a fine silt is 4.9. Thus, the filter strip length obtained from Figure 3-13 should be multiplied by this ratio to obtain the filter strip length for a fine silt. This would provide the same trap efficiency indicated on Figure 3-13. The settling velocity ratio of coarse silt to medium silt, fine sands, and medium sands are 1.3, 0.02, and 0.005, respectively (Wong and McCuen, 1982).

3.7.5. Construction Specifications

3.7.5.1. Site Preparation

(1) Install needed erosion and sediment control practices such as silt fences, dikes, and contour ripping, erosion stops, channel liners, sediment traps and sediment basins.

(2) If grading is required and topsoil is suitable for use remove and stockpile the topsoil.

Note: Topsoil salvaged from the existing site may often be used but it should meet the same standards as set forth in these specifications. The depth of topsoil to be salvaged shall be 6 inches unless the depth described as a representative profile for that particular soil type as described in the soil survey is less than 6 inches, in which case the lesser depth shall be removed.

(3) Grade as needed and feasible to permit the use of conventional equipment for seedbed preparation, seeding, mulch application, anchoring and maintenance.

(4) Liming: Where the subsoil is either highly acid or composed of heavy clays, ground dolomite limestone shall be spread at the rate of 2 tons per acre (100 pounds per 1,000 square feet). Lime shall be distributed uniformly over designated areas and worked into the soil in conjunction with tillage operations as described in the following procedures.

(5) Tilling: After the area to be topsoiled has been brought to grade, and immediately prior to dumping and spreading the top-soil, the subgrade shall be loosened by discing or by scarifying to a depth of at least 3 inches to permit bonding of the topsoil to the subsoil. Pack by passing a bulldozer vertically tracking over the

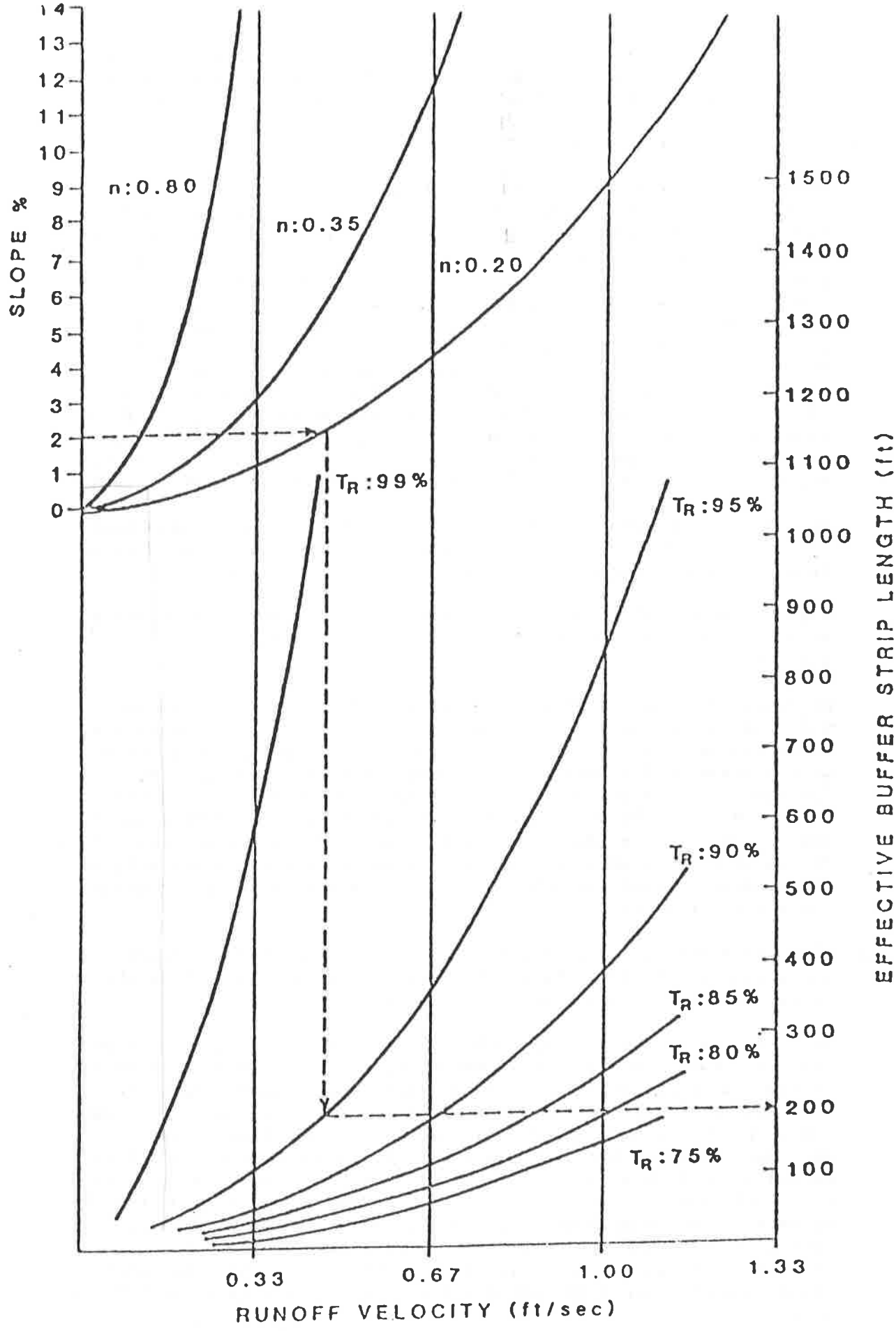


Figure 3-13. Effective Buffer Length Determination for Trap Efficiencies (T_R) of 75, 95, and 99 percent

Source: Wong and McCuen, 1982

entire surface area of the slope to create horizontal erosion check slots to prevent topsoil from sliding down the slope and rilling.

3.7.5.2. Soil Preparation and Amendments

(1) Materials: Topsoil shall be a loamy sand, sandy loam, loam or silt loam only and in that respective order of preference. It shall not have a mixture of contrasting textured subsoil and contain no more than 5 percent by volume of cinders, stones, slag, coarse fragment, gravel, sticks, roots, trash or other extraneous materials larger than 1-1/2 inches in diameter. Topsoil must be free of plants or plant parts of bermudagrass, quackgrass, Johnsongrass, nutsedge, poison ivy, Canada thistle, or others as specified. All topsoil shall be tested by a recognized laboratory for organic matter content, pH and soluble salts. A pH of 6.0 to 7.5 and an organic content of not less than 1.5 percent by weight is required. If pH value is less than 6.0, lime shall be applied and incorporated with the topsoil to adjust the pH to 6.5 or higher. Topsoil containing soluble salts greater than 500 parts per million shall not be used.

No sod or seed shall be placed on soil which has been treated with soil sterilants or chemicals used for weed control until sufficient time has elapsed to permit dissipation of toxic materials.

Note: Topsoil substitutes or amendments as approved by a qualified agronomist or soil scientist may be used in lieu of natural topsoil.

(2) Grading: The topsoil shall be uniformly distributed and tracked and shall be a minimum compacted depth of 4 inches. Spreading shall be performed in such a manner that sodding or seeding can proceed with a minimum of additional soil preparation and tillage. Any irregularities in the surface resulting from topsoiling or other operations shall be corrected in order to prevent the formation of depressions or water pockets. Topsoil shall not be placed while in a frozen or muddy condition, when the subgrade is excessively wet, or in a condition that may otherwise be detrimental to proper grading and seedbed preparation.

(3) Lime and fertilize according to soil tests: Lime and fertilizer needs can be determined by a soil testing laboratory, such as the University of Maryland's Soil Testing Laboratory.

(4) In lieu of soil tests apply 1,000 pounds 10-10-10 or equivalent per acre if ureaform fertilizer is not used, and 600 pounds of 10-10-10 or equivalent per acre if ureaform fertilizer is used. Apply the lime and fertilizer before seeding and harrow or disc uniformly into the soil to a minimum depth of 3 inches on slopes flatter than 3:1. On slopes steeper than 3:1 grade, the lime and fertilizer shall be worked in as best as possible. On sloping land, the final harrowing or discing operation should be on the contour wherever feasible. No attempt should be made to drag any disced area to make the soil surface very smooth after discing. When the 600 pounds per acre rate of 10-10-10 fertilizer rate is used, at the time of seeding, apply 400 pounds of a ureaform fertilizer of a grade of a least 30-0-0 per acre.

Note: The slow release ureaform fertilizer will supply nitrogen over a longer period of time and will result in a healthier grass stand.

3.7.5.3. Seeding

(1) Select a mixture from Table 3-5.

(2) Apply seed uniformly with a cyclone seeder, drill, cultipacker seeder or hydroseeder (slurry includes seed and fertilizer) on a firm, moist seedbed. Maximum seeding depth should be 1/4 inch on clayey soils and 1/2 inch on sandy soils, when using other than hydroseeder method of application.

Note: If hydroseeding is used and the seed and fertilizer is mixed, they will be mixed on site and the seeding shall be immediate without interruption.

3.7.5.4. Mulching

Mulch materials are listed in order of their effectiveness. Mulch mattings are normally only used on critical areas such as waterways or steep slopes.

(1) Materials and Amounts

(a) Mulch mattings: Such as jute or excelsior blanket shall be stapled to the surface in waterways and on steep slopes. Lighter materials of paper, plastic and cotton mulch mattings may be used where erosion hazard is not severe. If the area is to be mowed, do not use metal staples.

(b) Straw: Straw shall be unrotted small grain applied at the rate of 1-1/2 to 2 tons per acre, or 70 to 90 (two bales) pounds per 1,000 square foot. Mulch materials shall be relatively free of all kinds of weeds and shall be free of prohibited noxious weeds such as: thistles, Johnsongrass and quackgrass.

Spread uniformly by hand or mechanically. For uniform distribution of hand spread mulch, divide area into approximately 1,000 square feet section and place 70-90 pounds of mulch in each section.

(c) Wood chips: at the rate of approximately 6 tons per acre or 275 pounds per 1,000 square feet may be used when available and when feasible. These are particularly well-suited for utility and road rights-of-way. If wood chips are used, increase the application rate of nitrogen fertilizer by 20 pounds (200 pounds 10-10-10 or 66 pounds 30-0-0).

(d) Wood cellulose fiber: mulch at the rate of 1,500 pounds per acre or 35 pounds per 1,000 square foot may be applied by hydroseeding.

TABLE 3-5. PERMANENT SEEDING AND SEEDING DATES

Mix No.	SEEDING MIXTURES (Use Certified Seed if available)	SEEDING RATE Lbs/ Acre	Lbs/1000 Sq.Ft.	OPTIMUM SEEDING DATES (d) COASTAL PLAIN 2/1-4/30	COASTAL PLAIN 5/1-8/14	COASTAL PLAIN 8/15-10/31	PIEDMONT 3/1-4/30	PIEDMONT 5/1-7/31	PIEDMONT 8/1-10/15	MOUNTAINS 3/5-5/31	MOUNTAINS 6/1-7/31	MOUNTAINS 8/1-9/30
1	'Kentucky 31' Tall Fescue*	60	1.38	x	-	x	x	-	x	x	-	x
2	'Kentucky 31' Tall Fescue* 'Boer''Lehmans'(a) Weeping Lovegrass	60 2	1.38 .05	-	x	-	-	x	-	-	x	-
3	'Kentucky 31' Tall Fescue* 'Korean' lespedeza (b)inoculated(h)	50 15	1.15 .34	x	-	-	x	-	-	-	-	-
4	'Kentucky 31' Tall Fescue* 'Interstate' Sericea lespedeza(b)(h) inoculated(h)	40 20	.92 .46	x	-	x	x	-	x	x	-	x
5	'Kentucky 31' Tall Fescue* Birdsfoot trefoil, inoculated(h)	40 10	.92 .23	-	-	-	-	-	-	x 2000' elev. & above	-	-
6	Chemung Crownvetch, inoculated (h) Redtop	15 3	.34 .07	x	-	-	x	-	-	x	-	x
7	Chemung Crownvetch, inoculated(h) 'Kentucky 31' Tall Fescue*	15 40	.46 .92	x	-	-	x	-	-	x	-	-
8	'Kentucky 31'Tall Feacue (75%) Redtop (5%) Canada Bluegrass (10%) Kentucky Bluegrass (10%)(e)	90	2	x	-	x	x	-	x	x	-	x
9	Kentucky Bluegrass (50%) 'Pennlawn' Creeping Red Feacue(40%) Redtop (10%)(e)	90	2	x	-	x	x	-	x	x	-	x
Droughty Areas												
10	'Kentucky 31' Tall Fescue* Redtop	30 5	.69 .11	x	-	x	x	-	x	x	-	x
11	Weeping lovegrass Serecia lespedeza (b)inoculated(h)	2 20	.05 .46	x	x	-	x	x	-	x	x	-
Poorly Drained Areas												
12	'Kentucky 31' Tall Fescue*	30	.69	x	-	x	x	-	x	x	-	x
13	Reed canarygrass (c)	10	.23	-	-	x	-	-	x	-	-	x
Shaded Areas												
14	'Kentucky 31'Tall Fescue*	60	1.38	x	-	x	x	-	x	x	-	x
15	Red Feacue 'Jamestown' or 'Pennlawn'	40	.92	x	-	x	x	-	x	x	-	x
Lawns & High Maintenance Areas												
16	'Plush','Birka','Parade','Vantage') 'Columbia','Merion','Adelphi','South)** Dakota','Kenblue',Kentucky Bluegrass) Red Fescue, 'Pennlawn' or 'Jamestown'	90 10	2 .23	x	-	x	x	-	x	x	-	x
17	'Kentucky 31' Tall Fescue*(g)	220-260	5-6	x	x(f)	x	x	x(f)	x	x	x(f)	x

*Use Certified Seed Only
**Any three(3) varieties at 30 lbs. each to make the 90 lb mix.

Source: Maryland Standards and Specifications for Soil Erosion and Sediment Control, 1983

Footnotes - Table 3-5.

Permanent Seedings and Seeding Dates

(a) Use Weeping lovegrass to provide a stand of grass for erosion control during summer.

(b) Use hulless seed.

(c) Preferable to seed in fall with seed from current year's crop.

(d) Mixtures 1,3,4,5,6,7,8,10,11,12,13 and 14 may be seeded during winter months in an emergency if 2 tons per acre of a well-anchored mulch is used.

(e) Approved State Highway Administration Mixtures.

(f) Can be seeded during this period if irrigation water is used. Use 2 tons per acre of well-anchored straw mulch.

(g) Can use 10 percent Kentucky bluegrass. (MD AGRON MEMO #72).

(h) Leguminous Seeds. All leguminous seeds shall be inoculated or treated with unexpired approved culture for the specific legume in the proper proportions as specified on the package label. The inoculant shall be stored at room temperatures, out of direct sunlight and away from heating units. When seeding dry with mechanical seeders, the following method of mixing the inoculant with the seed shall be followed. The culture in powder form is preferred and shall be thoroughly mixed with the seed by using a very small quantity of water; just enough to dampen the seeds before the culture is powdered on. The leguminous seed is then mixed with the other seeds of the formula. Seeds inoculated with the powder shall be sown within 48 hours after treatment. Seeds inoculated with the liquid culture shall be sown within 24 hours after treatment. Inoculated seed not used within these time periods shall be reinoculatd. Inoculant and seed treated with inoculant shall not be exposed to sunlight for more than one hour prior to seeding. When seed is applied by hydraulic seeders, 10 times the quantity of inoculant recommended for dry leguminous seed application shall be used. Inoculated seed shall not be held in a slurry with fertilizer for more than one hour, otherwise reinoculation will be required before applying the seed.

(2) Mulch anchoring shall be accomplished immediately after mulch placement to minimize loss by wind or water. This may be done by one of the following methods, (listed by preference) depending upon size of area, erosion hazard, and cost. On sloping land, practice No. 1 below, should be done on the contour whenever possible. Contouring of all operations applies to all straw and to wood chip practices on more critical sites, except "tracking" should be done up and down the slope with 1-1/2 inch cleat marks running across the slope.

(a) Mulch Anchoring Tool and Tracking: A mulch anchoring tool is a tractor drawn implement designed to punch and anchor mulch into the surface 2 inches of soil. This practice affords maximum erosion control but is limited to flatter slopes where equipment can operate safely. "Tracking" is primarily used on 3:1 or steeper cut and fill slopes to cut and mulch into the soil by 1-1/2" track cleats of a bulldozer making groves across the slope.

(b) Mulch Nettings: Staple lighweight biodegradable paper, plastic or cotton nettings over the mulch according to manufacter's recommendations. Netting is usually available in rolls 4 feet wide and up to 300 feet long.

(c) Liquid Mulch Binders: Applications of liquid binders should be heavier at edges where wind catches mulch, in valleys, and at crests of banks. Remainder of area should be uniform in appearance. Caution should be used with asphalt in residential and similar areas.

(1) Cutback asphalt - rapid curing (RC-70, RC-250, and RC-800) or medium curing (MC-250 or MC-800). Apply 5 gallons per 1,000 square feet or 200 gallons per acre on flat areas and on slopes less than 8 feet high. On slopes 8 feet or more high, use 8 gallons per 1,000 square feet or 348 gallons per acre.

(2) Emulsified asphalt - (SS-1, CSS-1, CMS-2, MS-2, RS-1, RS-2, CRS-1, and CRS-2). Apply 5 gallons per 1,000 square feet or 200 gallons per acre on flat areas and on slopes less than 8 feet high. On slopes 8 feet or more high, use 8 gallons per 1,000 square feet or 348 gallons per acre.

All asphalt designations are from the Asphalt Institute Specifications.

(3) Synthetic binders: Synthetic binders such as Acrylic DL (Agri-Tac), DCA-70, Petroset or Terra Tac may be used at rates recommended by the manufacturer to anchor mulch material.

(d) Wood Cellulose Fiber: Wood cellulose fiber may be used for anchoring straw. The fiber binder shall be applied at a net dry weight of 750 pounds/acre. The wood cellulose fiber shall be mixed with water and the mixture shall contain a maximum of 50 pounds of wood cellulose fiber per 100 gallons.

TABLE 3-6. MAINTENANCE FERTILIZATION FOR PERMANENT SEEDINGS

Use Soil Test Recommendations or Rates Shown Below

Mixture No.	Seeding Mixture	Formulation	Lbs. Per Acre	Lbs. Per 1,000 Sq. Ft.	Time	Mowing
1,2,3,7,8 10	Tall fescue makes up 70% or more of cover.	10-10-10 or	500	11.5	Yearly, or as needed	*Not closer than 3" if occasional mowing is desired.
		38-0-0	400	9.2	Fall	
		10-10-10	600	13.8	Yearly, or as needed	
4,5,6,7	Crownvetch Sericea lespedeza Birdsfoot trefoil	0-20-20	400	9.2	Spring the year following establishment and every 4-5 years thereafter.	Do not mow crownvetch.
4,5	Fairly uniform stand of tall fescue and sericea lespedeza, or birdsfoot trefoil.	5-10-10	500	11.5	Fall the year following establishment and every 4-5 years thereafter.	Not required. Not closer than 4" if occasional mowing is desired, and then in fall after seed has matured.
11	Weeping lovegrass & sericea lespedeza Fairly uniform plant distribution.	5-10-10	500	11.5	Spring the year following establishment and every 3-4 years thereafter.	Not required. Not closer than 4" if occasional mowing is desired. and then in fall after sericea has matured.
9,12,13,14	Red fescue;	20-10-10	250	5.8	September, 30 days later.	Mow no closer than 2" for red fescue and Ky bluegrass; and no closer than 3" for fescue.
15,17	Kentucky bluegrass-red fescue mixture;	20-10-10	250	5.8	December,	
	'Ky-31'tall fescue	20-10-10	100	2.3	May 20-June 30, if needed.	

Source: Maryland Standards and Specifications for Soil Erosion and Sediment Control

(e) Peg and Twine: Drive 8- to 10-inch wooden pegs to within 2 to 3 inches of the soil surface every 4 feet in all directions. Stakes may be driven before or after applying mulch. Secure mulch to soil surface by stretching twine between pegs in a criss-cross within a square pattern. Secure twine around each peg with two or more complete turns.

Note: All names given above are registered trade names. This does not constitute a recommendation of these products to the exclusion of other products.

3.7.5.5. Irrigation

If soil moisture is deficient, supply new seedings with adequate water for plant growth until they are firmly established, if feasible. This is especially true when seedings are made late in the planting season, in abnormally dry or hot seasons, or on adverse sites.

3.7.6. Maintenance

Maintenance is a vital factor in maintaining an adequate vegetative erosion control cover. See Table 3-6 to obtain the maintenance fertilization program for permanent seedings.

(a) Irrigation: If soil moisture becomes deficient, irrigate to prevent loss of stand of protective vegetation, if feasible.

(b) Repairs: Inspect all seeded areas for failures and make necessary repairs, replacements, and reseedings within the planting season, if possible.

(1) If stand is inadequate for erosion control, overseed and fertilize using half of the rates originally applied.

(2) If stand is over 60 percent damaged, reestablish following original lime, fertilizer, seedbed preparation and seeding recommendations.

3.7.7. References

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CHAPTER 4

HYDROLOGIC DESIGN METHODS

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4.1 INTRODUCTION

Design procedures are presented in this chapter for five stormwater management methods: infiltration basins, infiltration trenches, dry wells, porous asphalt pavement, and vegetated swales with check dams.

As used herein, an infiltration basin is an open, surface storage area that has no primary hydraulic outlet. Outflow is assumed to be infiltration through the underlying soil and thru an emergency spillway.

Infiltration trenches and dry wells depend on subsurface storage; these two methods differ on the mechanism for input. Input to an infiltration trench is through a highly porous stone medium that overlays the trench or an inlet. Input to a dry well is through both infiltration and pipe inflow.

Porous asphalt pavement refers to a low density, permeable asphalt surface in which water is transmitted to a stone reservoir subbase for storage and released into the subsoil by infiltration. The subbase may have a positive underdrain system that controls runoff rates to the before development rate. It should be noted that providing a positive drain in the subbase converts the porous pavement into a subsurface detention structure rather than a strict infiltration structure.

4.1.1. Estimating the Runoff Depth Required for Control

The methods proposed herein are based on the control of increases in discharge rates either by storing the increased runoff depth due to changes in land use or by reducing both the contributing area and the runoff depth. Most stormwater management policies require the peak discharge for a selected return period(s) to be unchanged after development. However, if the increase in peak discharge cannot be managed, the infiltration practice can be designed to capture the first flush of runoff. Capturing the first flush of runoff will remove many of the waterborne pollutants.

The before development peak discharge (q_b) can be determined using the SCS graphical method:

$$q_b = q_{ub}\ AQ_b \qquad (4\text{-}1)$$

in which q_{ub} is the unit peak discharge, in cubic feet per second per square mile per inch of runoff (csm/in.), from Figure 4-1 based on the before development time of concentration (t_{cb}) in hours, Q_b is the before development depth of runoff in inches, and A is the drainage area in square

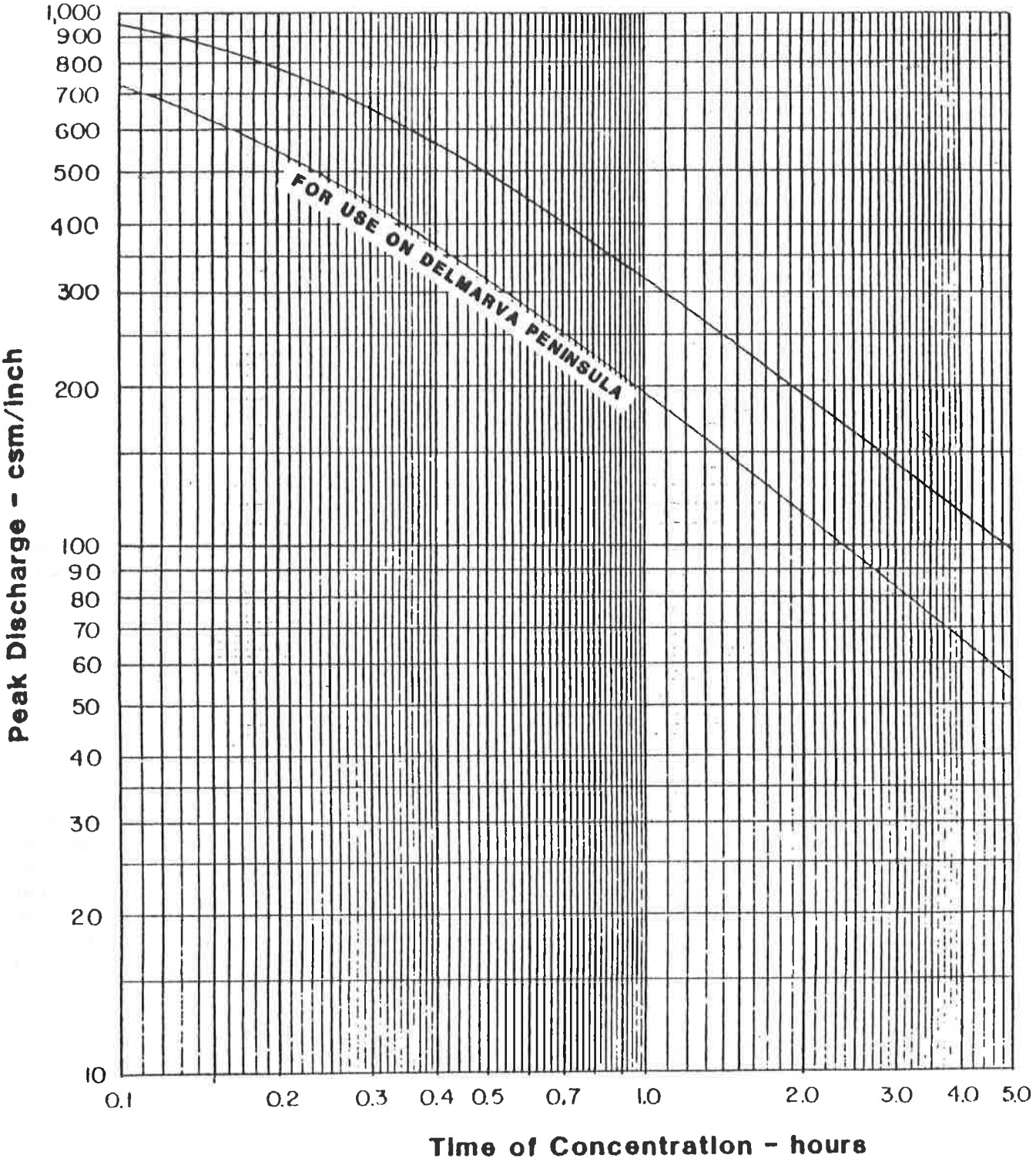


Figure 4-1. Graphical Method of Determining Peak Discharge (q_{up}) in csm per inch of Runoff For 24-Hour Type II Storm Distribution

miles. Using a subscript "a" to indicate "after development", the after development peak discharge (q_a) is given by:

$$q_a = q_{ua}\ AQ_a \tag{4-2}$$

While the total drainage area (A) will remain constant, both the unit peak discharge (q_u) and the runoff depth (Q) will probably be greater for the after development conditions. If development causes a decrease in the time of concentration, then the unit peak discharge will increase. Similarly, an increase in the percent of imperviousness will cause an increase in the volume of runoff. If the stormwater management policy requires q_a to equal q_b, then the policy could be met if a difference in depth of runoff ΔQ was controlled; this is determined as follows:

$$q_{ua}\ A(Q_a - \Delta Q) = q_{ub}\ AQ_b \tag{4-3}$$

Therefore, solving for ΔQ yields:

$$\Delta Q = Q_a - (q_{ub}/q_{ua})Q_b \tag{4-4}$$

If there is no change in t_c, then (q_{ub}/q_{ua}) equals 1.0, and $\Delta Q = Q_a - Q_b$. Since the development will usually decrease the time of concentration, q_{ub} will usually be less than q_{ua} and ΔQ will be greater than the difference in the runoff depths $(Q_a - Q_b)$.

In addition to controlling discharge rates by adjustments in the runoff depth, it is also feasible to limit discharge rates by reducing both the area and depth of the after development runoff. Specifically, if development causes an increase in both q_u and Q, then the rate of runoff can be reduced by decreasing A and Q_a in Equation 4-2. If a part of the watershed, which will be denoted by A_c is modified so that it does not contribute runoff to the watershed outlet, then it is possible for the after development peak discharge to equal the before peak discharge. Using Equations 4-1 and 4-2, the drainage area section A_c would be given by:

$$q_{ua}(A - A_c)Q_a = q_{ub}\ AQ_b \tag{4-5}$$

where Q_a is the total after development runoff depth minus the equivalent runoff volume stored by the infiltration measures ($\sum V_w/A$). Substituting the value of Q_a in Equation 4-5 and solving for A_c yields:

$$A_c = A\left[1 - \frac{q_{ub}Q_b}{q_{ua}(Q_a - \sum V_w/A)}\right] \tag{4-6}$$

If an area A_c is designed to be noncontributing, then the after development peak discharge rate will equal the before development rate even though the depth of runoff increases and/or the time of concentration is reduced.

4.1.2 General Design Situations

There are two general types of situations in which the above methods can be applied. First, one may be interested in the dimensions of the infiltration device that is required to control the increase in peak discharge rates. Second, site conditions may dictate the layout and capacity of the infiltration measures and one might be interested in determining the level of control provided by such a layout. In the latter case, control may not be sufficient and additional control, possibly using surface detention, may be required. It is important to emphasize that the same principles apply to both cases.

Design methodologies were developed for five methods: infiltration basins, infiltration trenches, dry wells, porous asphalt paving, and vegetated swales with check dams. The design procedures are based on either 1) total volume control of the area contributing runoff or 2) partial control of the runoff volume from an area (i.e., the difference in the before and after development runoff depths). For the TR-55 graphical method (Equations 4-1 and 4-2), it is assumed that the peak discharge could be controlled through either Q or A and Q. Dry wells, which provide total area and volume control, store all the runoff incident to the contributing surface area. Infiltration measures that provide partial volume control store the difference in the runoff volume necessary to meet the peak control criteria. These include the infiltration basin, infiltration trench, porous asphalt pavement, and swale storage. Any of the infiltration measures can control the total contributing area and volume of runoff if the after development design storm depth is stored.

The design equations may be defined for the cases of either total area control and partial volume control. The peak discharge for a watershed that is managed by total area control infiltration measures (e.g., dry wells) can be computed by:

$$q_p = q_u (A - \Sigma A_c)(Q - \Sigma V_w/A) \qquad (4\text{-}7)$$

in which q_p is the peak discharge (cfs); q_u is the unit peak discharge (csm/in); A is the total watershed area (mi^2); Q is the watershed depth of runoff (inches); ΣA_c is the sum of the noncontributing watershed areas totally controlled by infiltration measures (mi^2); and $\Sigma V_w/A$ is the sum of the equivalent watershed runoff depth completely controlled from the noncontributing watershed area (inches). The peak discharge for a watershed that is managed by partial volume control infiltration measures (e.g., infiltration basin, infiltration trench, and vegetated swales with check dams) can be computed by:

$$q_p = q_u A (Q - \Sigma V_w/A) \qquad (4\text{-}8)$$

in which $\sum V_w/A$ is the sum of the equivalent watershed runoff depth controlled by the infiltration measures (inches).

When a hydrograph analysis is desired, the TR-55 Tabular method can be used in place of the TR-55 graphical method. Equations 4-7 and 4-8 will only have to be slightly modified to apply the techniques. Instead of the unit peak discharge from Figure 4-1, the unit discharges of the Tabular method table are used; Equation 4-7 and 4-8 are then applied for each ordinate of the hydrograph.

4.2 DESIGN OF INFILTRATION BASIN

(IB)

An infiltration basin is defined as an open area that has no outlet for direct runoff other than an emergency spillway. The storm runoff, which includes both rainfall that falls on the surface of the basin and direct runoff from the upland area, will either infiltrate or evaporate. Since evaporation is usually negligible during periods of heavy rainfall, the design is to be based on water loss by way of infiltration only.

The required size of the basin will depend greatly on the increase in runoff volume from development and the maximum allowable ponding time. A maximum ponding time of 3 days is allowed within the basin. The approving agency and the design engineer may select other specific ponding times provided that the maximum 3 days is not exceeded. If the available area for the basin is smaller than that required to meet the specific peak control criteria, the basin can be designed to capture the first flush of runoff. Capturing the first flush of runoff may remove many of the waterborne pollutants.

4.2.1 Site Layout

For purposes of definition, the site will consist of two areas: (1) the portion of the watershed that contributes direct runoff to the basin, which is denoted as A_u; and (2) the portion of the watershed allocated to the basin, which is denoted as A_b. The subscript u and b are used to indicate the upland and basin drainage areas, respectively. Notations for the site layout are given in Figure 4-2.

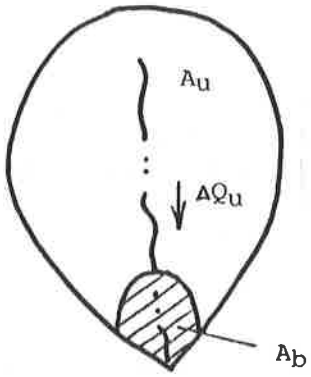
4.2.2 Feasibility Test

Before designing an infiltration basin, it is necessary to determine the textural class of soils underlying the basin such that a feasible design is possible. Soils with infiltration rates less than 0.27 inches per hour should not be considered for an infiltration basin. Those soil textural classes that have slow infiltration rates (i.e. less than 0.27 inches per hour) limit the flow of water through the soil. Additionally, the allowable depth of storage may be too shallow to be practical when constructing the structure, based on the maximum ponding time of 3 days. Thus, the suitable textural class of the soil underlying the basin shall be either a silt loam, loam, sandy loam, loamy sand, or sand.

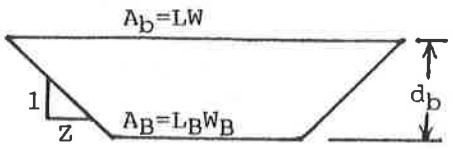
The design of the infiltration basin is also based upon the maximum depth of the basin (d_{max}). The maximum allowable depth shall meet the following criteria:

$$d_{max} = f \cdot T_p = \text{Inches} \qquad (4\text{-}9)$$

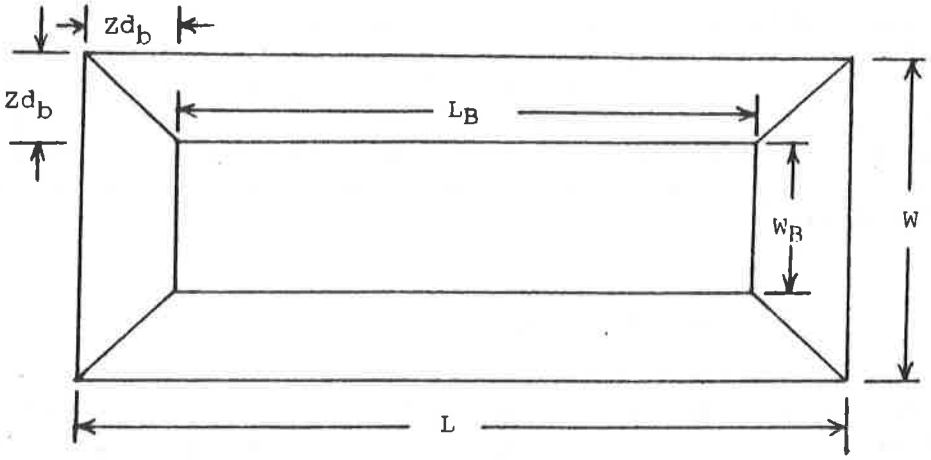
where f is the final infiltration rate of the basin area in inches per hour, and T_p is the maximum allowable ponding time not to exceed 72 hours. The



(a) Plan View of Site



(b) Cross Section of Basin



(c) Top View of Basin

Notation

A_u	=	upland drainage area (acres)
ΔQ_u	=	upland increase in runoff depth (ft)
A_b	=	top surface area of basin (ft^2)
A_B	=	bottom surface area of basin (ft^2)
L	=	top length of basin (ft)
L_B	=	bottom length of basin (ft)
W	=	top width of basin (ft)
W_B	=	bottom width of basin (ft)
d_b	=	basin depth (ft)
Z	=	basin side slope ratio

Figure 4-2. Schematic of Infiltration Basin

maximum allowable depths are given in Table 2-2 for selected values of f and T_p.

4.2.3 Design Method

The design method is based on controlling the increased runoff for a specific frequency storm event. The design return period shall be either the 2 or 10 year frequency storm events depending upon the particular county in Maryland. If the increase in peak discharge associated with the 2 or 10 year storm event cannot be managed, a first flush event should be the minimum selected for design.

The basin is sized to accept the increased runoff volume that enters the basin during the design storm. The design volume of the basin equals the increased upland runoff volume ($\Delta Q_u A_u$) to the basin, plus the volume of rain that falls on the surface area of the basin (PA_b), minus the exfiltration volume (fTA_b) out of the bottom of the basin. Based on the SCS hydrograph analysis, the effective basin filling time (T) will generally be less than two hours. The exfiltration volume is small during the two hour period of time to fill the basin. Therefore, the volume of water that enters the soil during the filling of the basin is not significant compared to the much greater upland runoff volume to the basin and may be ignored with little loss in accuracy. The volume of water that must be stored in the basin (V_w) is defined as:

$$V_w = \Delta Q_u A_u + PA_b \qquad (4\text{-}10)$$

where ΔQ_u is the increased upland runoff depth (ft), A_u is the upland runoff area (ft^2), P is the design rainfall event (ft), and A_b is the basin surface area (ft^2). The increased upland runoff depth (ΔQ_u) is determined by:

$$\Delta Q_u = Q_a - (q_{ub}/q_{ua})Q_b \qquad (4\text{-}11)$$

The volume of rainfall and runoff entering the basin can be defined in terms of the basin geometry. The geometry of the basin will generally be in the shape of an excavated trapezoid with specified side slopes, shown in Figure 4-2. The volume of a trapezoidal shaped basin can be approximated by:

$$V_w = \frac{(LW + L_B W_B)d_b}{2} \qquad (4\text{-}12)$$

where LW is the top surface area of the basin (ft^2), $L_B W_B$ is the bottom surface area of the basin (ft^2), and d_b is the basin depth (ft). The

bottom length and width of the basin can be defined in terms of the top length and width as:

$$L_B = L - 2Zd_b$$
$$W_B = W - 2Zd_b \qquad (4\text{-}13)$$

where Z is a specified side slope ratio (h:v). By setting Equations 4-10 and 4-12 equal and substituting the above relationships for L_B and W_B, the following equation is derived for the basin top length :

$$L = \frac{\Delta Q_u A_u + Zd_b^2 (W - 2Zd_b)}{W(d_b - P) - Zd_b^2} \qquad (4\text{-}14)$$

The surface dimensions of the basin are determined by selecting a top width (W) and side slope ratio (Z), and solving for the top length (L) from Equation 4-14. Both the top width and length must be greater than $2Zd_b$ such that the bottom dimensions are feasible. All the variables in Equation 4-14 are in units of feet or square feet. The solution to Equation 4-14 is provided in Figures 4-3 through 4-8 for P = 3 inches, Z = 2 or 3, and d_b = 3,4,5,6,8,or 10 feet. Equation 4-14 may be used to solve for the top length (L) for values not given in Figures 4-3 through 4-8. A maximum side slope ratio of 2:1 for a vegetated basin and 3:1 for a non-vegetated pit is recommended.

In the event that the basin is constructed with an embankment, the basin area and volume will be determined from the natural ground contours. By planimetering the area of the contours above the base of the embankment, a relationship can be developed for depth and surface area to obtain the volume of the basin. The basin volume from the contour data shall be greater than or equal to the volume determined by Equation 4-10.

4.2.4 Design Procedure

(1) Determine the before and after development runoff volumes (Q_b & Q_a) and unit peak factors (q_{ub} & q_{ua}) from the before and after development curve numbers, and times of concentration (velocity method), from the SCS TR-55 Manual. Figure 4-1 on page 4-3 can also be used to determine q_u. Equation 4-11 is used to compute the increase in the upland runoff volume (ΔQ_u):

$$\Delta Q_u = Q_a - (q_{ub}/q_{ua})Q_b$$

(2) Compute the maximum allowable basin depth (d_{max}) from the feasibility equation, $d_{max} = f\ T_p$. Select the basin design depth (d_b) based on the depth that is at least two feet above the seasonal high groundwater table, or the depth less than or equal to d_{max}, whichever results in the smaller depth.

(3) The basin surface area dimensions can be determined from Figures 4-3 through 4-8 or directly by Equation 4-14. If the Figures are used, compute the value $\Delta Q_u A_u (ft^3)$, select a top width (W) greater than $2Zd_b$, a side slope ratio (Z), and determine the required top length (L). If the variables ($\Delta Q_u A_u$, Z, d_b, P, W) are different than those given in the Figures, use the Figures only as a first trail to find an approximate width and length combination. The exact basin top length (L) is determined from Equation 4-14:

$$L = \frac{\Delta Q_u A_u + Zd_b^2 (W - 2Zd_b)}{W(d_b - P) - Zd_b^2}$$

The basin top length (L) and width (W) must be greater than $2Zd_b$ for a feasible solution. If L and W are not greater than $2Zd_b$, the basin would have no bottom dimensions. In this case, the basin depth (d_b) shall be reduced for a feasible solution.

The same design procedure above may be used for the first flush design except that ΔQ_u used in Equation 4-14 will be equal to the total runoff volume associated with a smaller rainfall amount.

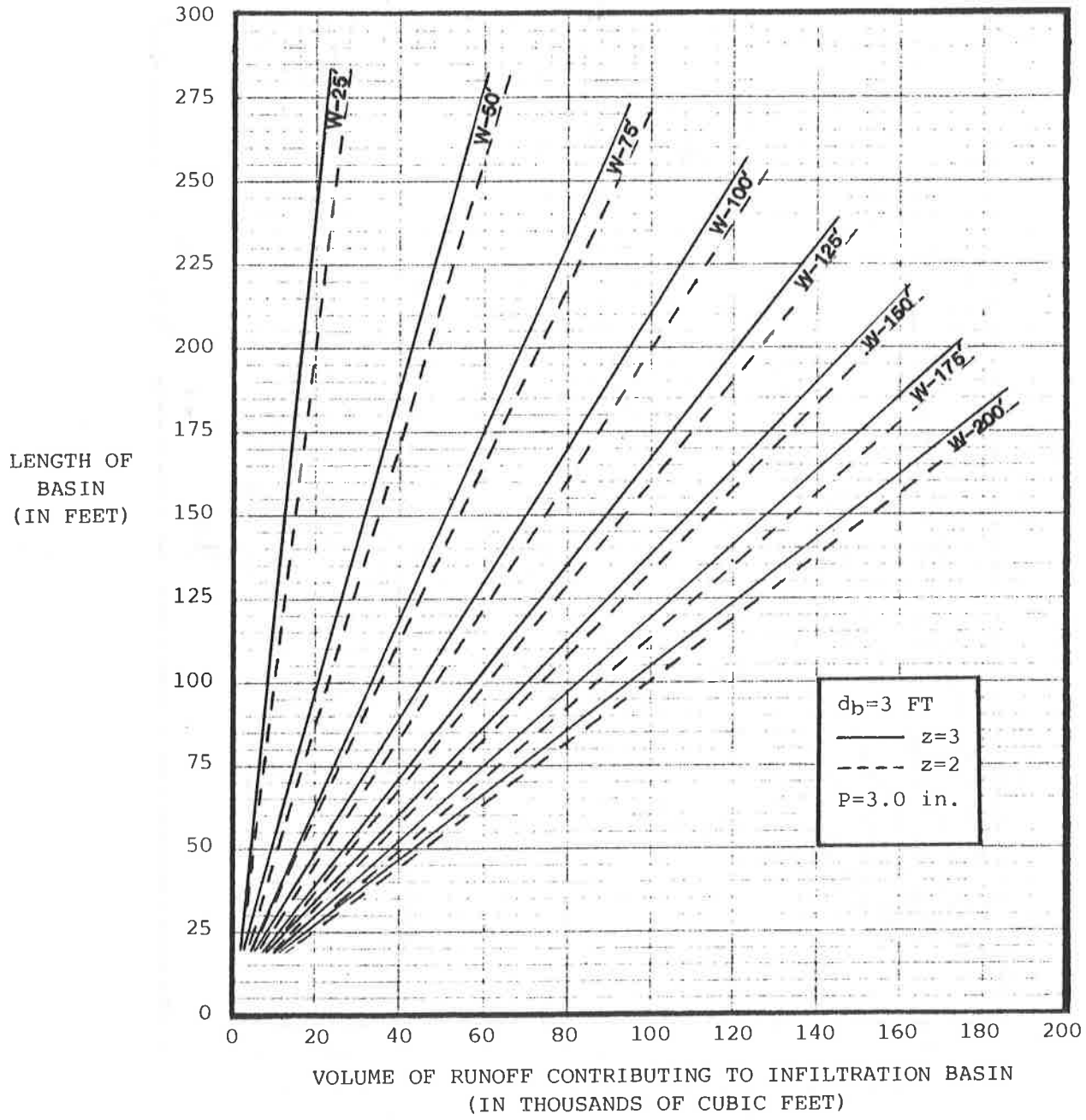


Figure 4-3. Determination of Infiltration Basin Length

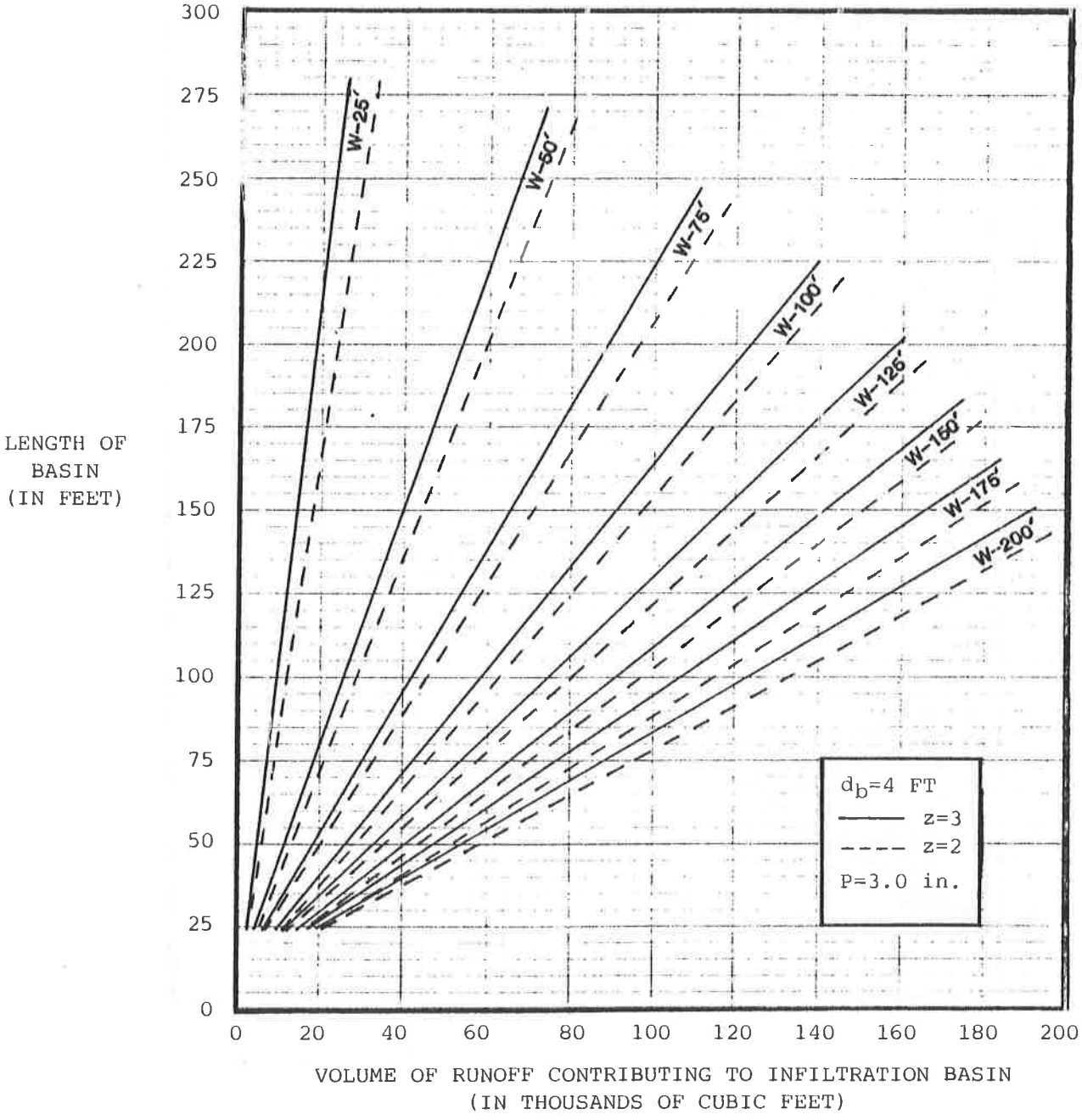


Figure 4-4. Determination of Infiltration Basin Length

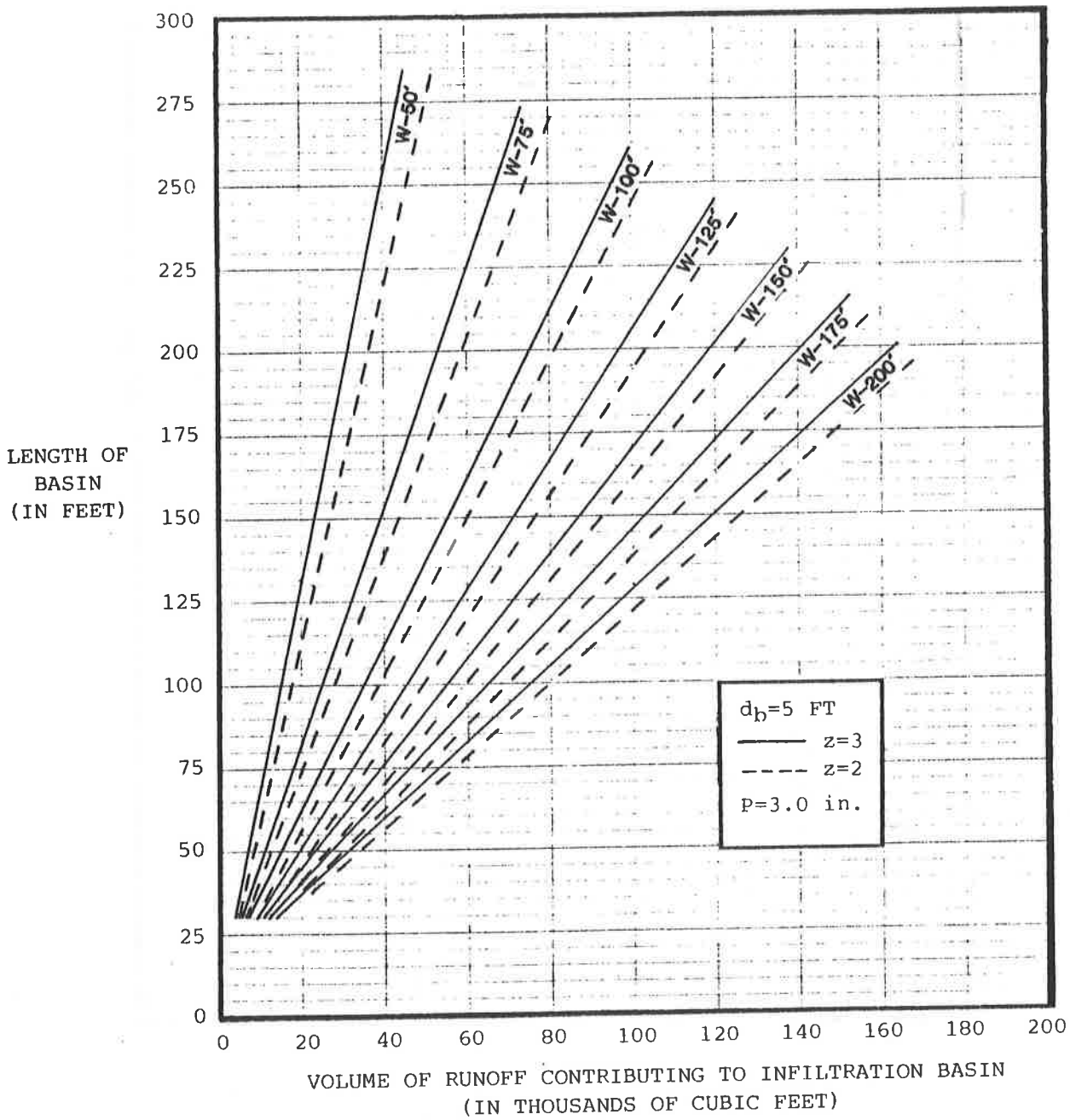


Figure 4-5. Determination of Infiltration Basin Length

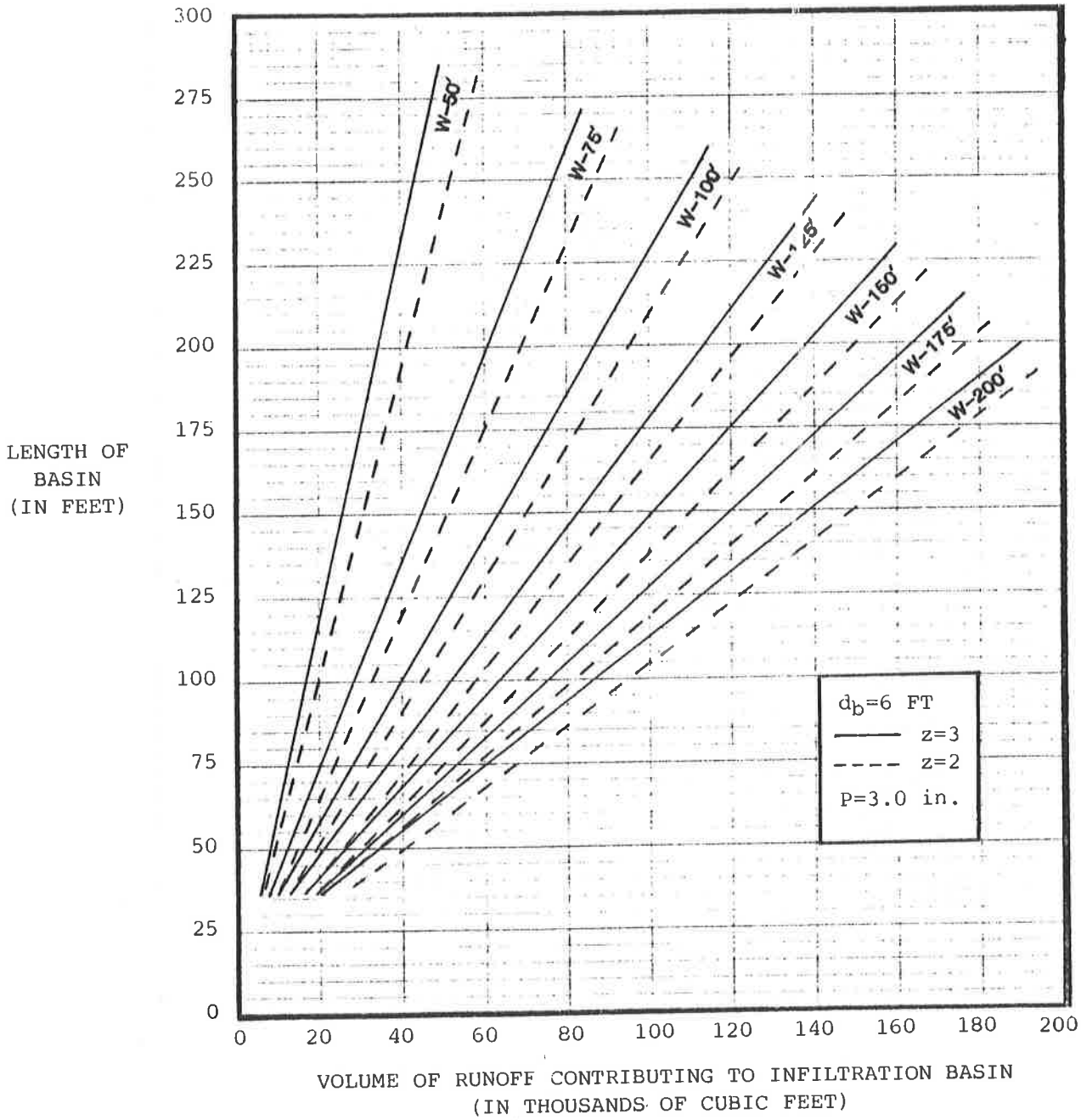


Figure 4-6. Determination of Infiltration Basin Length

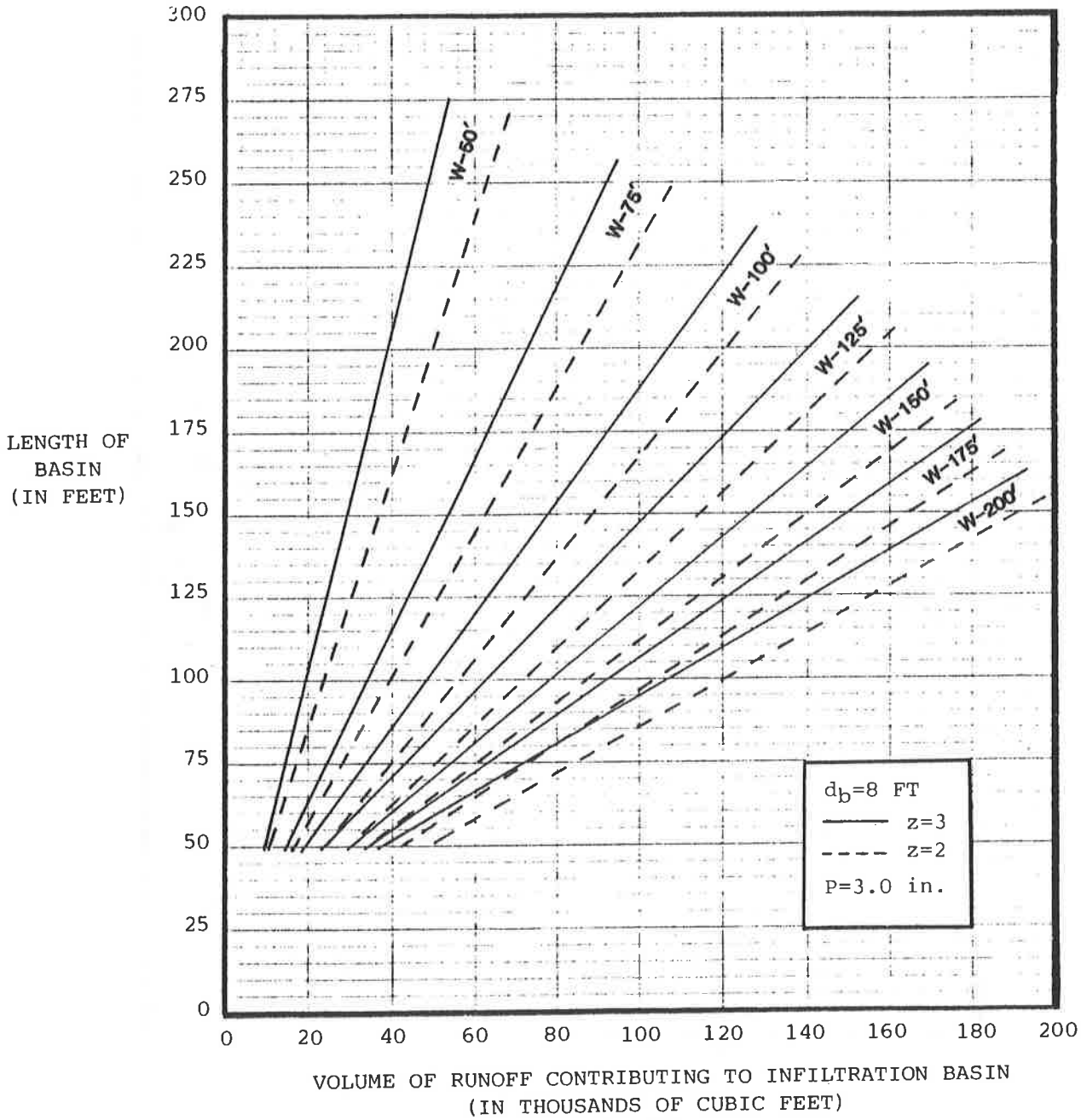


Figure 4-7. Determination of Infiltration Basin Length

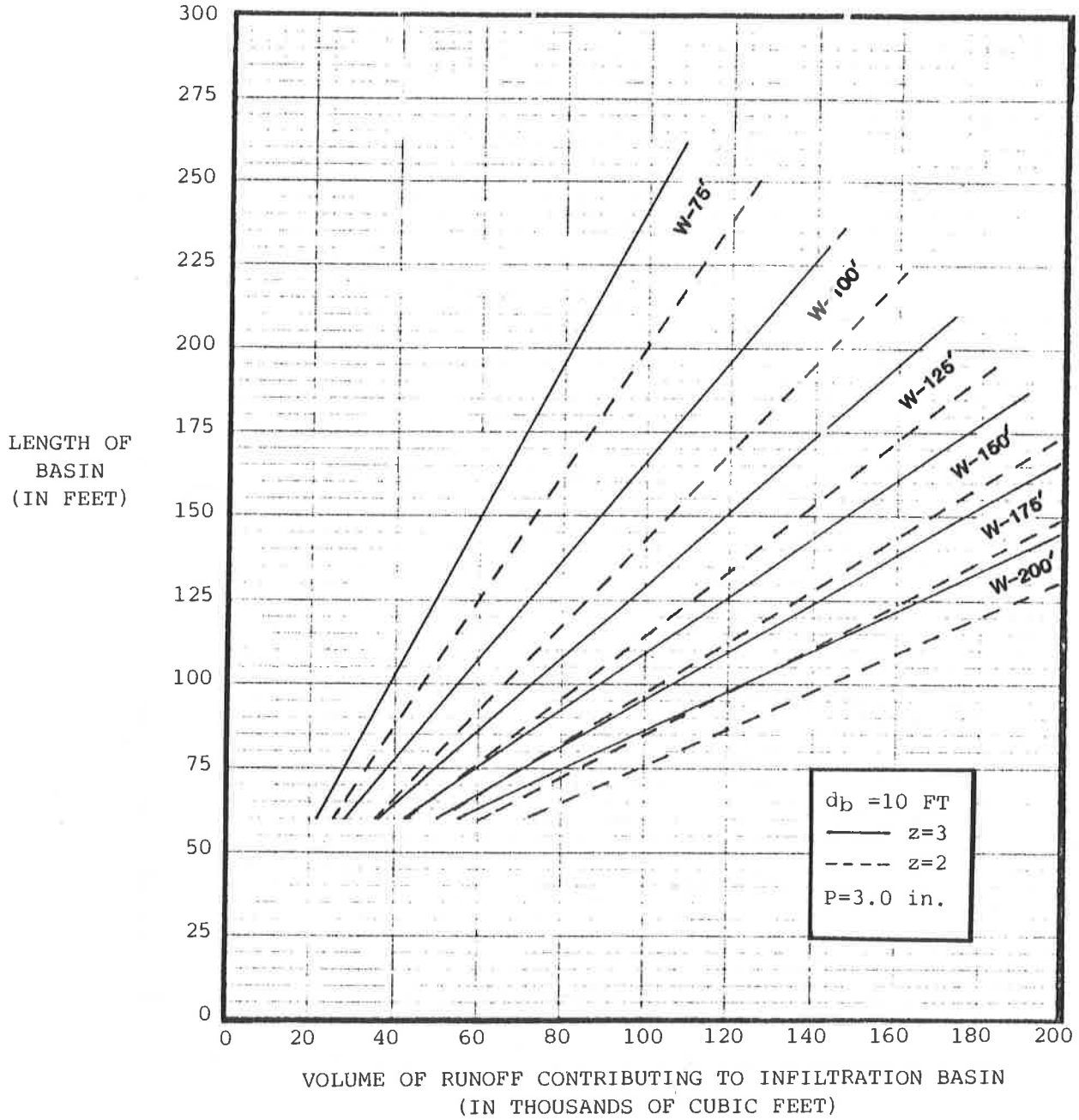


Figure 4-8. Determination of Infiltration Basin Length

4.3 DESIGN OF INFILTRATION TRENCHES

(IT)

An infiltration trench is defined as a subsurface trench that is used to temporarily store runoff in a stone filled reservoir and exfiltrate the runoff through the surrounding soil media. The surface of the trench will consist of either a stone covered area or a grass covered area with an inlet, shown in Figure 4-9. If the trench surface area consists entirely of stone, gabion mattresses or large size stone shall be placed on the surface to prevent loss of stone. A grassed trench surface will require an inlet so runoff can effectively enter the stone filled reservoir storage area. The inlet shall be designed to remove heavier sediments to prevent the clogging of the stone void spaces, as shown in Figure 4-10. A filter fabric material will be required at the interface of the soil and reservoir area or below the gabion mattress and around the sides and bottom of the trench. A minimum 20 foot vegetated buffer strip is required around the perimeter of the trench to prevent sediments from entering the trench and thus, increase the life of the trench.

4.3.1 Site Layout

The site for an infiltration trench consists of two areas: (1) the portion of the watershed that contributes runoff directly to the trench, which is denoted as A_u; and (2) the portion of the watershed allocated to the trench which is denoted as A_t. A schematic of an infiltration trench is given in Figure 4-9. The use of an infiltration trench may be in combination with a grassed swale to provide additional storage below the swale.

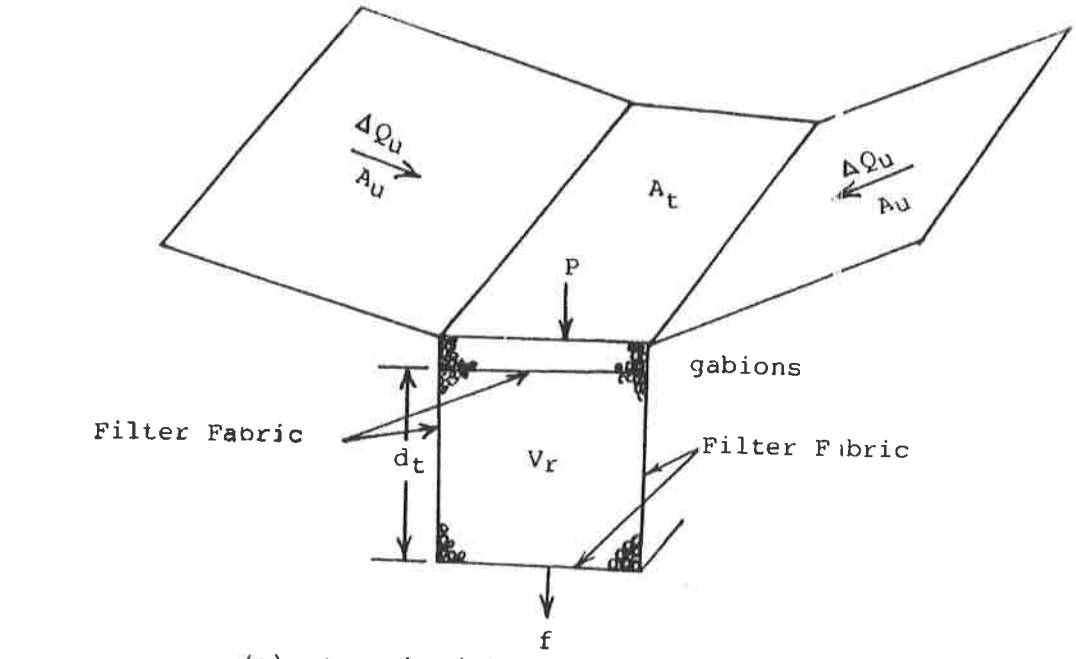
4.3.2 Feasibility Test

Before designing an infiltration trench, it is necessary to determine the textural class of the soils underlying the trench such that a feasible design is possible. Soils with infiltration rates less than 0.27 inches per hour should not be considered for an infiltration trench. Those soil textural classes that have slow infiltration rates (i.e. less than 0.27 inches per hour) limit the flow of water through the soil. Additionally, the allowable depth of storage may be too shallow to be practical when constructing the structure, based on a maximum storage time of 3 days. Thus, the suitable textural class of the soil underlying the trench should be either a silt loam, loam, sandy loam, loamy sand, or sand.

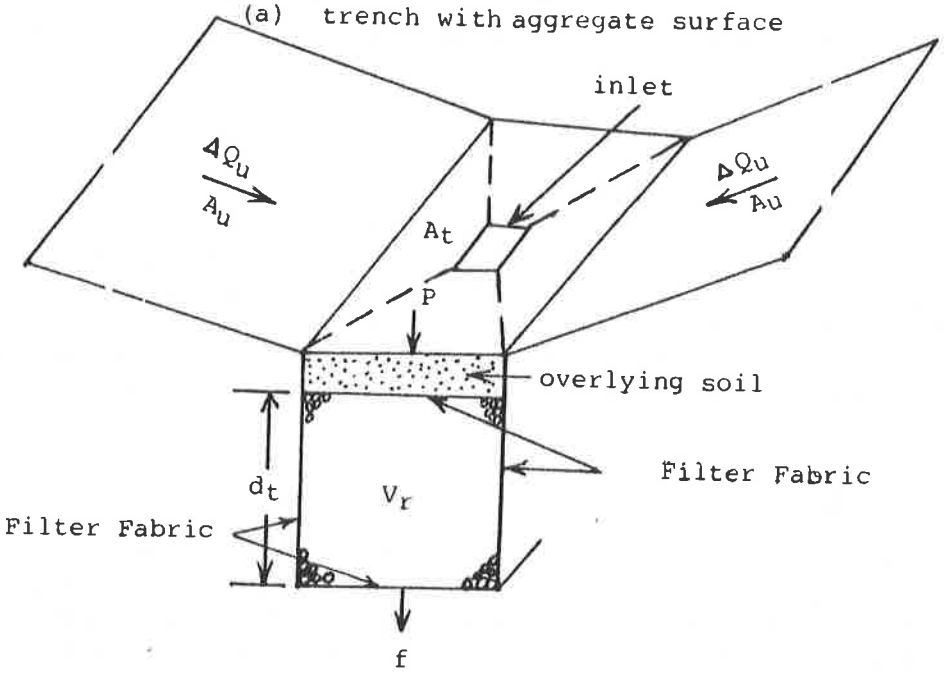
The design of an infiltration trench is also based upon the maximum allowable depth of the trench (d_{max}). The maximum allowable depth should meet the following criteria:

$$d_{max} = f \cdot T_s/V_r \qquad (4\text{-}15)$$

where f is the final infiltration rate of the trench area in inches per hour, T_s is the maximum allowable storage time of 72 hours, and V_r is the void



(a) trench with aggregate surface



(b) trench with vegetated surface with inlet

Notation

P = rainfall depth (feet)

ΔQ_u = upland increase in runoff depth (feet)

A_u = upland drainage area (acres)

A_t = trench surface area (acres)

d_t = trench depth (feet)

f = final infiltration rate (feet/hour)

V_r = void ratio of stone in trench

T = time during which the trench fills with water. Based on SCS hydrograph analysis, T will generally be less than two hours.

Figure 4-9. Schematic of Infiltration Trench

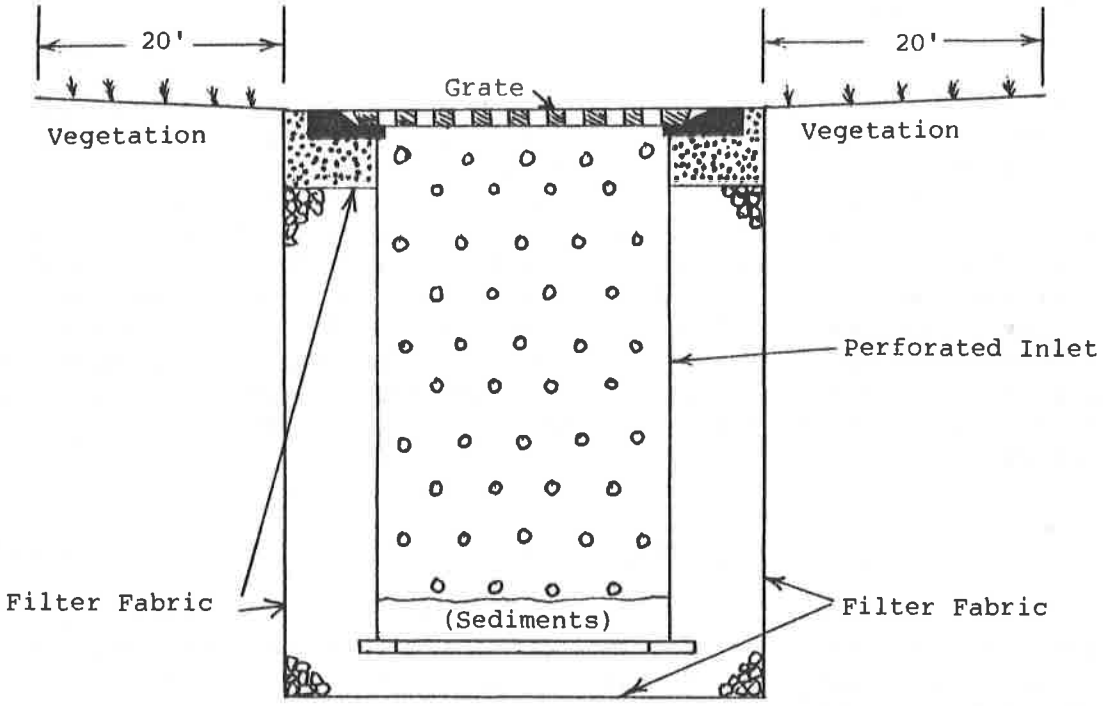


Figure 4-10. Typical Inlet to Infiltration Trench

ratio of the stone reservoir. The maximum allowable depths are given in Table 2-2 for selected values of f, T_s, and V_r.

4.3.3 Design Method

The design method is based on controlling the increased runoff for a specific frequency storm event. The design return period shall be either the 2 or 10 year frequency storm events depending upon the particular county in Maryland. If the increase in peak discharge associated with the 2 or 10 year storm event cannot be managed, a first flush event should be the minimum selected for design.

An infiltration trench is designed based on the increase in the upland runoff volume contributing to the trench during the design storm. The design volume of the trench equals the increased upland volume ($\Delta Q_u A_u$) contributing to the trench, plus the volume of rain that falls on the surface area of the trench (PA_t), minus the exfiltration volume (fTA_t) out the bottom of the trench. For designs based on the SCS type II storm, the trench filling time (T) is less than a 2-hour duration of time that the flow into the trench exceeds the flow out of the trench. Thus, a duration of 2-hours is used for a value of T. The volume of water exfiltrating during the filling period of the trench may be significant for permeable soils and cannot be ignored. The volume of water that must be stored in the trench (V_w) is estimated as:

$$V_w = \Delta Q_u A_u + PA_t - fTA_t \qquad (4\text{-}16)$$

where units of cubic feet are used to represent the volume. The increased upland runoff depth (ΔQ_u) for the upland contributing area (A_u) is determined as:

$$\Delta Q_u = Q_a - (q_{ub}/q_{ua})Q_b \qquad (4\text{-}17)$$

The volume of rainfall and runoff entering the trench can be defined in terms of the trench geometry. The gross volume of the trench (V_t) is equal to the ratio of the volume of the water that must be stored (V_w) to the void ratio (V_r) of the stone reservoir in the trench; V_t is also equal to the product of the depth (d_t) and the surface area (A_t):

$$V_t = V_w/V_r = d_t A_t \qquad (4\text{-}18)$$

Combining Equations 4-16 and 4-18 yields the following relationship:

$$d_t A_t V_r = \Delta Q_u A_u + PA_t - fTA_t \qquad (4\text{-}19)$$

Since both dimensions of the trench (d_t and A_t) are unknown, Equation 4-19

may be rearranged to determine the area of the trench (A_t) if the value of d_t were set based on either the location of the water table or the maximum allowable depth of the trench (d_{max}):

$$A_t = \frac{\Delta Q_u A_u}{(V_r d_t - P + fT)} \qquad (4\text{-}20)$$

Additionally, if the width of a trench was set, Equation 4-20 would yield the required trench length:

$$L_t = \frac{\Delta Q_u A_u}{(V_r d_t - P + fT) W_t} \qquad (4\text{-}21)$$

Equations 4-20 and 4-21 are used to develop a graphical relationship for A_t and L_t with values of the other variables. The solution to Equations 4-20 and 4-21 are provided in Figures 4-11 through 4-20 for four different soil types. All variables in Equations 4-20 and 4-21 must be in units of feet.

4.3.4 Design Procedure

(1) Determine the before and after development runoff volumes (Q_b & Q_a) and unit peak factors (q_{ub} & q_{ua}) from the before and after development curve numbers, and times of concentration (velocity method), from the SCS TR-55 Manual. Figure 4-1 on page 4-3 can also be used to compute q_u. Equation 4-17 is used to determine the upland increase in runoff volume (ΔQ_u):

$$\Delta Q_u = Q_a - (q_{ub}/q_{ua})Q_b$$

(2) Compute the maximum allowable trench depth (d_{max}) from the feasibility equation, $d_{max} = f\ T_s/V_r$. Select the trench design depth (d_t) based on the depth that is at least two feet above the seasonal high groundwater table, or a depth less than or equal to d_{max}, whichever results in the smaller depth.

(3) Determine the trench surface area (A_t) from Figures 4-11 through 4-15, for the particular soil type or compute the trench area directly by Equation 4-20:

$$A_t = \frac{\Delta Q_u A_u}{(V_r d_t - P + fT)}$$

If the variables ($\Delta Q_u A_u$, $V_r d_t$, P, fT) are different than those given in the Figures, use Equation 4-20 for the exact solution.

(4) If the width of the trench is set at either 3 or 6 feet, Figures 4-16 through 4-20 may be used to determine the trench length or computed directly from Equation 4-21:

$$L_t = \frac{\Delta Q_u A_u}{(V_r d_t - P + fT) W_t}$$

If the variables ($\Delta Q_u A_u$, $V_r d_t$, P, fT) are different than those given in the Figures, use the Figures only as a first trail to find an approximate width and length combination.

In the event that the side walls of the trench must be sloped for stability during construction, the surface dimensions of the trench area should be based on the following equation:

$$A_t = (L - Zd_t)(W - Zd_t) \qquad (4\text{-}22)$$

where L and W are the top length and width, and Z is the trench side slope ratio. The design procedure would begin by selecting a top width (W) that is greater than $2Zd_t$ for a specified side slope ratio (Z). The side slope ratio value will depend on the soil type and depth of the trench. The top length (L) is then determined as:

$$L = Zd_t + \frac{A_t}{(W - Zd_t)} \qquad (4\text{-}23)$$

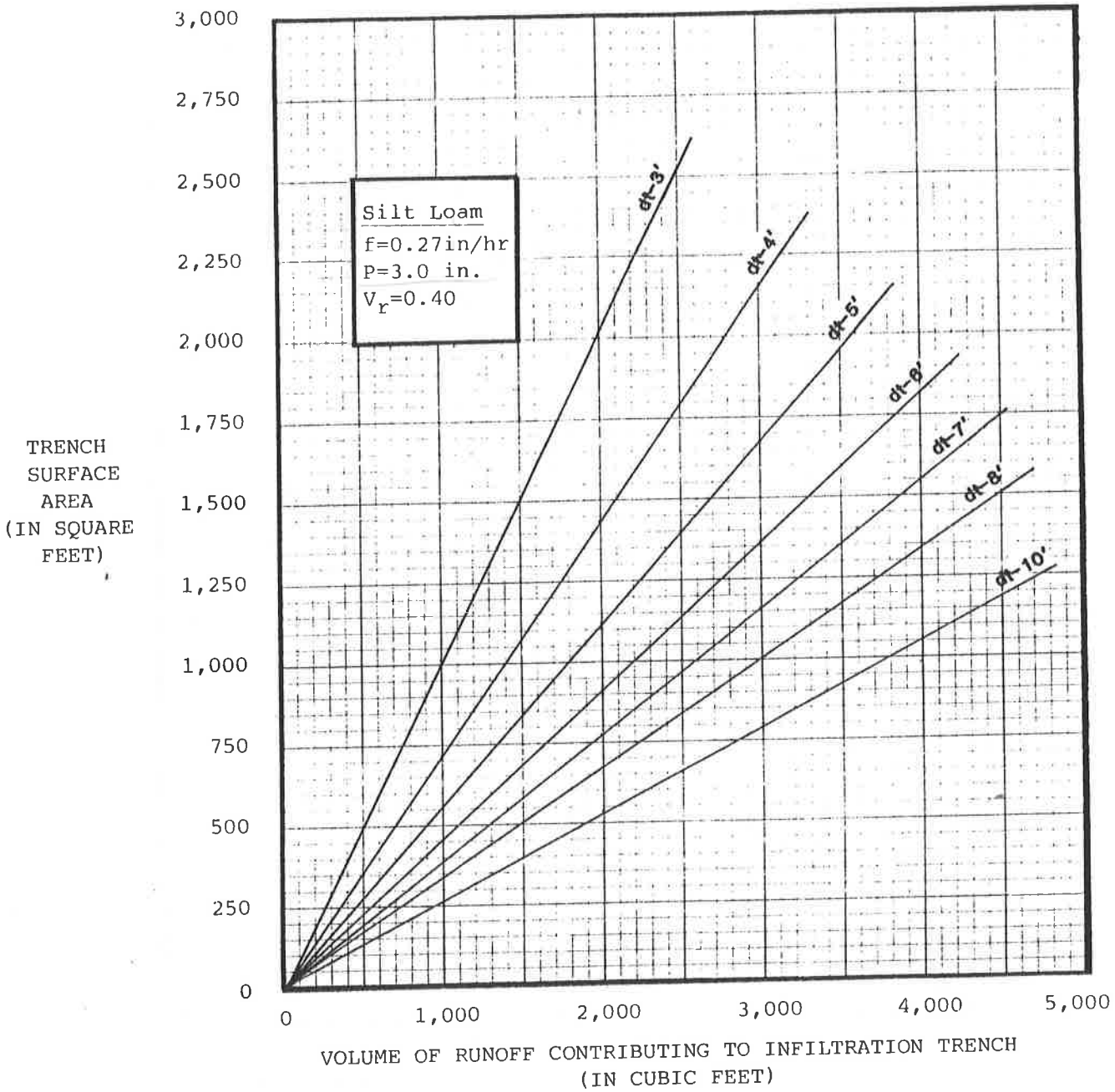


Figure 4-11. Determination of Infiltration Trench Surface Area

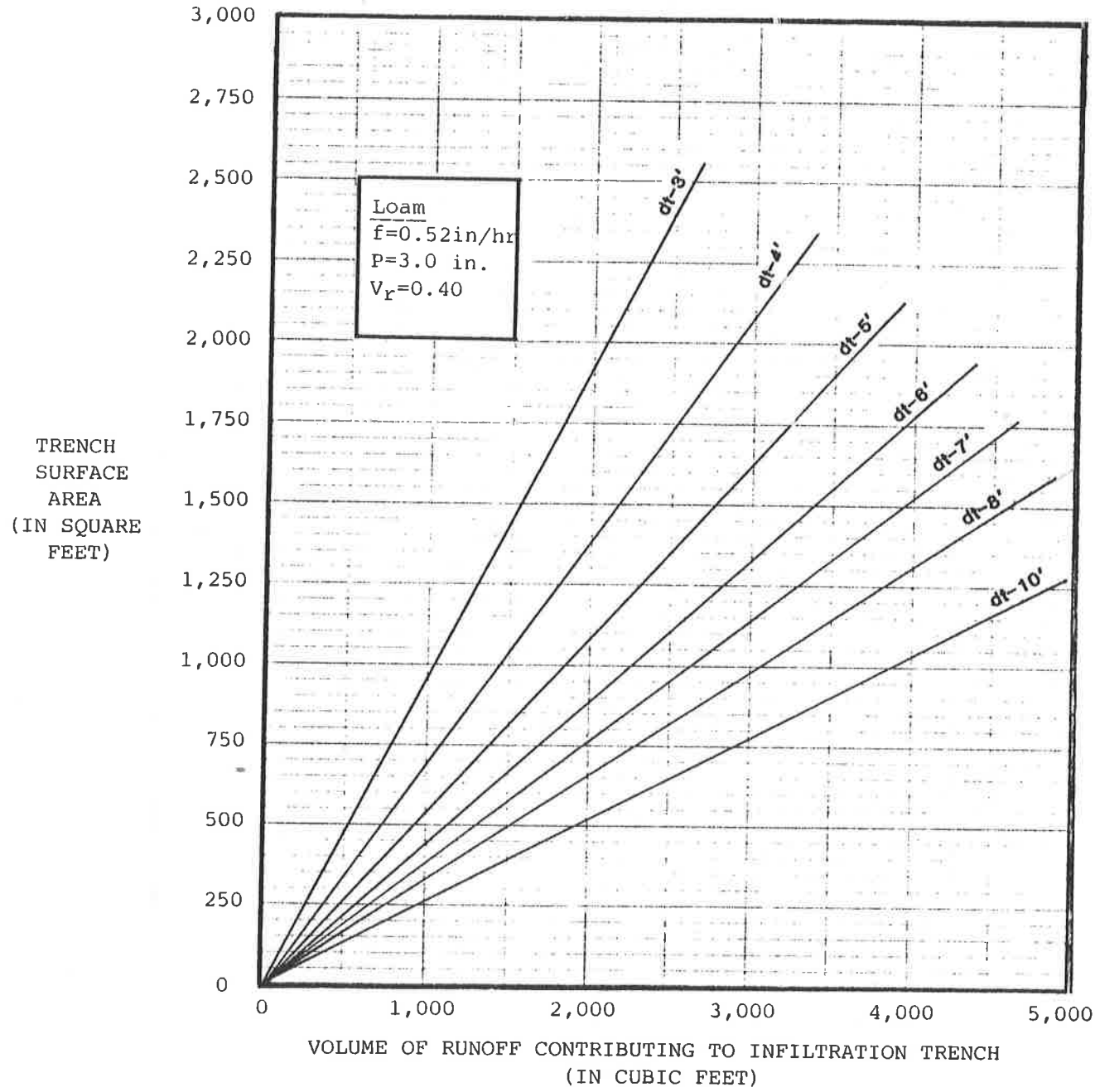


Figure 4-12. Determination of Infiltration Trench Surface Area

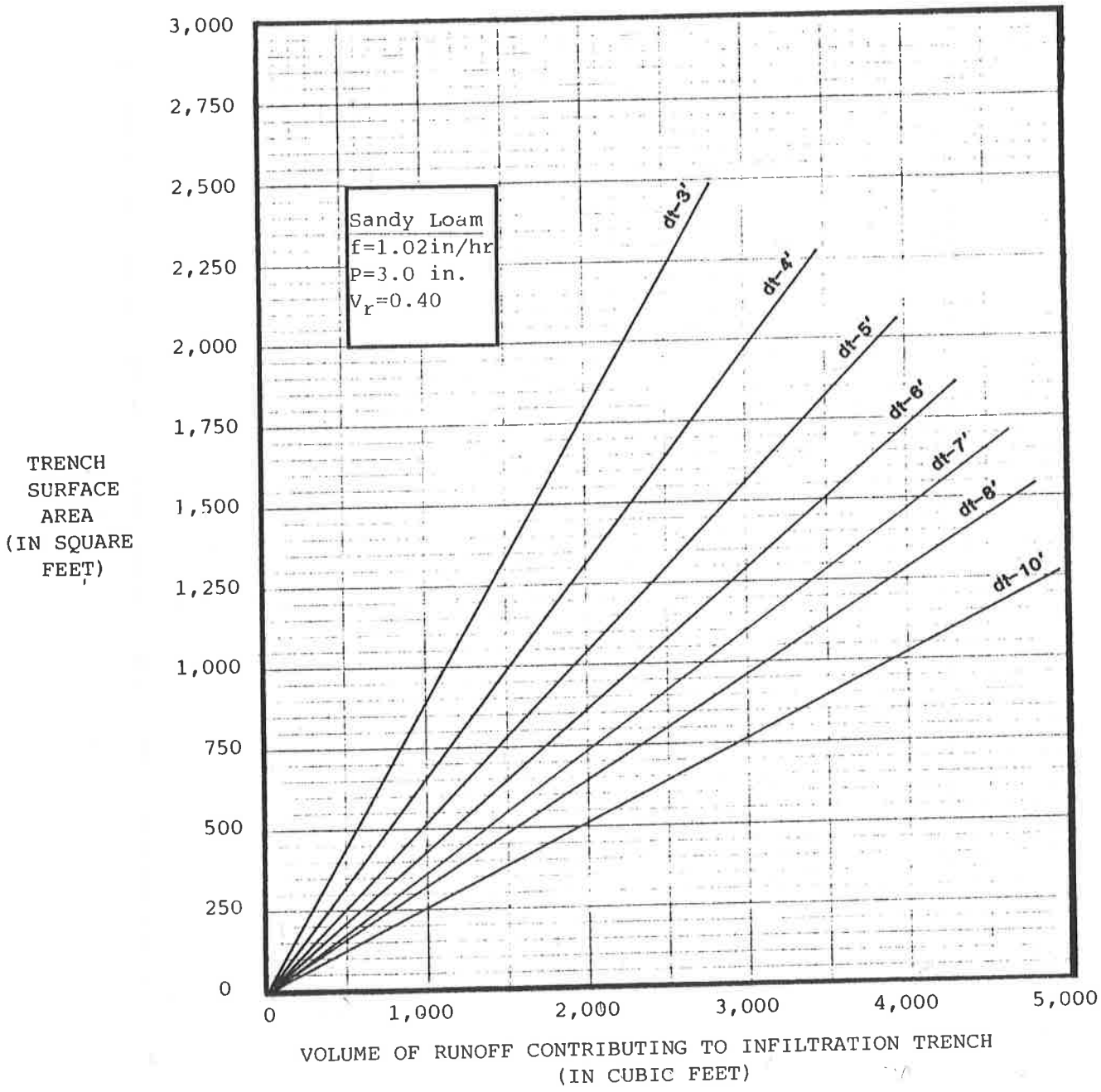


Figure 4-13. Determination of Infiltration Trench Surface Area

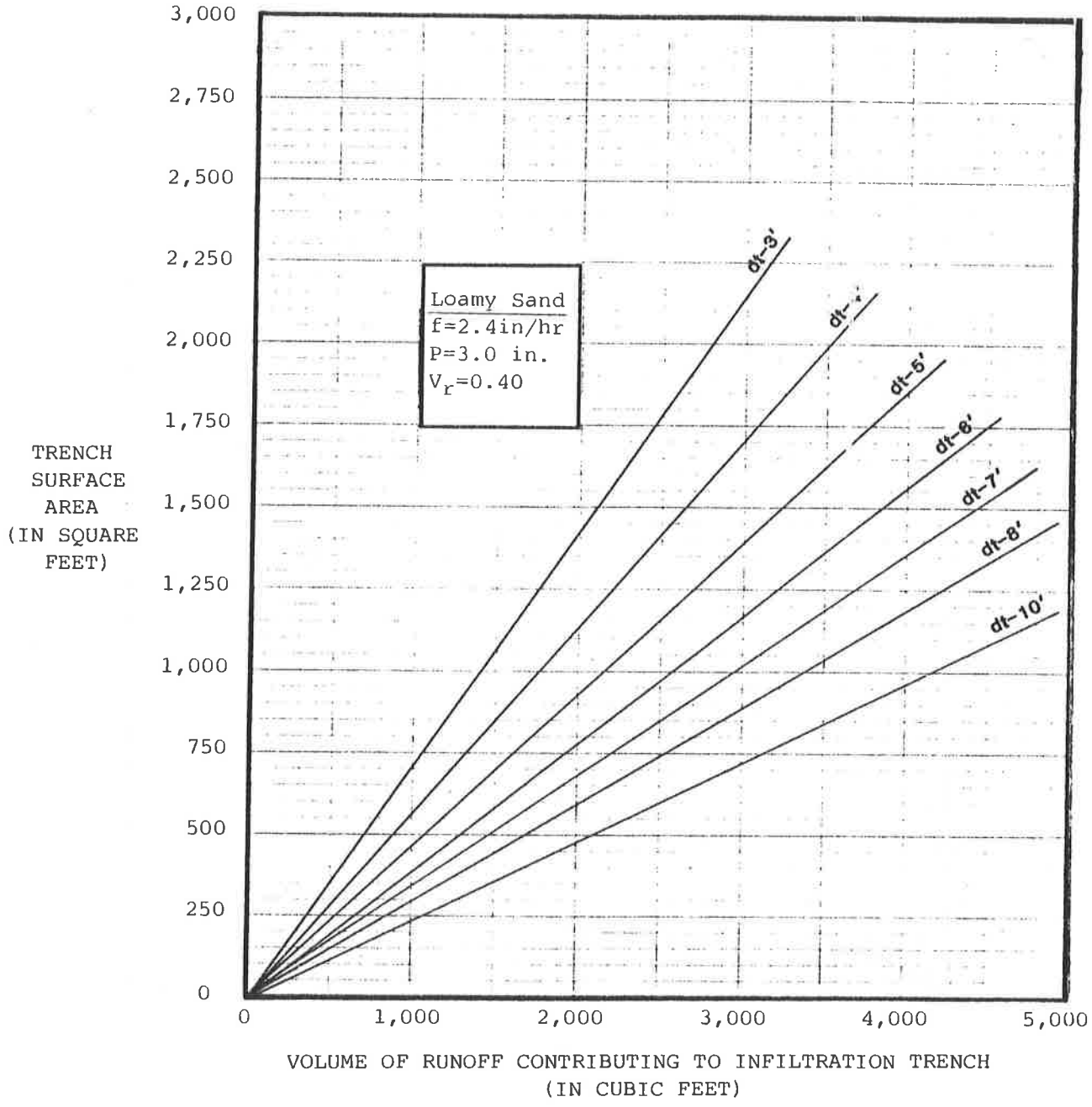


Figure 4-14. Determination of Infiltration Trench Surface Area

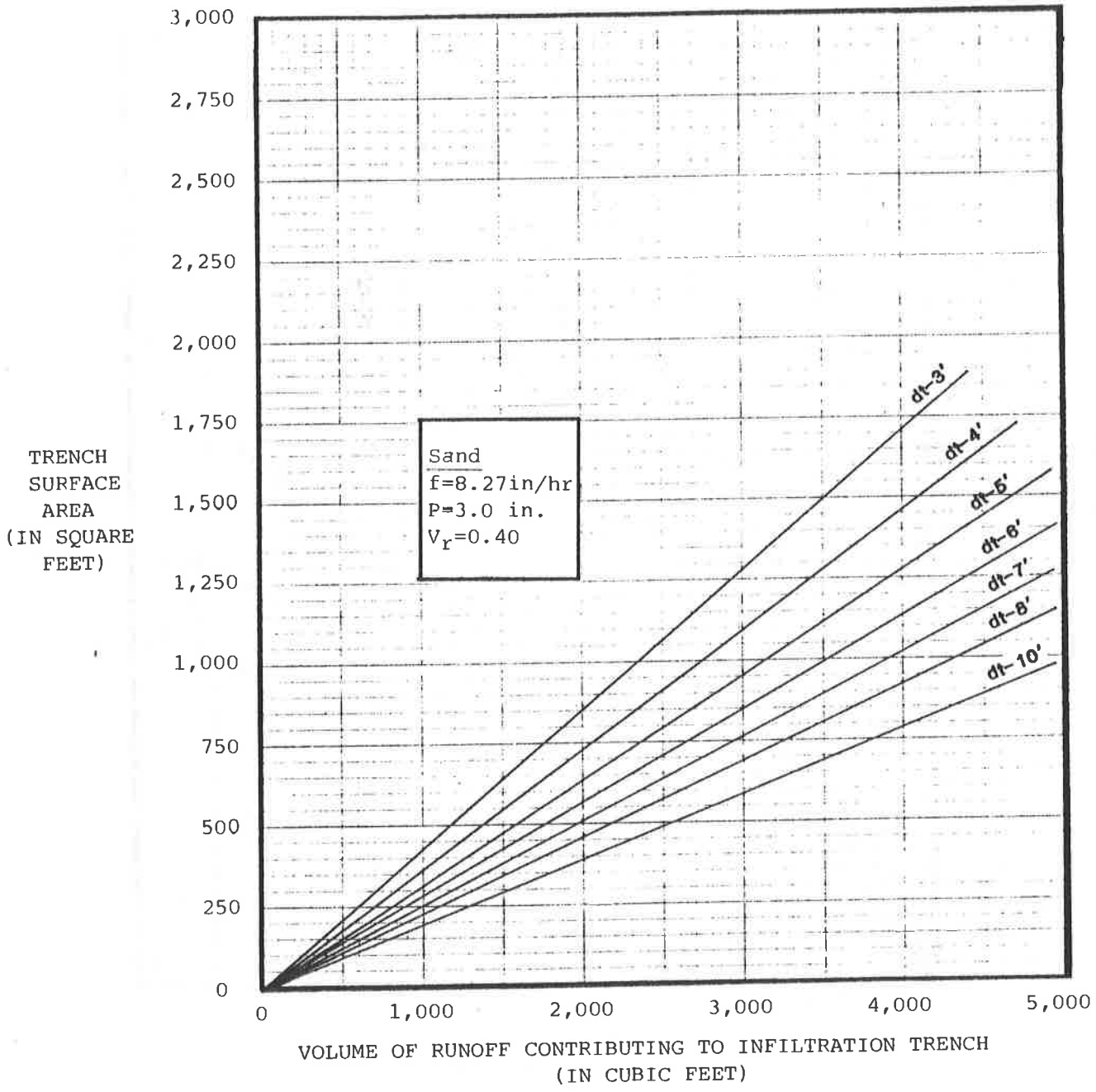


Figure 4-15. Determination of Infiltration Trench Surface Area

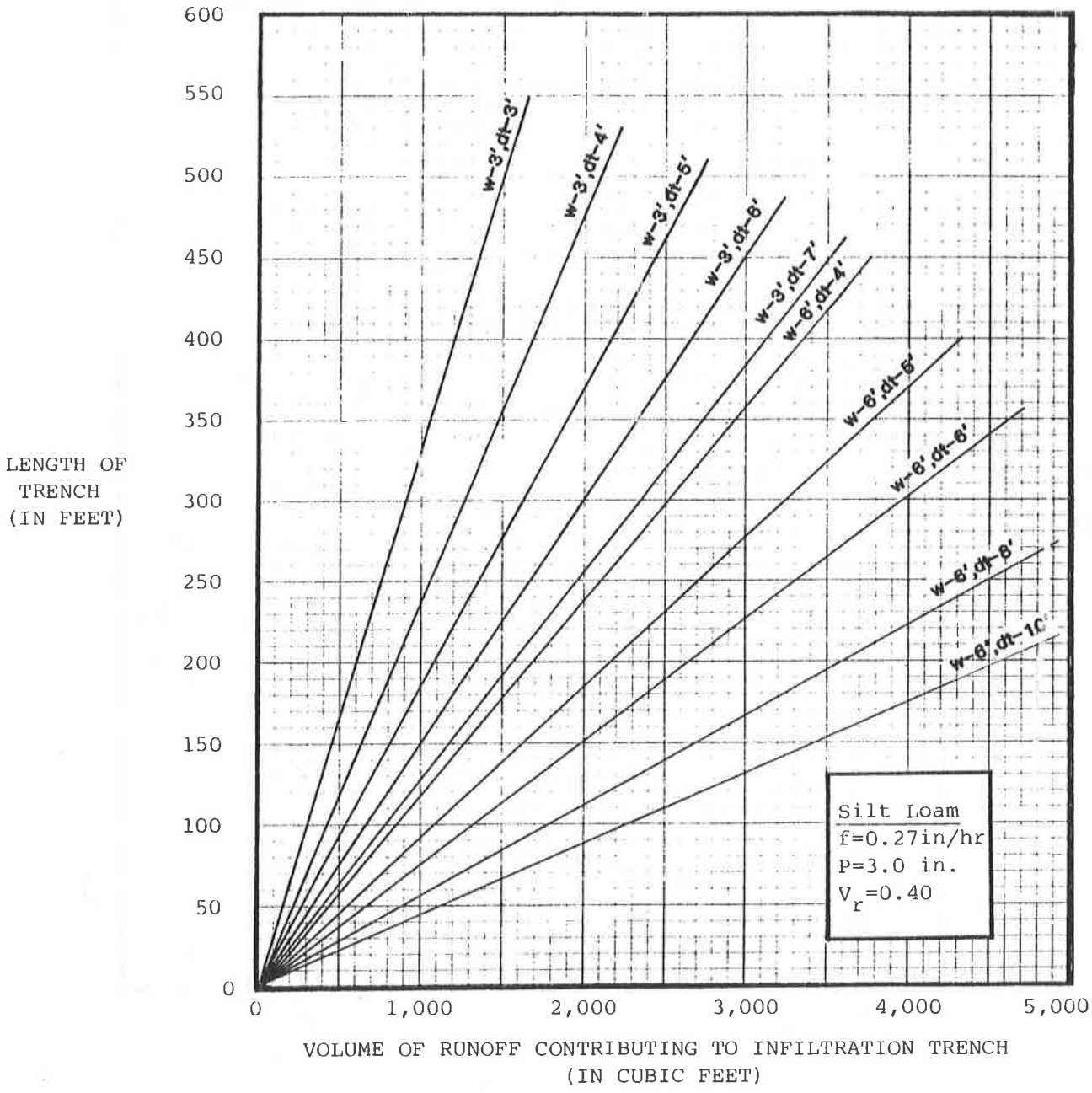


Figure 4-16. Determination of Infiltration Trench Length

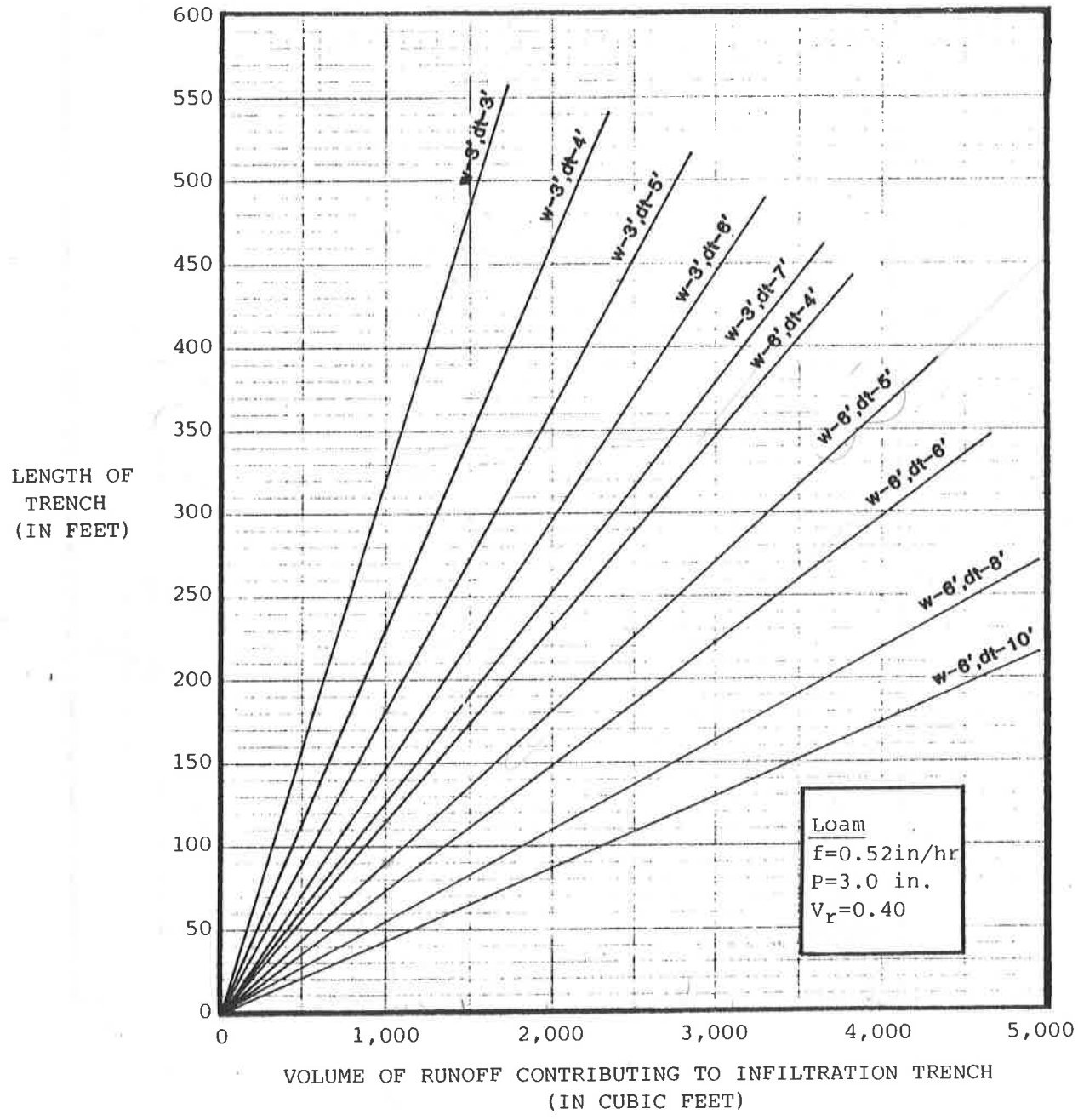


Figure 4-17. Determination of Infiltration Trench Length

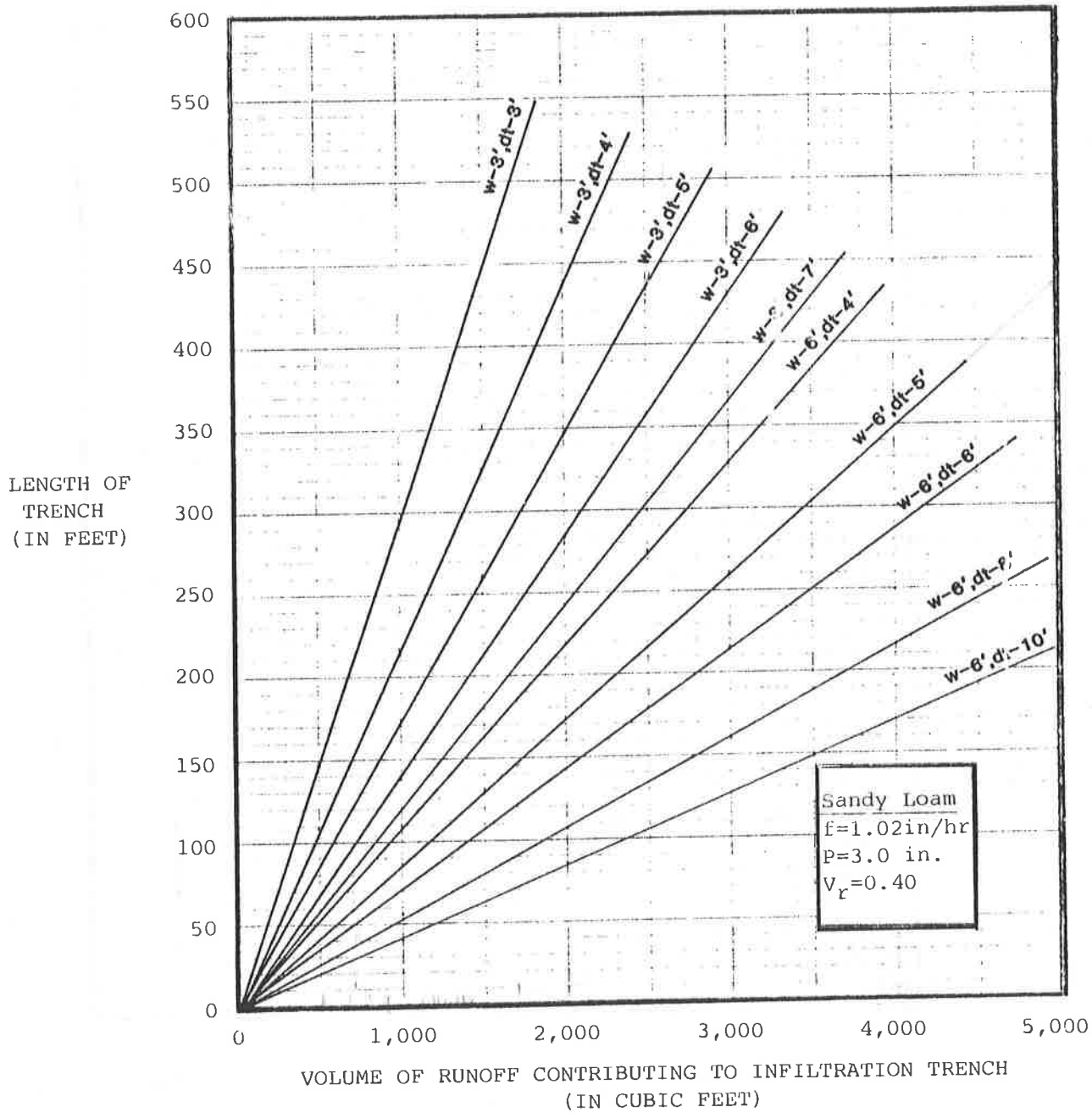


Figure 4-18. Determination of Infiltration Trench Length

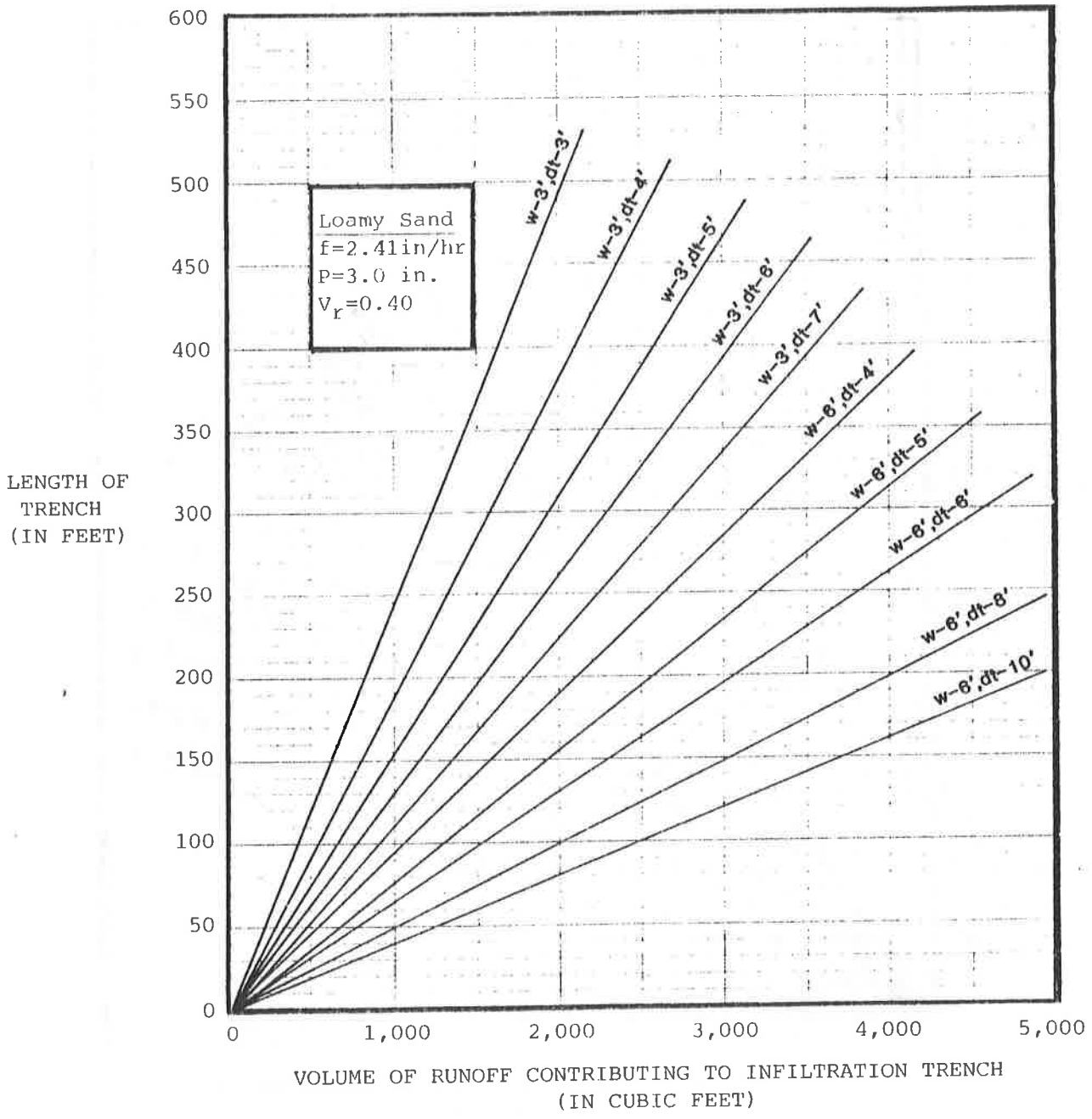


Figure 4-19. Determination of Infiltration Trench Length

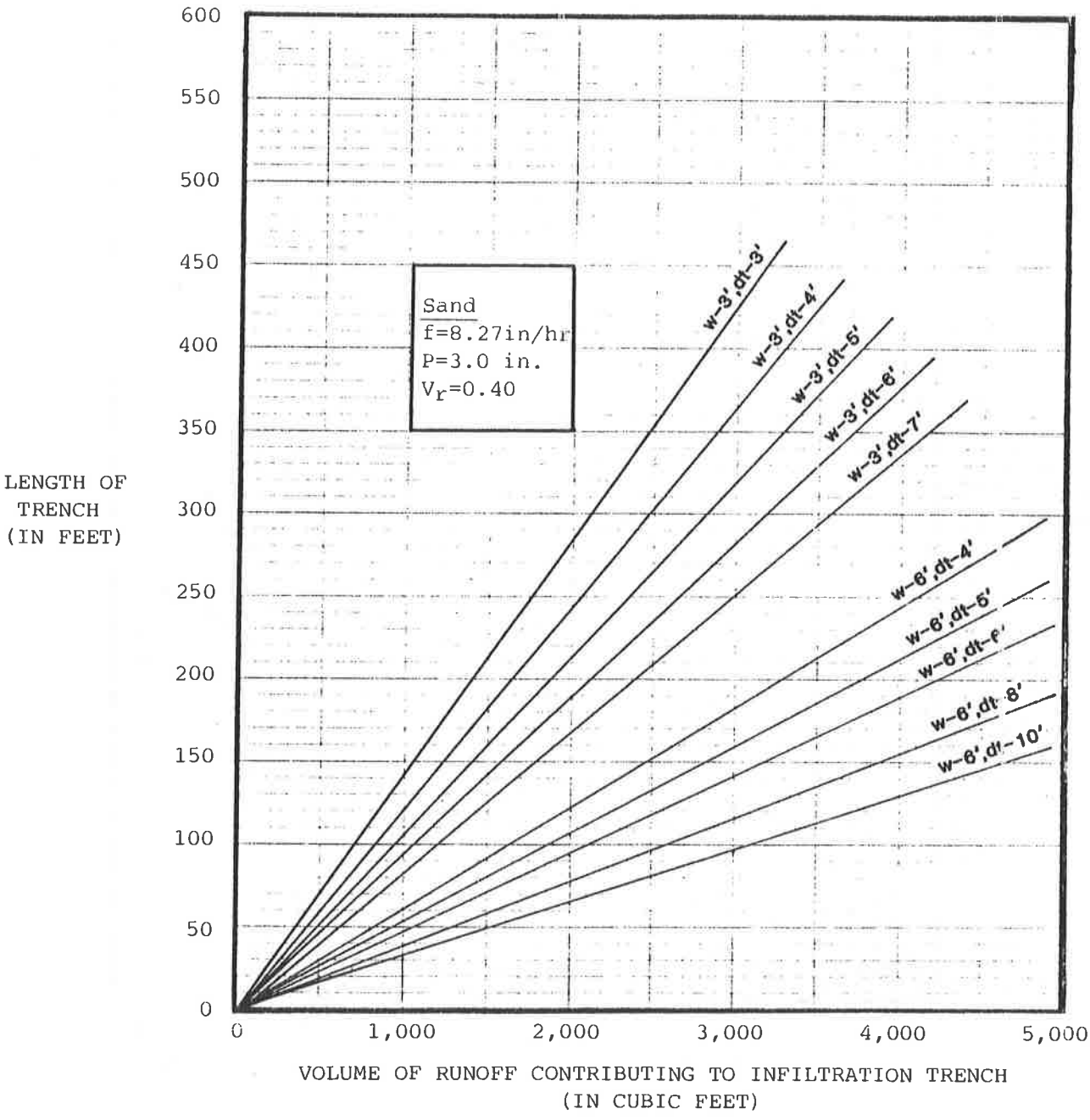


Figure 4-20. Determination of Infiltration Trench Length

4.4 DESIGN OF DRY WELLS

(DW)

Dry well storage is defined as subsurface storage in which inflow is by way of both pipe inlet(s) and infiltrating water through the overlying soil. The volume of storage in the dry well must accommodate runoff from a contributing area (A_c in Figure 4-21) as well as water that infiltrates through the overlying soil (A_w in Figure 4-21).

While a dry well serves to control runoff using concepts similar to that of infiltration trenches and porous pavements, the areal extent of the runoff control methods serves as an important distinguishing factor. As used herein, dry wells have small areal extents in comparison to both porous pavements and infiltration trenches. The time of concentration of runoff from the contributing area is very small; in fact, it may be considered as instantaneous in comparison to both the duration of the design storm and the smallest time increment for routing through such systems. For example, the time required for rooftop runoff to be discharged from a downspout could probably be measured in seconds rather than minutes.

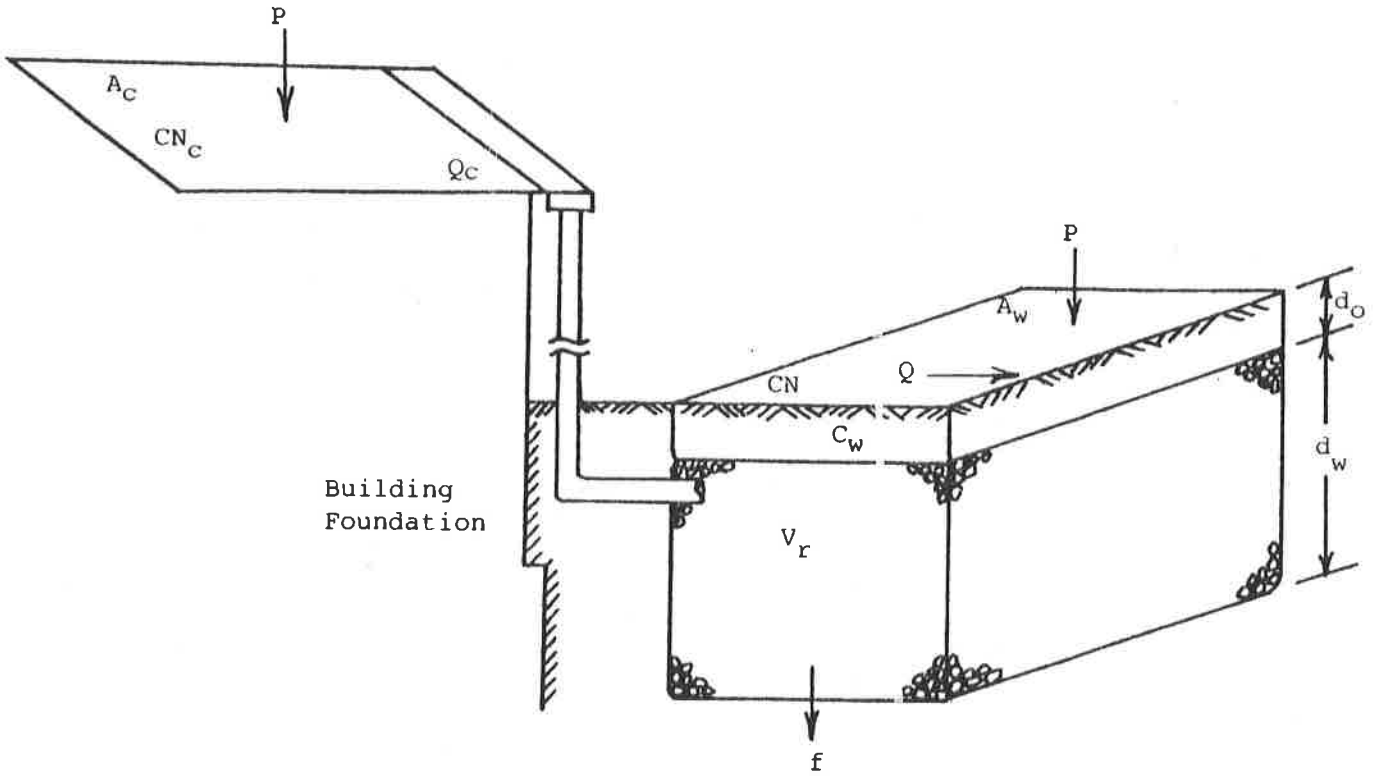
4.4.1. Site Layout

Dry well storage is subsurface storage in which inflow is by way of pipe inlet(s) draining runoff from rooftop areas (A_c) with gutters leading directly into the stone filled reservoir area (A_w) below the overlying soil shown in Figure 4-21. In special cases, the dry well may be designed with a surface inlet to capture runoff from an upland drainage area, although its functioning life may be reduced due to sediments clogging the stone reservoir. A filter fabric material shall be required directly below the overlying soil surface and around the sides and bottom of the dry well. Any surface inlet above the dry well shall have a minimum 20 foot vegetated buffer strip on each side of the inlet. The vegetated buffer strip will prevent sediments from entering the well and clogging the stone voids and thus, increase life of the dry well.

4.4.2. Feasibility Test

Before designing a dry well, it is necessary to determine the textural class of the soils underlying the well such that a feasible design is possible. Soils with infiltration rates less than 0.27 inches per hour should not be considered for a dry well. Those soil textural classes that have slow infiltration rates (i.e. less than 0.27 inches per hour) limit the flow of water through the soil. Additionally, the allowable depth of storage may be too shallow to be practical when constructing the structure, based on the maximum storage time of 3 days. Thus, the suitable textural class of the soil underlying the dry well should be either a silt loam, loam, sandy loam, loamy sand, or sand.

The design of a dry well is also based upon the maximum allowable depth



Notation

P = rainfall depth (ft)

CN_C = CN for contributing area

A_C = area contributing runoff to dry well (ft^2)

Q_C = depth of runoff from contributing area (ft)

A_W = surface area of dry well (ft^2)

Q = runoff depth from overlying area A_W (ft)

CN = CN of overlying soil

C_W = water capacity of overlying soil (in/in)

d_O = depth of soil overlying dry well (ft)

d_W = depth of dry well storage (ft)

V_r = void ratio in dry well

f = final infiltration rate below dry well (ft/hr)

Figure 4-21. Schematic of a Dry Well

of the trench (d_{max}). The maximum allowable depth should meet the following criteria:

$$d_{max} = f \cdot T_s/V_r \qquad (4\text{-}24)$$

where f is the final infiltration rate of the dry well area in inches per hour, T_s is the maximum allowable storage time of 72 hours, and V_r is the void ratio of the stone reservoir. The maximum allowable depths are given in Table 2-2 for selected values of f, T_s, and V_r.

4.4.3. Design Method

The design method is based on controlling the increased runoff for a specific frequency storm event. The design return period shall be either the 2 or 10 year frequency storm events depending upon the particular county in Maryland. If the increase in peak discharge associated with the 2 or 10 year storm event cannot be managed, a first flush event should be the minimum selected for design.

The design method proposed herein is based on the conceptual framework of Figure 4-21. Rainfall produces runoff from both the surface area of the dry well (A_w) and the contributing area (A_c). Runoff from the contributing area (Q_c) passes to the dry well by way of a pipe. Rain that falls onto the surface area (A_w) will run off (Q) according to the curve number (CN) of the dry well area; Q will be based on the overlying soil and grass cover. That which does not run off (i.e., P-Q) will be available for infiltration through the overlying soil and into the dry well. The depth that infiltrates into the dry well during the storm will also depend on the depth of the overlying soil (d_o) and the water capacity of the overlying soil (C_w). The flow out of the base of the dry well will depend on the infiltration rate (f), the area (A_w), and the time that the flow into the dry well exceeds the flow out of the dry well, or the effective filling time (T). Values of f should be obtained from Table 2-1. For designs based on the SCS type II storm, a time of one hour will be used for a value of T because, for storm volumes typically used for design, the inflow rate will exceed the outflow rate during a time period less than one hour.

The volume of water that must be stored (V_w) is the sum of the runoff from the contributing area (A_cQ_c), plus the volume of water entering the dry well surface $(P - Q)A_w$ less than volume of water stored in the overlying soil ($d_oC_wA_w$) minus the volume of water exfiltrating out of the dry well bottom (fTA_w):

$$V_w = A_cQ_c + (P - Q - d_oC_w)A_w - fTA_w \qquad (4\text{-}25)$$

in which $(P - Q - d_oC_w)$ must be greater than or equal to 0.0.

The volume of the dry well may be defined in terms of the well geometry.

The gross volume of the dry well (V_s) is equal to the product of the depth (d_w) and the surface area (A_w); V_s also equals the ratio of the volume of the water that must be stored (V_w) to the void ratio (V_r) of the aggregate reservoir in the dry well:

$$V_s = V_w/V_r = d_w A_w \qquad (4\text{-}26)$$

Combining Equations 4-25 and 4-26 yields the following relationship:

$$d_w A_w V_r = A_c Q_c + (P - Q - d_o C_w)A_w - fTA_w \qquad (4\text{-}27)$$

Since both dimensions of the dry well (d_w and A_w) are unknown, Equation 4-27 represents one equation with two unknowns. Thus, there are a number of combinations of d_w and A_w that can be used. If the value of d_w were set based on either the location of the water table or the maximum allowable depth (d_{max}), then the area A_w could be determined by rearranging Equation 4-27.

$$A_w = \frac{Q_c A_c}{V_r d_w - P + Q + d_o C_w + fT} \qquad (4\text{-}28)$$

Equation 4-28 is used to graph the relationship between A_w and d_w for values of the other variables, shown in Figures 4-22 through 4-26. The overlying soil was assumed to be a 12 inch deep loam textural class soil having a water capacity of 0.19 in/in and a runoff curve number of 61. All variables used in Equation 4-28 must be in units of feet.

4.4.4 Design Procedure

(1) From the selected design rainfall (P) and runoff curve numbers, compute the runoff depths for the overlying soil (Q, based on grass cover) and the contributing area (Q_c, curve number = 98 for impervious surface).

(2) Compute the maximum allowable dry well depth (d_{max}) from the feasibility equation, $d_{max} = fT_s/V_r$. Select the dry well design depth (d_w) based on the depth that is at least two feet above the seasonal high groundwater table, or a depth less than or equal to d_{max}, whichever results in the smaller depth.

(3) Determine the dry well surface area (A_w) from Figures 4-22 through 4-26 or compute the required surface area of the dry well from

Equation 4-28:

$$A_w = \frac{Q_c A_c}{V_r d_w - P + Q + C_w d_o + fT}$$

C_w and f are obtained from Table 2-1 based on the overlying and underlying soil types of the dry well, respectively. Use a T value of one hour for design. If the variables ($Q_c A_c$, $V_r d_w$, P, Q, $C_w d_o$, fT) are different than those given in the Figures, use Equation 4-28 for the exact solution.

In the event that the side walls of the dry well must be sloped for stability during construction, the surface dimensions of the dry well area should be based on the following equation:

$$A_w = (L - Zd_w)(W - Zd_w)$$

where L and W are the top length and width, and Z is the dry well side slope ratio. The design procedure would begin by selecting a top width (W) that is greater than $2Zd_w$ for a specified side slope ratio (Z). The side slope ratio value will depend on the soil type and depth of dry well. The top length (L) is then determined as:

$$L = Zd_w + \frac{A_w}{(W - Zd_w)}$$

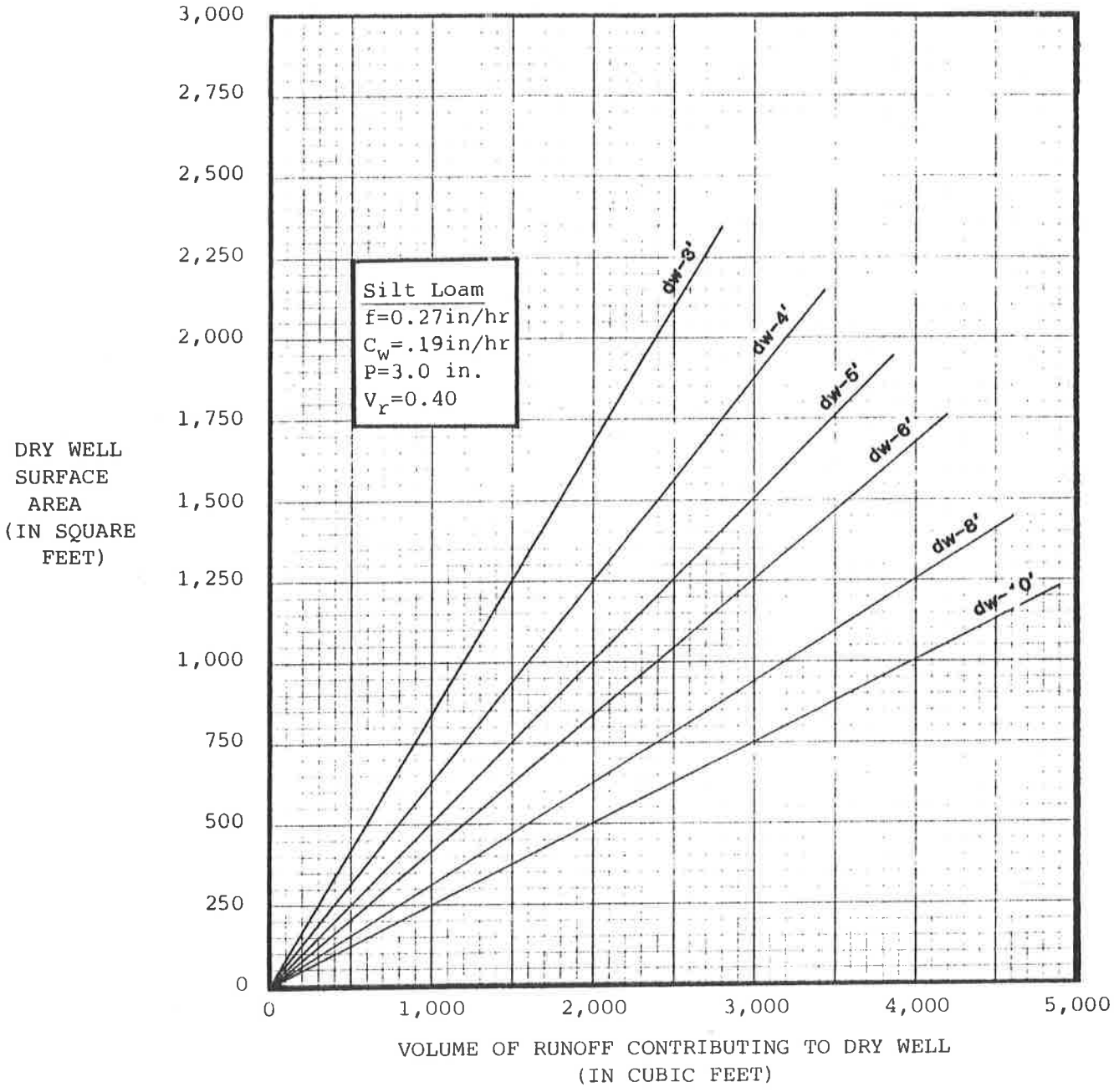


Figure 4-22. Determination of Dry Well Surface Area

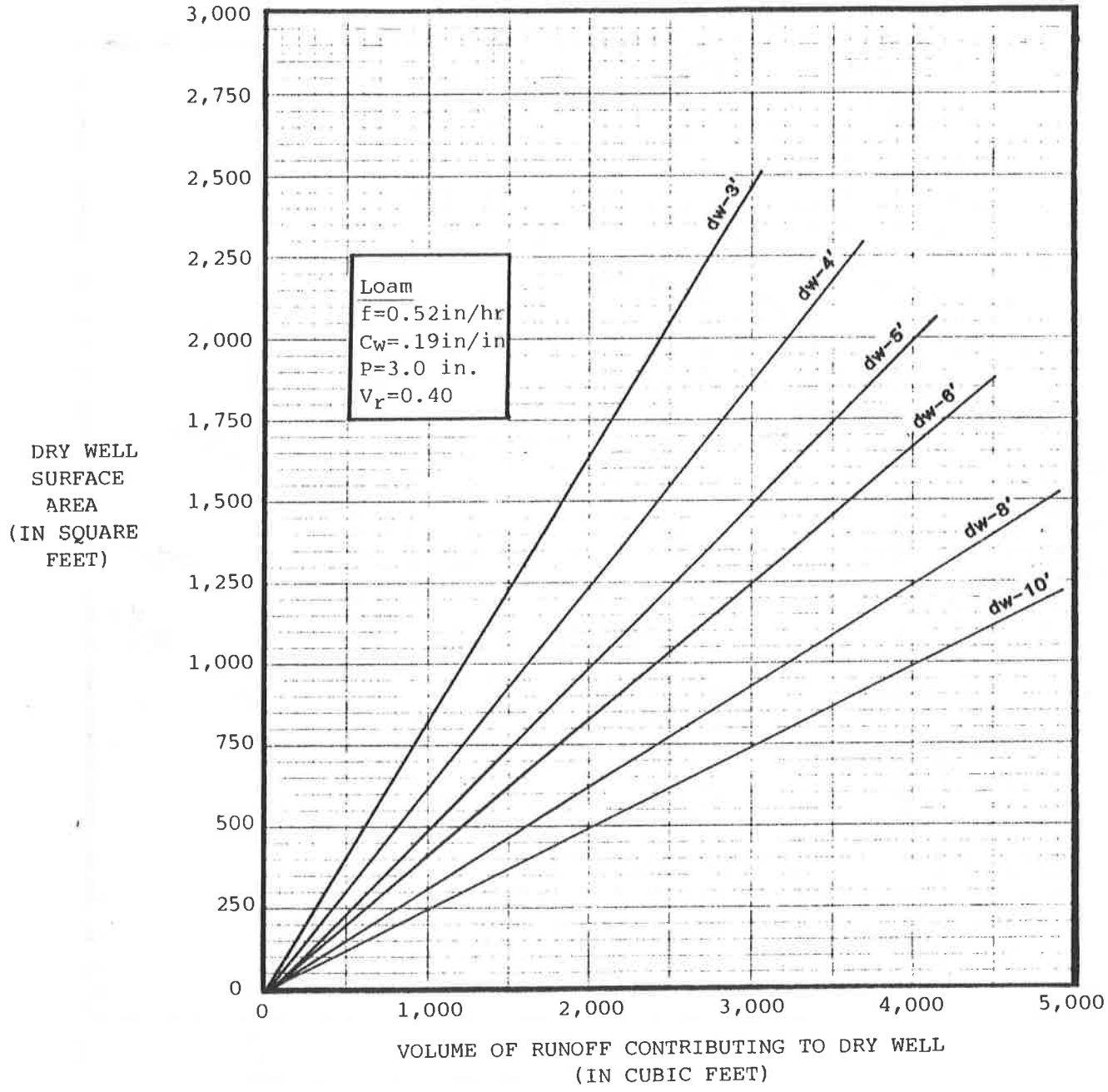


Figure 4-23. Determination of Dry Well Surface Area

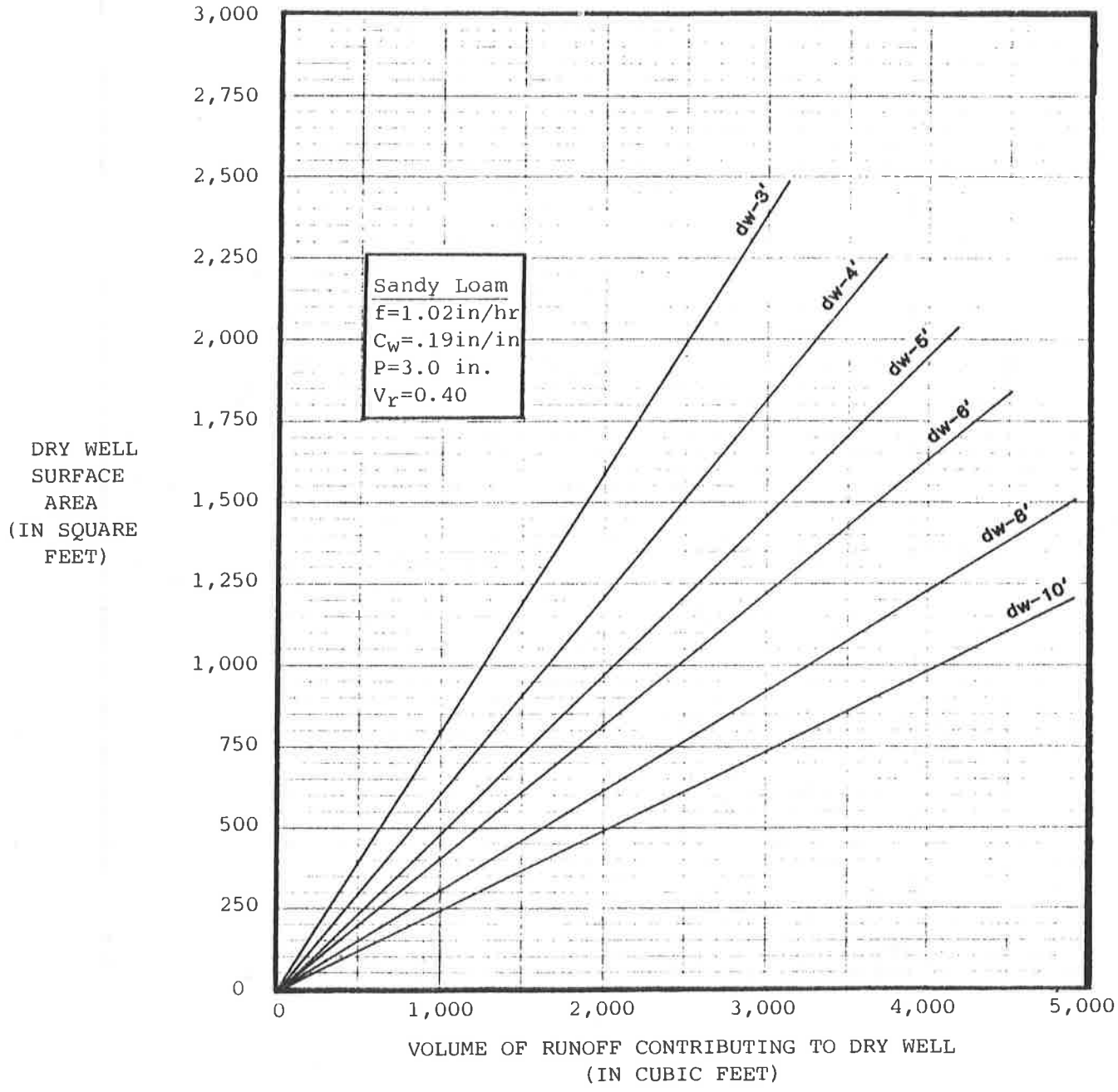


Figure 4-24. Determination of Dry Well Surface Area

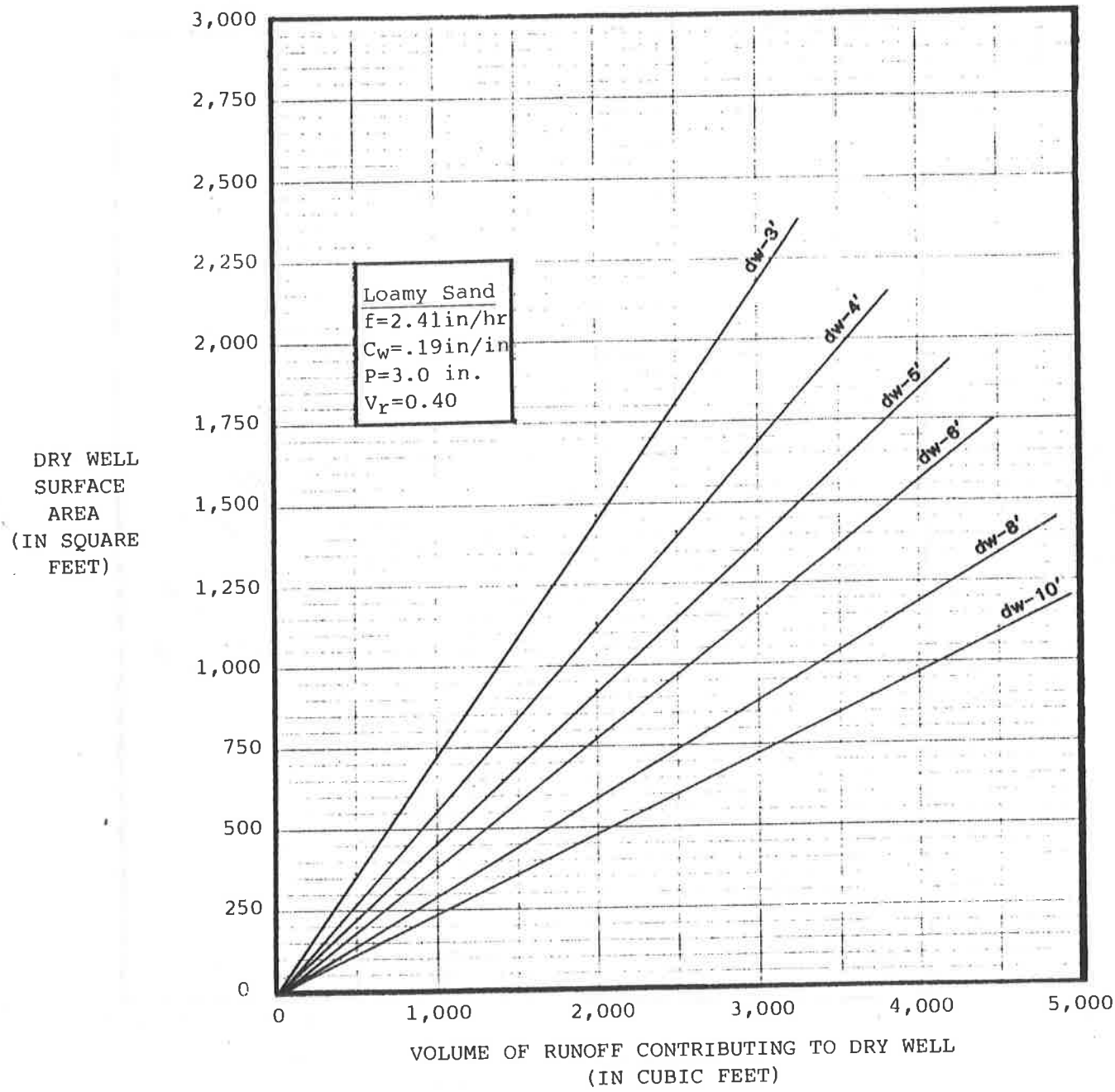


Figure 4-25. Determination of Dry Well Surface Area

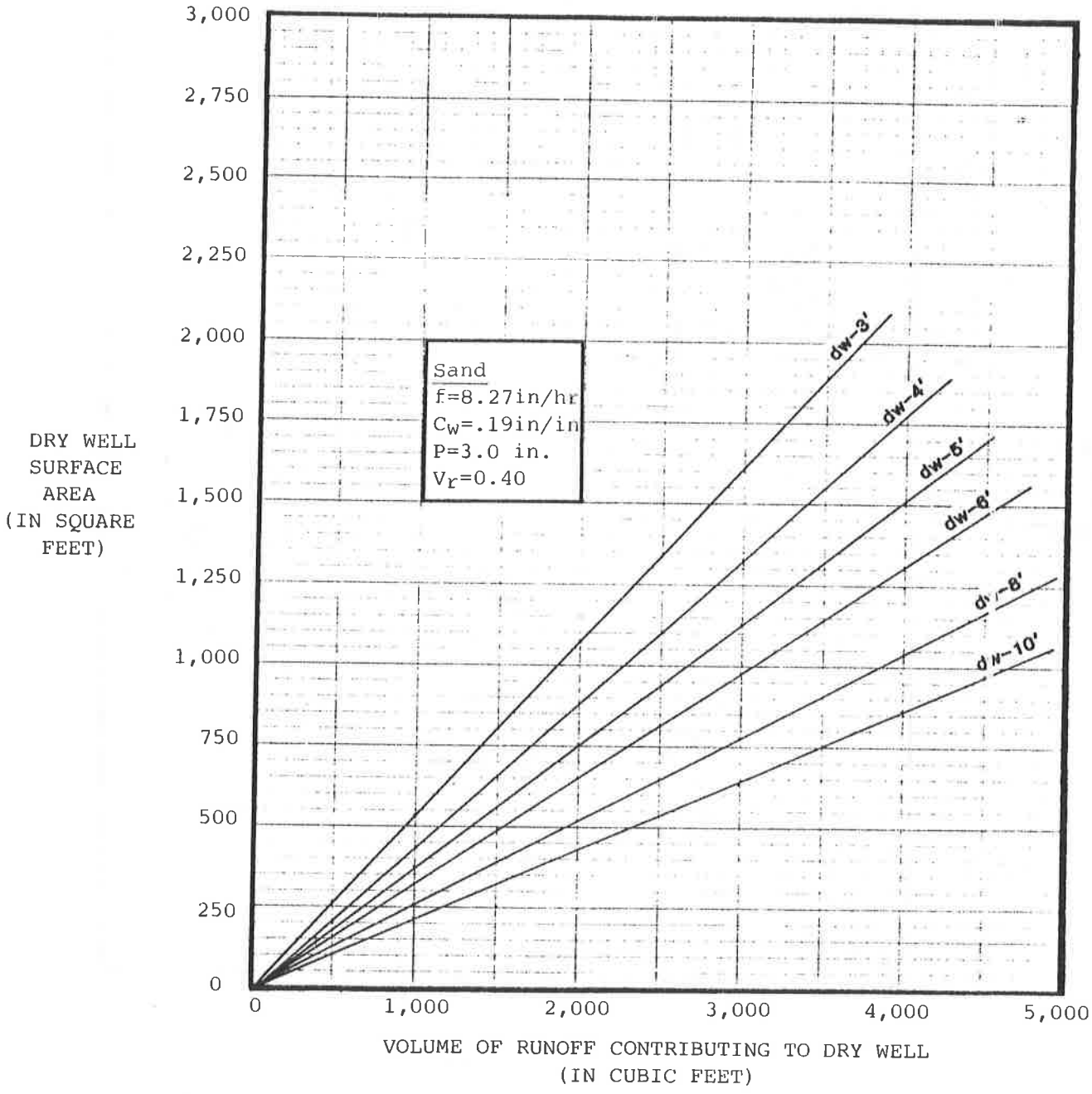


Figure 4-26. Determination of Dry Well Surface Area

4.5 Design of Porous Asphalt Pavement

(PA)

Porous asphalt pavement is defined as a low density, permeable asphalt surface in which water is rapidly transmitted to an aggregate reservoir subbase for storage. Water is released from the subbase into the underlying soil by infiltration. In some cases where the underlying soil infiltration rate is low, subsurface drains may be installed to remove water rapidly from the reservoir subbase so that it does not saturate the subgrade for an extended period of time and weaken it. However, by installing subsurface drains, the porous asphalt pavement becomes an underground detention structure. In this case, the porous asphalt pavement reservoir is designed in the same manner as a surface stormwater management pond where conventional design methodologies may be used. The design in this section is based on removal of water from the subbase by infiltration through the underlying soil.

4.5.1 Site Layout

The site for porous asphalt pavement will consist of the surface area of the pavement in addition to the adjacent contributing area. A schematic of a porous asphalt pavement section and the design parameters are shown in Figure 4-27. The subbase is sized to store the runoff volume from both the pavement area and the adjacent contributng areas.

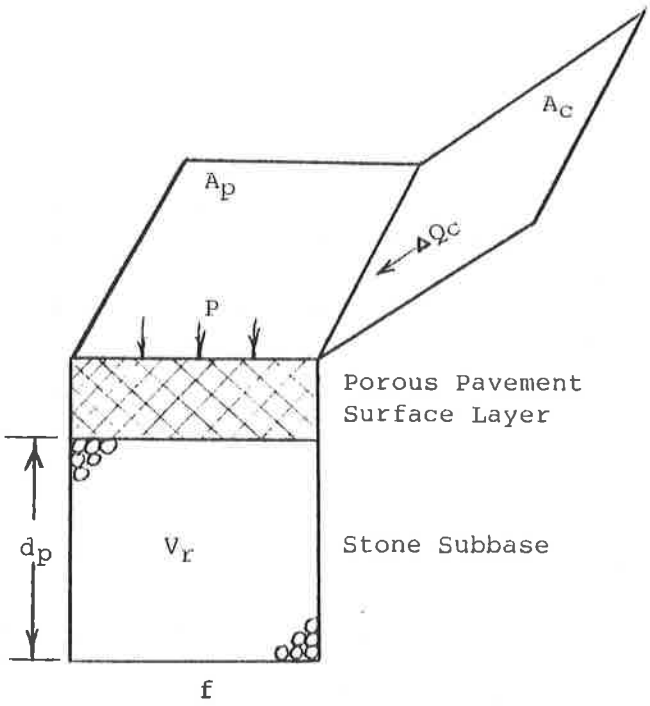
4.5.2 Feasibility Test

Before designing porous asphalt pavement, it is necessary to determine the textural class of the soils underlying the pavement such that a feasible design is possible. Soils with infiltration rates less than 0.27 inches per hour should not be considered for porous asphalt pavement. Those soil textural classes that have slow infiltration rates (i.e. less than 0.27 inches per hour) limit the flow of water through the soil. Additionally, the allowable depth of storage may be too shallow to be practical when constructing the structure, based on a maximum storage time of 3 days. Thus, the suitable textural class of the soil underlying the pavement should be either a silt loam, loam, sandy loam, loamy sand, or sand.

The design of porous asphalt pavement is also based upon the maximum allowable depth of the pavement (d_{max}). The maximum allowable depth should meet the following criteria:

$$d_{max} = f \cdot T_s/V_r \qquad (4\text{-}29)$$

where f is the final infiltration rate of the soil underlying the pavement in inches per hour, T_s is the maximum allowable storage time of 72 hours, and V_r is the void ratio of the stone reservoir. The maximum allowable depths are given in Table 2-2 for selected values of f, T_s, and V_r.



Notation

A_c = contributing area (square feet)

ΔQ_c = increased runoff from contributing area (feet)

A_p = surface area of porous pavement (square feet)

P = design storm rainfall depth (feet)

f = final infiltration rate of underlying soil (feet/hour)

d_p = depth of stone subbase (feet)

V_r = void ratio of stone subbase

T = time in which the inflow rate exceeds the outflow rate (hours)

Figure 4-27. Schematic of Porous Pavement Section

4.5.3 Design Method

The design method is based on controlling the increased runoff for a specific frequency storm event. The design return period will be either the 2 or 10 year frequency storm events depending upon the particular county in Maryland. If the increase in peak discharge associated with the 2 or 10 year storm event cannot be managed, a first flush event should be the minimum selected for design.

The design volume of water to be stored in the porous asphalt pavement stone subbase (V_w) is equal to the runoff volume from the adjacent contributing area ($\Delta Q_c A_c$), plus the rainfall volume falling on the porous asphalt pavement (PA_p), minus the exfiltration volume into the underlying soil (fTA_p), as shown in Figure 4-7. Values of f should be obtained from Table 2-1. For designs based on the SCS type II storm, the pavement subbase filling time (T) is generally less than a 2-hour duration in which the flow into the pavement exceeds the flow out of the pavement. Thus, a duration of 2-hours is used for the value of T. The volume of water that must be stored (V_w) may be defined as:

$$V_w = \Delta Q_c A_c + PA_p - fTA_p \qquad (4\text{-}30)$$

The volume of the stone subbase can also be defined in terms of its geometry:

$$V_p = V_w/V_r = d_p A_p \qquad (4\text{-}31)$$

where d_p is the depth of the stone subbase, A_p is the porous asphalt pavement surface area, and V_r is the stone void ratio. Setting Equations 4-30 and 4-31 equal, will result in the following relationship:

$$d_p A_p V_r = \Delta Q_c A_c + PA_p - fTA_p \qquad (4\text{-}32)$$

The surface area of the porous asphalt pavement (A_p) and the depth of the stone subbase (d_p) can be defined in the following forms from Equation 4-32:

$$A_p = \frac{\Delta Q_c A_c}{V_r d_p - P + fT} \qquad (4\text{-}33)$$

and

$$d_p = \frac{\Delta Q_c R + P - fT}{V_r} \qquad (4\text{-}34)$$

where R is equal to the ratio of the contributing area and the porous asphalt paving area (A_c/A_p). Equation 4-34 will be the most widely used form since the surface area of the pavement is normally known and the depth of the stone subbase is to be determined. All units in Equations 4-33 and 4-34 are in terms of feet and cubic feet. The solution to Equation 4-34 is shown graphically in Figures 4-28 through 4-31. The graphs are based on storing the entire contributing area runoff volume ($Q_c A_c$) based on curve number for an impervious area (CN = 98).

4.5.4 Design Procedure

There are two methods to design the porous asphalt pavement storage area. The first method is to compute the minimum depth of the stone subbase given the surface area of the porous asphalt pavement (minimum depth method) or, secondly, compute the minimum surface area of the porous asphalt pavement given the required design depth of the stone reservoir subbase (minimum area method). The minimum depth method will be the more frequent method used in most cases.

Minimum Depth Method

(1) From the selected design rainfall (P) and the runoff curve number, compute the increased runoff volume from the contributing area (ΔQ_c).

(2) Compute the depth of the aggregate subbase (d_p) from Equation 4-34:

$$d_p = \frac{\Delta Q_c R + P - fT}{V_r}$$

Figures 4-28 through 4-31 may be used to determine the approximate aggregate subbase depth if the total runoff depth (Q_c) is to be stored.

(3) Compute the maximum allowable depth (d_{max}) of the aggregate subbase by the feasibility formula:

$$d_{max} = f \cdot T_s/V_r$$

where d_p must be less than or equal to d_{max} and at least 2 feet above the seasonal high ground water table. If d_p does not satisfy this criteria, the surface area of the porous asphalt pavement must be increased or a smaller design storm must be selected.

Minimum Area Method

(1) From the selected design rainfall (P) and the runoff curve number, compute the increased runoff depth from the contributing area (ΔQ_c).

(2) Compute the maximum allowable depth (d_{max}) of the aggregate subbase from the feasibility formula:

$$d_{max} = fT_s/V_r$$

Select a design depth of the aggregate subbase (d_p) less than or equal to d_{max} or the depth at least 2 feet above seasonal high ground water table, whichever is smaller.

(3) Compute the minimum required surface area of the porous asphalt pavement (A_p) from Equation 4-33:

$$A_p = \frac{\Delta Q_c A_c}{V_r d_p - P + fT}$$

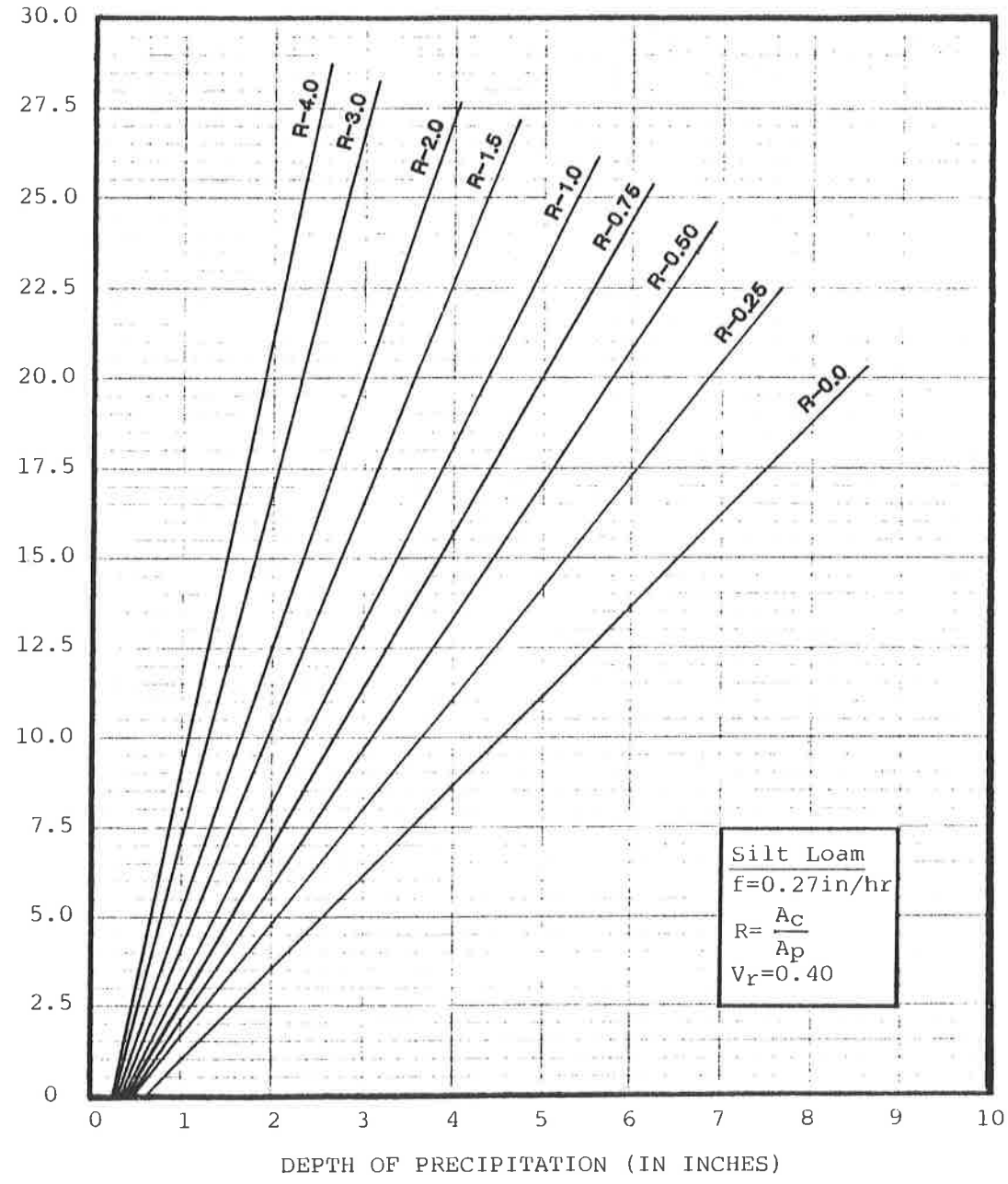


Figure 4-28. Determination of Porous Paving Reservoir Depth

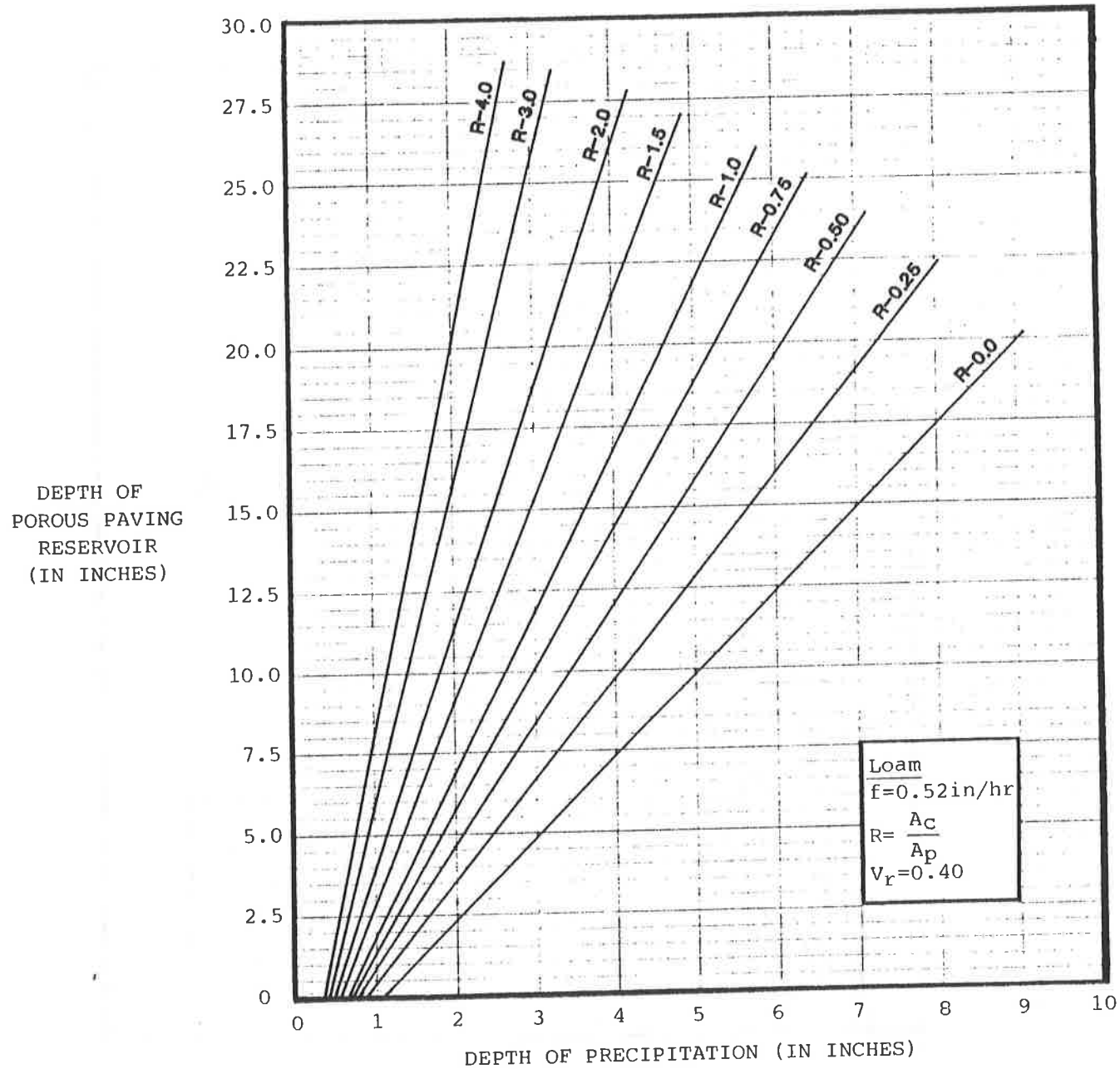


Figure 4-29. Determination of Porous Paving Reservoir Depth

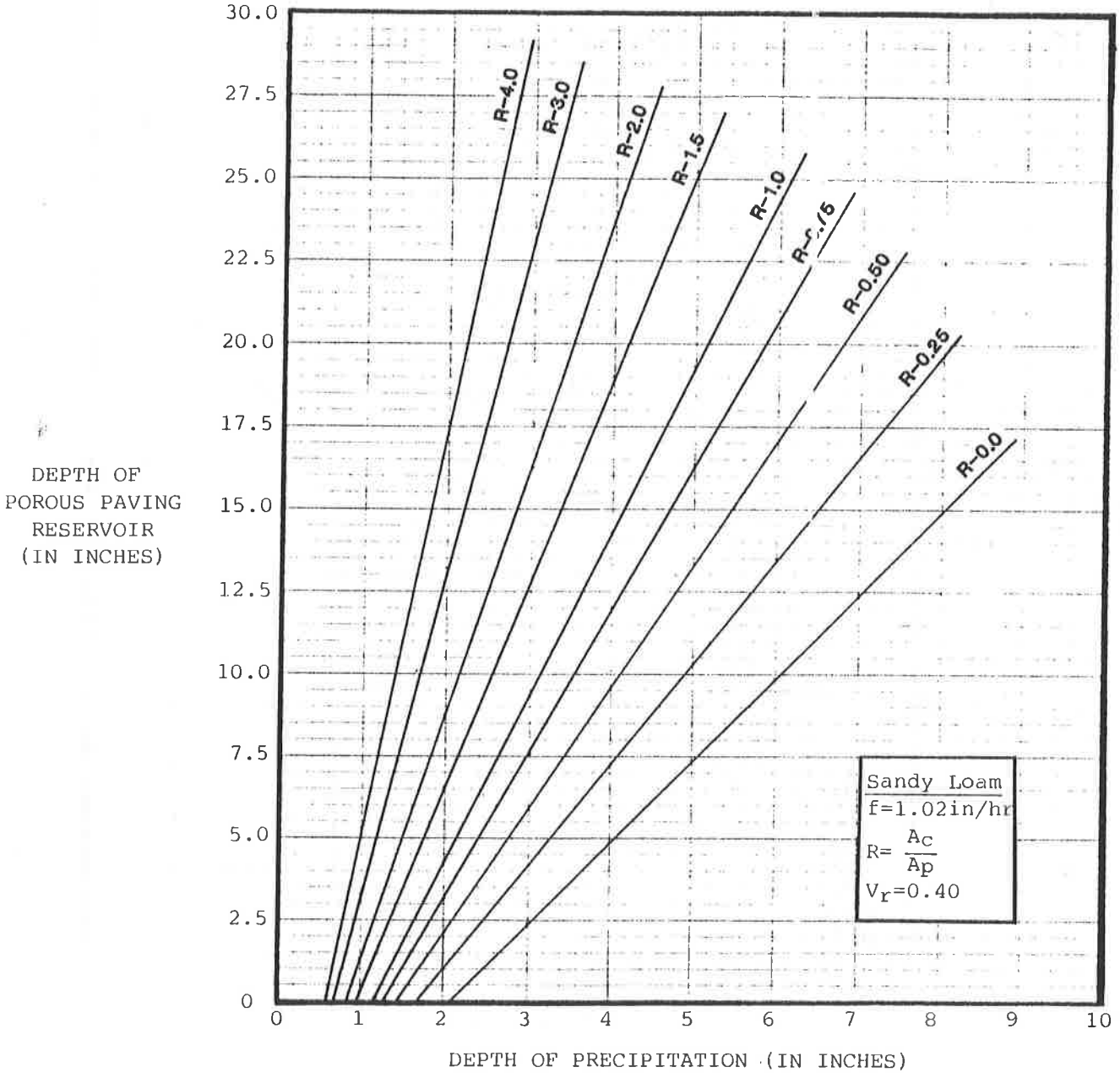


Figure 4-30. Determination of Porous Paving Reservoir Depth

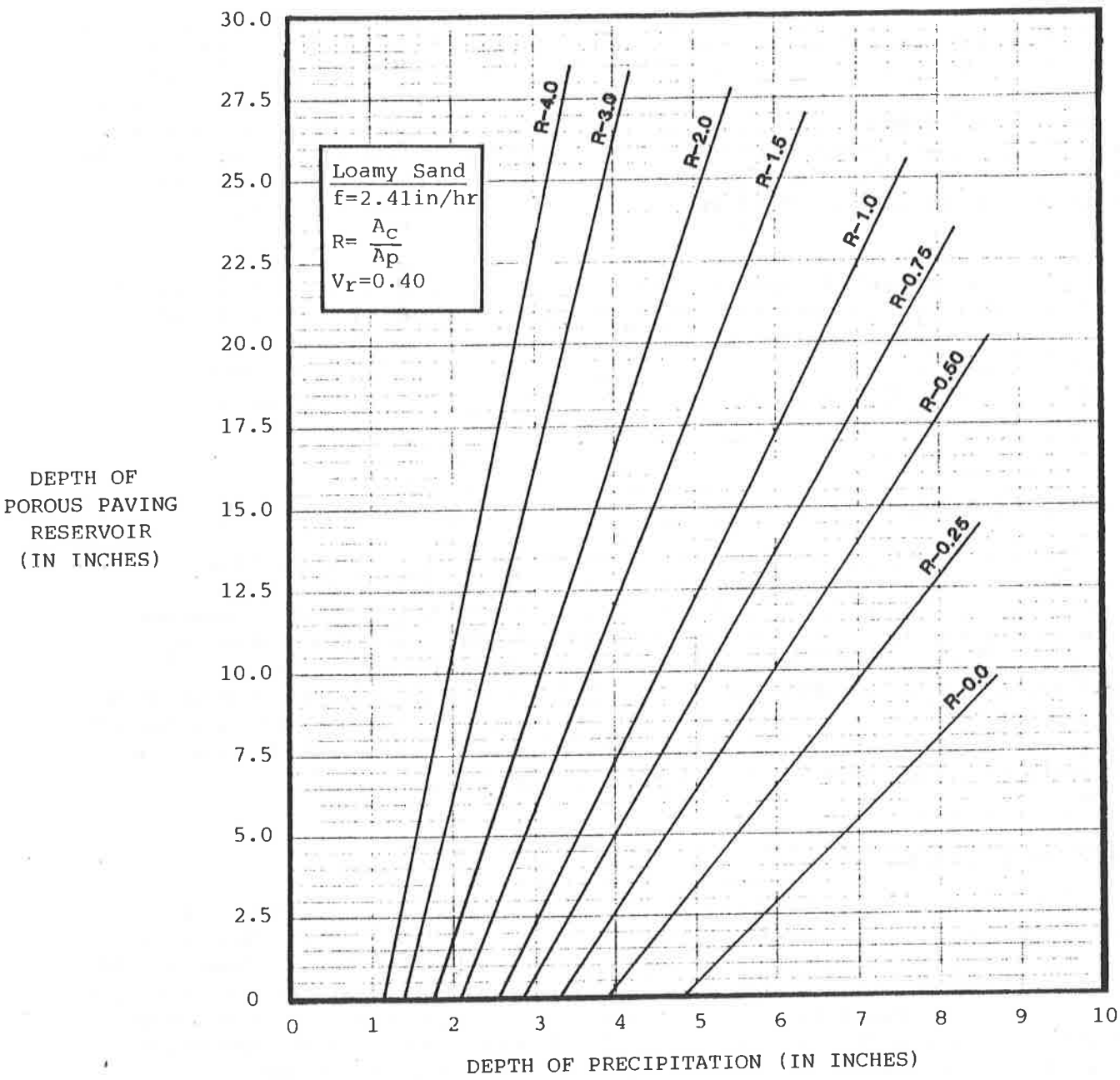


Figure 4-31. Determination of Porous Paving Reservoir Depth

4.6 DESIGN OF VEGETATED SWALES WITH CHECK DAMS

(VS)

A vegetated swale with a check dam is a grassed channel with a small earth check dam that is used to store and infiltrate storm runoff. The small check dams will generally be 6 to 24 inches in height to create small infiltration pools. The use of small check dams to create infiltration pools is limited to swale slope gradients of 5 percent or less. Swale gradients greater than 5 percent may cause erosion and will limit the volume of runoff stored behind the check dams. The volume of water stored by a swale will depend on the land slope, the depth, and width of the swale at the top of the check dam.

A vegetated swale without a check dam is encouraged over conventional curbs and gutters to remove some nutrients and pollutants from runoff and reduce the volume of runoff for small storm events (less than a 2 year frequency storm event). The design of swales without check dams can be accomplished with the existing SCS design methods by the appropriate modification of the flow length and the time of concentration.

4.6.1 Site Layout

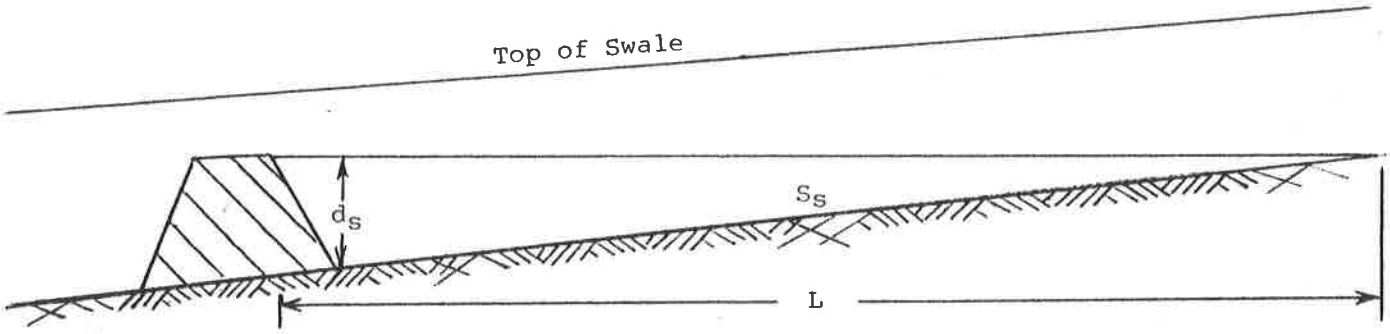
The site layout will consist of the portion of the watershed that contributes direct runoff to the swale area or the upland area, which is denoted as A_u; and the portion of the watershed allocated for swale storage, which is denoted as A_s. It is important to note that the upland area (A_u) does not include the area allotted to the swale surface (A_s). Swale locations are usually either on the side or back of the property line or along the side of roadways. Installation of berms or check dams at certain intervals along the length of the swale will result in storage. Figure 4-32 shows the schematic of a vegetated swale with a check dam.

4.6.2 Feasibility Test

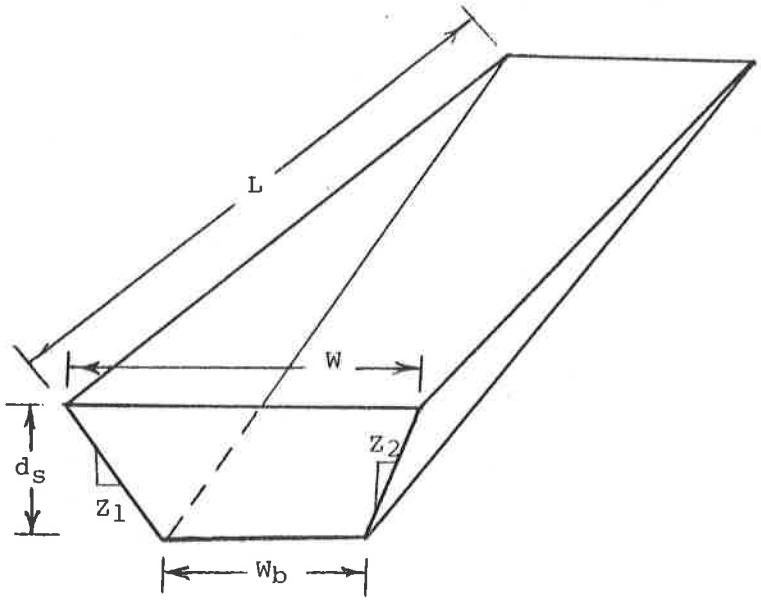
Before designing a vegetated swale, it is necessary to determine the textural class of soils underlying the swale such that a feasible design is possible. Soils with infiltration rates less than 0.27 inches per hour should not be considered for a vegetated swale. Those soil textural classes that have slow infiltration rates (i.e. less than 0.27 inches per hour) limit the flow of water through the soil. Additionally, the allowable depth of storage may be too shallow to be practical when constructing the structure, based on the maximum ponding time of 24 hours. Thus, the suitable textural class of the soil underlying the swale should be either a silt loam, loam, sandy loam, loamy sand, or sand.

The design of a vegetated swale is also based upon the maximum depth of the check dam (d_{max}). The maximum allowable depth should meet the following criteria:

$$d_{max} = f \cdot T_p \qquad (4\text{-}35)$$



(a) Cross Section of Swale with Check Dam



(b) Dimensional View of Swale Impoundment Area

Notation

L	=	length of swale impoundment area per check dam (ft)
d_s	=	depth of check dam (ft)
S_s	=	bottom slope of swale (ft/ft)
W	=	top width of check dam (ft)
W_b	=	bottom width of check dam (ft)
Z_1 & Z_2	=	ratio of horizontal to vertical change in swale side slope (ft/ft)

Figure 4-32. Schematic of a Vegetated Swale with Check Dam

where f is the final infiltration rate of the swale area in inches per hour, and T_p is the maximum allowable ponding time of 24 hours. The maximum allowable depths are given in Table 2-2 for selected values of f and T_p.

4.6.3 Design Method

The design method is based on controlling the increased runoff for a specific frequency storm event. The design return period shall be either the 2 or 10 year frequency storm events depending upon the particular county in Maryland. If the increase in peak discharge associated with the 2 or 10 year storm event cannot be managed, a first flush event should be the minimum selected for design.

The vegetated swale is sized to store the increased runoff volume that contributes from the upland area for a selected design storm. The design volume of the swale (V_w) equals the increased upland runoff volume ($\Delta Q_u A_u$) to the swale, plus the volume of rain that falls on the surface of the swale (PA_s), minus the exfiltration volume (fTA_s) out of the bottom of the swale. Based on the SCS type II storm, the effective swale filling time will generally be less than a two hour duration. The effective filling time is the duration in which flow into the swale exceeds the exfiltration out of the swale. Thus, a duration of 2 hours is used for the value of T. The volume of water that must be stored in the swale (V_w) is defined as:

$$V_w = \Delta Q_u A_u + PA_s - fTA_s \qquad (4\text{-}36)$$

where units of feet are used to get volumes in terms of cubic feet. The increased upland runoff depth (ΔQ_u) for the upland contributing area (A_u) is determined as:

$$\Delta Q_u = Q_a - (q_{ub}/q_{ua})Q_b \qquad (4\text{-}37)$$

The volume of rainfall and runoff stored in the swale may be defined in terms of the swale geometry. The total volume of swale storage is determined as:

$$V_w = \frac{d_s\ (W + W_b)L}{4}(N_s) \qquad (4\text{-}38)$$

where d_s is the depth of the swale check dam (ft), W is the swale top width (ft), W_b is the swale bottom width (ft), L is the length of each swale impoundment behind a check dam (ft), and N_s is the number of check dams along the total hydraulic length of the swale (L_T). The length (L) behind each

swale check dam may be determined by:

$$L = \frac{d_s}{S_s} \tag{4-39}$$

where S_s is the longitudinal slope (ft/ft) along the length of the swale. The number of check dams (N_s) that may be installed along the total length of swale (L_T) may be determined by:

$$N_s = \frac{L_T}{L} \tag{4-40}$$

By setting Equations 4-36 and 4-38 equal, the total hydraulic length of the swale needed to store the increase in upland runoff is given as:

$$L_T = \frac{\Delta Q_u A_u}{\left[\frac{d_s(W + W_b)}{4} + W(fT - P)\right]} \tag{4-41}$$

where W is the top width of the swale check dam and is determined as:

$$W = W_b + d_s (Z_1 + Z_2) \tag{4-42}$$

where Z_1 and Z_2 are the side slope ratios of the swale cross sectional area, horizontal to vertical. Frequently, the side slope ratios will be the same on both sides of the swale, given as Z (ft/ft); substituting into Equation 4-42 yields:

$$W = W_b + 2d_s Z \tag{4-43}$$

Swale cross sections may also be vee-shaped or parabolic and the top widths for each of these shapes are given in Figure 3-12.

When the site layout is such that it restricts the swale dimensions to a specific configuration, the level of control provided, given swale dimensions, may be determined as:

$$Q_s = \frac{V_w}{A_u} \qquad (4\text{-}44)$$

where Q_s is the depth of runoff controlled by the swale and V_w is determined by Equation 4-38 for the given swale dimensions. All parameters in the equations must be converted to feet.

4.6.4 Design Procedure

(1) Determine the before and after development runoff volumes (Q_b & Q_a) and unit peak factors (q_{ub} & q_{ua}) from the before and after development curve numbers, and times of concentration (velocity method), from the SCS TR-55 Manual. Figure 4-1 on page 4-3 can also be used to determine qu. Equation 4-10 is used to compute the increase in the upland runoff volume (ΔQ_u):

$$\Delta Q_u = Q_a - (q_{ub}/q_{ua})Q_b$$

(2) Compute the maximum allowable swale depth (d_{max}) from the feasibility equation, $d_{max} = fT_p$. Select the swale design depth (d_s) based on a depth that is at least two feet above the seasonal high groundwater table, or the depth less or equal to d_{max}, whichever results in the smaller depth.

(3) The swale surface area dimensions can be determined from Equations 4-41 and 4-43. The bottom width (W_b) is selected along with the side slope ratio (Z), and depth of check dam (d_s). The swale top width (W) and total hydraulic length (L_T) may be computed as:

$$W = W_b + 2d_sZ$$

and:

$$L_T = \frac{\Delta Q_u A_u}{\left[\frac{d_s(W + W_b)}{4} + W(fT - P)\right]}$$

(4) The number of check dams needed to impound and store the increased runoff volume is determined as:

$$N_s = \frac{L_T}{L}$$

The maximum require spacing between check dams is computed as:

$$L = \frac{d_s}{S_s}$$

If L_T is restricted by the site layout, the level of control provided by the swales is determined by equation 4-44:

$$Q_s = \frac{V_w}{A_u}$$

where:

$$V_w = \frac{d_s(W + W_b)L}{4}(N_s)$$

The same design procedure above may be used for the first flush design except that ΔQ_u used in Equation 4-41 will be equal to the total runoff volume associated with a smaller rainfall amount.

CHAPTER 5

CASE STUDIES

CHAPTER 5

CASE STUDIES

5.1 INTRODUCTION

Six case studies are provided to illustrate the use of the design procedures described in Chapter 4 for the various infiltration practices for a variety of conditions. The six case studies include residential and commercial land uses. For each of the first five layouts, the computations were performed for 24-hour rainfall depths of 3 and 5 inches and for each of the allowable soil groups. The sixth case study is based on a 1.0 inch rainfall event. All peak discharge calculations were performed using the SCS TR-55 Graphical Method, and time of concentration estimates were made using the velocity method of TR-55; a minimum t_c of 0.1 hours was used. A meadow land use was selected as the before development condition. Runoff curve numbers for the after development condition were computed using a CN of 98 for the impervious surfaces and the meadow CN for the pervious surfaces. Minimum infiltration rates of 2.41, 1.02, and 0.27 inches/hour were used for soil groups A, B, and C, respectively.

5.2 CASE STUDY NO. 1

Medium density residential lots of 1/4 acres are to be developed. A total of 24 lots will be created. The site will be designed to be managed with vegetated swales with check dams located along the back of the lots. See Figure 5-1 for the lot size and site layout.

Total Area = 24 units x 1/4 acres = 6.0 acres.
Area per unit:

Roadway	1,040	
House	1,600	
Garage	500	
Driveway	600	
Sidewalk	300	
Patio	100	
Impervious Area	4,140 ft²	(38%)
Pervious Area	6,750 ft²	(62%)
Total Area per Unit	10,890 ft²	

5.2.1 Time of Concentration Determination

Before Development

Hydraulic Length = 970 ft (diagonal length of site)
Velocity = 0.35 ft/sec (from TR-55, Figure 3-1, assuming 2 percent slope, meadow overland flow conditions)
Time of Concentration:

$$t_c = \frac{970 \text{ ft}}{(0.35 \text{ ft/sec})(60 \text{ sec/min})} = 46.2 \text{ min.} = 0.77 \text{ hrs.}$$

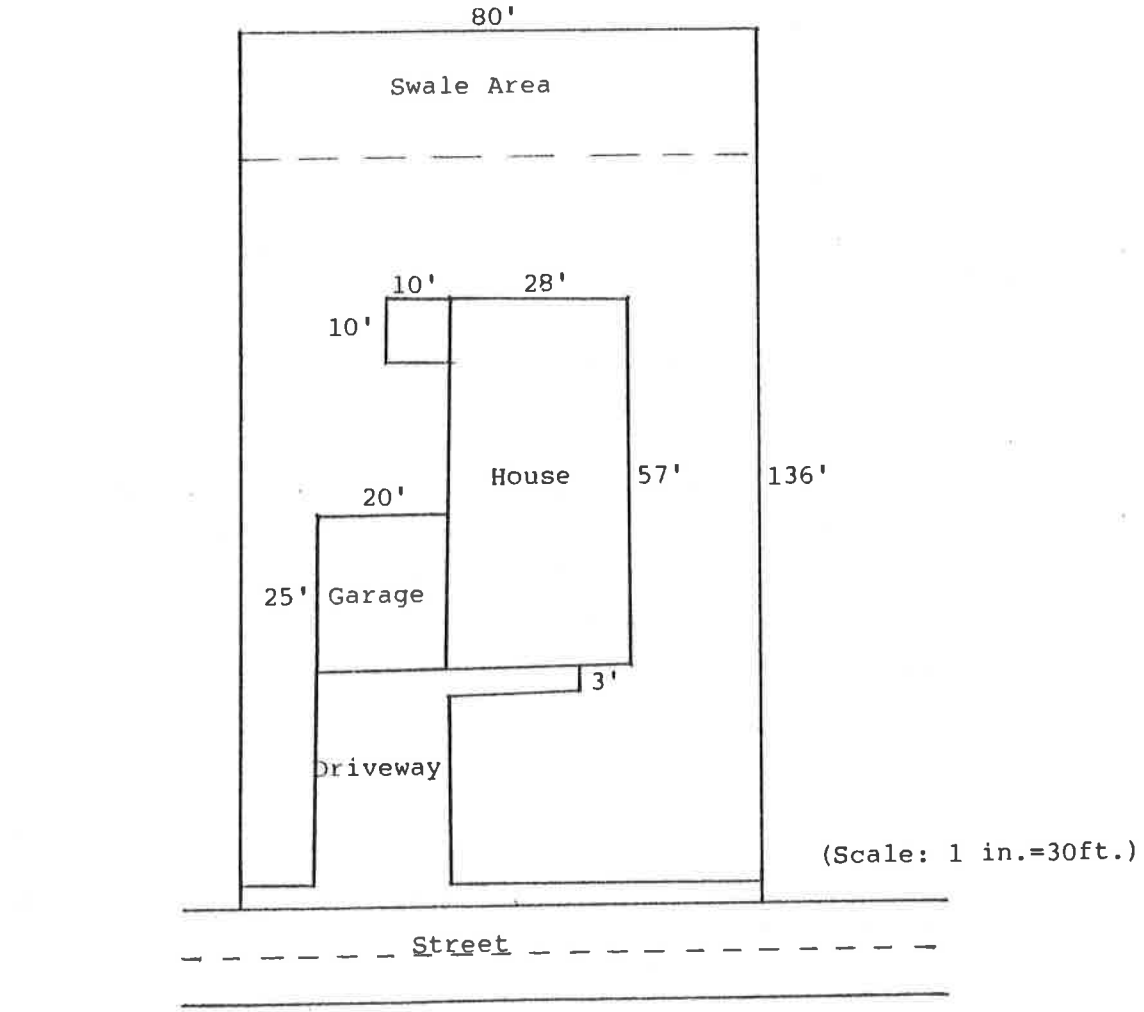
Peak Factor (from TR-55, Figure 5-2):
q_{ub} = 375 cfs/mi²/in.

After Development

Hydraulic Length = 1,015 ft (diagonal length of one lot plus the swale length behind lots)
Velocity = 1.0 ft/sec (from TR-55, Figure 3-1, assuming 2 percent slope, grass flow conditions)
Time of Concentration:

$$t_c = \frac{1{,}015 \text{ ft}}{(1.0 \text{ ft/sec})(60 \text{ sec/min})} = 16.92 \text{ min.} = 0.28 \text{ hrs.}$$

Peak Factor (from Tr-55, Figure 5-2):
q_{ua} = 700 cfs/mi²/in.



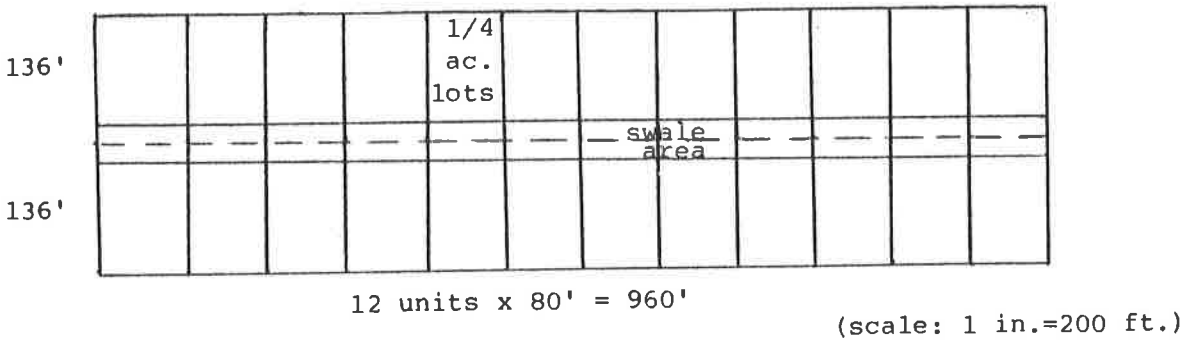


Figure 5-1. 1/4 Acre Lot and Site Layout for Case Study No. 1

5.2.2 Peak Discharge Determination

Area (A_u) = 6.0 acres = 0.009 mi²

Before Development	2-Year (P = 3.0 in.) A Soil	B	C	10-Year (P = 5.0 in.) A	B	C
CN	30	58	71	30	58	71
Q_b (in.)	0.0	0.27	0.76	0.0	1.17	2.12
q_{ub} (cfs/mi²/in.)	375	375	375	375	375	375
q_p (cfs)	0.0	0.95	2.68	0.0	4.12	7.47

After Development	2-Year (P =3.0 in.) A Soil	B	C	10-Year (P = 5.0 in.) A	B	C
CN	61	75	83	61	75	83
Q_a (in.)	0.37	0.96	1.45	1.37	2.45	3.17
q_{ua} (cfs/mi²/in.)	700	700	700	700	700	700
q_p (cfs)	2.43	6.30	9.52	8.99	16.08	20.80

Note: The SCS graphical method is used to compute the peak discharge (q_p) from the following equation:

$$q_p = q_u A Q$$

5.2.3 Design Procedure for Vegetated Swales with Check Dams

(1) Determine increase in the upland runoff volume (ΔQ_u) from Equation 4-37:

$$\Delta Q_u = Q_a - (q_{ub}/q_{ua})Q_b$$

2-Year Design Storm

A Soil: ΔQ_u = 0.37 in. - (375/700)(0.00 in.) = 0.37 in.
B Soil: ΔQ_u = 0.96 in. - (375/700)(0.27 in.) = 0.82 in.
C Soil: ΔQ_u = 1.45 in. - (375/700)(0.76 in.) = 1.04 in.

10-Year Design Storm

A Soil: ΔQ_u = 1.37 in. - (375/700)(0.00 in.) = 1.37 in.
B Soil: ΔQ_u = 2.45 in. - (375/700)(1.17 in.) = 1.82 in.
C Soil: ΔQ_u = 3.17 in. - (375/700)(2.12 in.) = 2.03 in.

(2) Compute the maximum allowable swale depth (d_{max}) from the feasibility equation:

$$d_{max} = fT_p$$

Soil	f (in/hr)	T_p (hrs.)	d_{max} (in.)	d_{max} (ft.)
A	2.41	24	57.8	4.82
B	1.02	24	24.5	2.04
C	0.27	24	6.5	0.54

(3) Select the swale check dam design depth (d_s); for the case study the depth to the groundwater table and bedrock is assumed to be greater than d_{max}.

Soil	d_s (ft)
A	2.5
B	2.0
C	0.5

(4) Select the swale bottom width (W_b) and the swale side slope ratio (Z), assuming the same side slopes. Determine the top width (W) of the swale check dam from:

$$W = W_b + 2d_sZ$$
$$Z = 5h/1v$$

Soil	W_b (ft)	W (ft)
A	14	39
B	12	32
C	10	15

(5) The site layout for the case study allows for a swale length of 960 feet along the back of all the lots. The total swale length (L_T) is fixed so that the volume of swale storage (V_W) may be determined from the dimensions given:

$$V_W = \frac{d_S\ (W + W_b) L_T}{4}$$

Soil	d_S (ft)	W_b (ft)	W (ft)	V_W (ft³)
A	2.5	14	39	31,800
B	2.0	12	32	21,120
C	0.5	10	15	3,000

(6) The number of swale check dams (N_S) that needs to be constructed to achieve the volume of storage over the total swale length will vary with the depth of each check dam (d_S), given as:

$$N_S = \frac{L_T}{L}$$

where L is the length of swale behind each check dam, given as:

$$L = \frac{d_S}{S_S}$$

Soil	S_S (ft/ft)	d_S (ft)	L (ft)	N_S	Adjusted L (ft)
A	0.03	2.5	83.0	11.5 (use 12)	80.0
B	0.03	2.0	67.0	14.4 (use 14)	68.5
C	0.03	0.5	17.0	57.6 (use 58)	16.5

The adjusted length behind each check dam is determined as $L = L_T / N_S$.

(7) Determine the reduction in runoff depth (Q_S) stored by the swales from the following equation:

$$Q_S = \frac{V_W}{A_u}$$

Soil	f (in/hr)	T (hrs)	L_T (ft)	W (ft)	V_W (ft³)	Q_S (ft)	Q_S (in)
A	2.41	2	960	39	31,800	0.12	1.46
B	1.02	2	960	32	21,120	0.08	0.97
C	0.27	2	960	15	3,000	0.01	0.14

(8) Determine the after development peak discharge with swale storage from the following form of the Graphical Equation:

$$q_p = q_{ua} A \ (Q_a - Q_s)$$

Soil	Q_a (in.) (P=3.0in.)	Q_a (in.) (P=5.0in.)	$Q_a - Q_s$ (in.) (P=3.0in.)	$Q_a - Q_s$ (in.) (P=5.0in.)	q_p (cfs) (P=3.0in.)	q_p (cfs) (P=5.0in.)
A	0.37	1.37	0.0	0.0	0.0	0.0
B	0.96	2.45	0.0	1.48	0.0	9.71
C	1.45	3.17	7.44	3.03	9.45	19.88

(9) Summary of conditions:

	q_p (cfs) 2-Year			q_p (cfs) 10-Year		
	A Soil	B	C	A	B	C
Before Development	0.0	0.95	2.68	0.0	4.12	7.47
After Development w/o Swales	2.43	6.30	9.52	8.99	16.08	20.80
After Development w/ Swales	0.0	0.0	9.48	0.0	9.71	19.88

Adequate peak control is provided for the 2-year storm on the A and B soils and the 10-year storm on A soils only, for the case study design. The swale design for the C soil does not provide benefit in reducing the peak discharge for the given dimensions. Due to the limited swale depth (d_{max}), the width of the swale bottom (W_b) may be widened to possibly improve the level of control on C soils.

5.3 CASE STUDY NO. 2

An infiltration basin will be used to control the 1/4 acre residential development given in Case Study 1.

Upland Drainage Area (A_u) = 6.0 acres

5.3.1 Peak Discharge Determination

Area (A_u) = 6 acres = 0.009 mi²

	2-Year (P = 3.0 in.)			10-Year (P = 5.0 in.)		
Before Development	A Soil	B	C	A	B	C
CN	30	58	71	30	58	71
Q_b (in.)	0.0	0.27	0.76	0.0	1.17	2.12
q_{ub} (cfs/mi²/in.)	375	375	375	375	375	375
q_p (cfs)	0.0	0.95	2.68	0.0	4.12	7.47

	2-Year (P = 3.0 in.)			10-Year (P = 5.0 in.)		
After Development	A Soil	B	C	A	B	C
CN	61	75	83	61	75	83
Q_a (in.)	0.11	0.96	1.45	1.11	2.45	3.11
q_{ua} (cfs/mi²/in.)	700	700	700	700	700	700
q_p (cfs)	0.41	6.30	9.11	6.99	16.08	20.00

Note: The SCS graphical method is used to compute the peak discharge (q_p) from the following equation:

$$q_p = q_u A Q$$

5.3.2 Design Procedure for Infiltration Basins

(1) Determine the increase in the upland runoff volume (ΔQ_u) from the following equation:

$$\Delta Q_u = Q_a - (q_{ub}/q_{ua})Q_b$$

2-Year Design Storm

A Soil: $\Delta Q_u = 0.37$ in. - (375/700)(0.00 in.) = 0.37 in.
B Soil: $\Delta Q_u = 0.96$ in. - (375/700)(0.27 in.) = 0.82 in.
C Soil: $\Delta Q_u = 1.45$ in. - (375/700)(0.76 in.) = 1.04 in.

10-Year Design Storm

A Soil: $\Delta Q_u = 1.37$ in. - (375/700)(0.00 in.) = 1.37 in.
B Soil: $\Delta Q_u = 2.45$ in. - (375/700)(1.17 in.) = 1.82 in.
C Soil: $\Delta Q_u = 3.17$ in. - (375/700)(2.12 in.) = 2.03 in.

(2) Compute the maximum allowable basin depth (d_{max}) from the feasibility equation:

$$d_{max} = fT_p$$

Soil	f (in/hr)	T_p (hrs.)	d_{max} (in.)	d_{max} (ft.)
A	2.41	72	173.5	14.5
B	1.02	72	73.4	6.1
C	0.27	72	19.4	1.6

(3) Select the design basin depths (d_b) that are no greater than d_{max} and at least 2 feet above the groundwater table. For this example, the groundwater table is assumed to be at 10 feet below the ground elevation.

Soil	d_s (ft)
A	8.0
B	6.0
C	1.5

(4) Compute the basin surface dimensions using a side slope (Z) of 2h/1v and selecting a top width (W) to determine the top length (L) from:

$$L = \frac{\Delta Q_u A_u + Z d_b^2 (W - 2Z d_b)}{W(d_b - P) - 2d_b^2}$$

where A_u = 6 acres = 261,360 ft²

(All parameters must be converted to feet)

2-Year (P = 3.0 in)

Soil	ΔQ_u (in)	ΔQ_u (ft)	d_b (ft)	W (ft)	L (ft)
A	0.37	0.03	8.0	44.0	45.0
B	0.82	0.07	6.0	50.0	91.6
C	1.04	0.09	1.5	100	191.5

10-Year (P = 5.0 in)

Soil	ΔQ_u (in)	ΔQ_u (ft)	d_b (ft)	W (ft)	L (ft)
A	1.37	0.11	8.0	75.0	80.2
B	1.82	0.15	6.0	75.0	124.9
C	2.03	0.17	1.5	175.0	209.9

5.4 CASE STUDY NO. 3

An infiltration trench with surface inlets will be used to control the increase in the 2 and 10 year peak discharges from the 5 acre commercial area shown in Figure 5-2.

site area = 415 ft. x 525 ft. = 5 acres
building area = 141 ft. x 309 ft. = 1 acre
parking area = 4 acres

5.4.1 Time of Concentration Determination

Before Development

Hydraulic Length = 670 ft.
Velocity = 0.35 ft/sec (from TR-55, Figure 3-1, assuming a 2% basin slope and meadow landuse)
Time of Concentration:

$$t_c = \frac{670 \text{ ft}}{(0.35 \text{ ft/sec})(60 \text{ sec/min})} = 32 \text{ min.} = 0.53 \text{ hrs.}$$

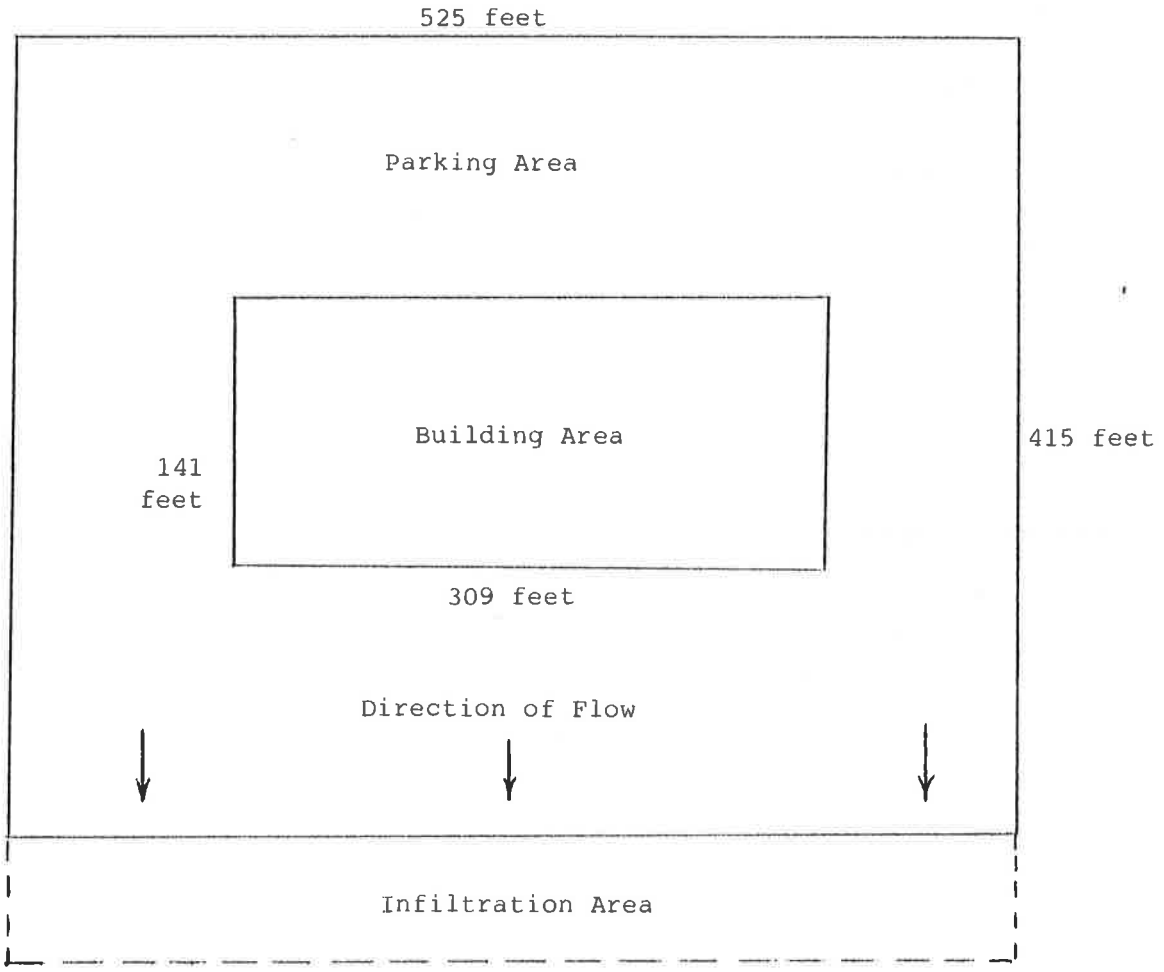
Peak Factor (from TR-55, Figure 5-2):
q_{ub} = 500 cfs/mi²/in.

After Development

Hydraulic Length = 670 ft.
Velocity = 2.75 ft/sec (from TR-55, Figure 3-1, assuming a 2% basin slope over a paved area)
Time of Concentration:

$$t_c = \frac{670 \text{ ft}}{(2.75 \text{ ft/sec})(60 \text{ sec/min})} = 4.1 \text{ min.} = 0.07 \text{ hrs.}$$

Peak Factor (from TR-55, Figure 5-2 with t_c = 0.1 hrs.):
q_{ua} = 990 cfs/mi²/in.



Scale: 1 in. = 100 ft.

Figure 5-2. Layout for Commercial Site

5.4.2 Peak Discharge Determination

Area = 5 acres = 0.0078 mi^2

	2-Year (P = 3.0 in.)			10-Year (P = 5.0 in.)		
Before Development	A Soil	B	C	A	B	C
CN	30	58	71	30	58	71
Q_b (in.)	0.0	0.27	0.76	0.0	1.17	2.12
q_{ub} ($cfs/mi^2/in.$)	500	500	500	500	500	500
q_p (cfs)	0.0	1.05	2.97	0.0	4.57	8.28

	2-Year (P = 3.0 in.)			10-Year (P = 5.0 in.)		
After Development	A Soil	B	C	A	B	C
CN	98	98	98	98	98	98
Q_a (in.)	2.77	2.77	2.77	4.76	4.76	4.76
q_{ua} ($cfs/mi^2/in.$)	990	990	990	990	990	990
q_p (cfs)	21.42	21.42	21.42	36.82	36.82	36.82

Note: The SCS graphical method is used to compute the peak discharge (q_p) from the following equation:

$$q_p = q_u A Q$$

5.4.3 Design Procedure for Infiltration Trench

(1) Compute the upland increase in runoff volume (ΔQ_u) by:

$$\Delta Q_u = Q_a - (q_{ub}/q_{ua})Q_b$$

2-Year Design Storm

A Soil: $\Delta Q_u = 2.77 - (500/990)(0.00 \text{ in.}) = 2.77 \text{ in.}$
B Soil: $\Delta Q_u = 2.77 - (500/990)(0.27 \text{ in.}) = 2.63 \text{ in.}$
C Soil: $\Delta Q_u = 2.77 - (500/990)(0.76 \text{ in.}) = 2.39 \text{ in.}$

10-Year Design Storm

A Soil: $\Delta Q_u = 4.76 - (500/990)(0.00 \text{ in.}) = 4.76 \text{ in.}$
B Soil: $\Delta Q_u = 4.76 - (500/990)(1.17 \text{ in.}) = 4.17 \text{ in.}$
C Soil: $\Delta Q_u = 4.76 - (500/990)(2.12 \text{ in.}) = 3.69 \text{ in.}$

(2) Compute the maximum allowable trench depth (d_{max}) by the feasibility formula:

$$d_{max} = fT_s/V_r$$

Soil	f (in/hr)	T_s (hr)	V_r	d_{max} (in.)	d_{max} (ft.)
A	2.41	72	0.4	434	36.2
B	1.02	72	0.4	184	15.3
C	0.27	72	0.4	49	4.1
	.6	72	0.4	108	9

The depth to the groundwater table is assumed to be at 15 feet. The depth to bedrock is assumed to be greater than 15 feet.

(3) Select a trench design depth greater than d_{max} and at least two feet above the groundwater table (subtract one foot for the overlying soil cover with surface inlets).

Soil	d_t (ft)
A	12.0
B	12.0
C	4.0

(4) Compute the trench surface area (A_t) by the equation:

$$A_t = \frac{\Delta Q_u A_u}{V_r d_t - P + fT}$$

where A_u = 5 ac x 43560 ft²/ac = 217,800.0 ft²;
V_r = 0.40;
T = 2 hrs.; and
P, ΔQ_u, and d_t are given below.

(All parameters must be converted from inches to feet)

			2-Year (P = 3.0 in)			10-Year (P = 5.0 in)		
			ΔQ_u			ΔQ_u		
Soil	f (in/hr)	d_t (ft)	(in.)	(ft.)	A_t (ft)	(in.)	(ft.)	A_t (ft)
A	2.41	12.0	2.77	0.23	10,153	4.76	0.40	18,055
B	1.02	12.0	2.63	0.22	10,113	4.17	0.35	16,622
C	0.27	4.0	2.39	0.20	31,096	3.69	0.31	48,010

The actual surface area of the trench may have to be increased for the "A" and "B" soils since a vertical cut over 10 feet will be very difficult without slope failure.

5.5 CASE STUDY NO. 4

A dry well will be designed for the 5 acre commercial site given in case study No. 3. The dry well will be designed to capture all the runoff from the roof of the 1 acre building during the 2 and 10 year storm events.

site area = 415 ft. x 525 ft. = 5 acres
building area = 141 ft. x 309 ft. = 1 acre
parking area = 4 acres

5.5.1 Time of Concentration Determination

(Refer to Case Study No. 3)

5.5.2 Peak Discharge Determination

Area = 5 acres = 0.0078 mi^2

	2-Year (P = 3.0 in.)			10-Year (P = 5.0 in.)		
Before Development	A Soil	B	C	A	B	C
CN	30	58	71	30	58	71
Q_b (in.)	0.0	0.27	0.76	0.0	1.17	2.12
q_{ub} (cfs/mi^2/in.)	500	500	500	500	500	500
q_p (cfs)	0.0	1.05	2.97	0.0	4.57	8.28

	2-Year (P = 3.0 in.)			10-Year (P = 5.0 in.)		
After Development	A Soil	B	C	A	B	C
CN	98	98	98	98	98	98
Q_a (in.)	2.77	2.77	2.77	4.76	4.76	4.76
q_{ua} (cfs/mi^2/in.)	990	990	990	990	990	990
q_p (cfs)	21.42	21.42	21.42	36.82	36.82	36.82

Note: The SCS graphical method is used to compute the peak discharge (q_p) from the following equation:

$$q_p = q_u A Q$$

5.5.3 Design procedure for Dry Well

(1) Compute the runoff depths from the contributing impervious area (Q_c) and the grass covered overlying soil (Q), from the 2 and 10 year rainfall depths (P) and runoff curve numbers. Q will be dtermined from a sandy loam overlying soil ("B" soil) with a CN = 61.

	2 Year (P=3.0 in.)	10 Year (P=5.0 in.)
CN	61	61
Q (in.)	0.37	1.37
CN_c	98	98
Q_c (in.)	2.77	4.76

(2) Compute the maximum allowable depth (d_{max}) of the stone subbase by the feasibility formula:

$$d_{max} = fT_s/V_r$$

Soil	f (in/hr)	T_s (hr)	V_r	d_{max} (in.)	d_{max} (ft.)
A	2.41	72	0.4	434	36.2
B	1.02	72	0.4	184	15.3
C	0.27	72	0.4	49	4.1

The depth to the groundwater table is assumed to be at 15 feet. The depth to bedrock is assumed to be greater than 15 feet.

(3) Select the dry well depth greater than d_{max} and at least two feet above the groundwater table (subtract one foot for the overlying soil cover).

Soil	d_w (ft)
A	12.0
B	12.0
C	4.0

(4) Compute the dry well surface area (A_w) from the following equation:

$$A_w = \frac{Q_c A_c}{V_r d_w - (P - Q) + d_o C_w + fT}$$

where A_c = 43,560 ft² (1 ac. roof area);
V_r = 0.40;
d_o = 1.0 ft (soil cover);
T = 1.0 hrs.; and
P, f, C_w, Q_c and d_w are given below.

(All parameters must be converted from inches to feet)

Soil	f (in/hr)	C_w (in/in)	d_w (ft)	2-Year (P = 3.0 in) Q_c (in)	Q (in)	A_w (ft²)	10-Year (P = 5.0 in) Q_c (in)	Q (in)	A_w (ft²)
A	2.41	0.31	12.0	2.77	0.37	2,011	4.76	1.37	3,455
B	1.02	0.25	12.0	2.77	0.37	2,058	4.76	1.37	3,575
C	0.27	0.17	4.0	2.77	0.37	6,391	4.76	1.37	11,597

Note: $d_o C_w \leq P - Q$; for the 2-year storm, A and B soils and the 10-year storm, A soil, $d_o C_w$ is set equal to P - Q.

(5) Compute the after development discharges with dry well by the equation:

$$q_p = q_{ua} (A - A_c)(Q_a - V_w/A)$$

where: q_{ua} = 990 (cfs/mi²/in);
A = 5 ac. = 0.0078 mi²;
A_c = 1 ac. = 0.0016 mi²; and
$V_w = Q_c A_c$

	q_{ua}	$(A - A_c)$ (mi²)	Q_c (in)	Q_a (in)	V_w/A (in)	$(Q_a - V_w/A)$ (in)	q_p (cfs)
2-Year	990	0.0063	2.77	2.77	0.55	2.22	13.74
10-Year	990	0.0063	4.76	4.76	0.95	3.81	23.57

5.5.4 Discharge Summary

	q_p (cfs)					
	(P = 3.0 in.)			(P = 5.0 in.)		
(Soil)	A	B	C	A	B	C
Before Development	0.0	1.05	2.97	0.0	4.57	8.28
After Development	21.42	21.42	21.42	36.82	36.82	36.82
After Development w/Dry Well	13.74	13.74	13.74	23.57	23.57	23.57

The dry well will manage 36 to 42 percent of the increase in the 2-year discharge, and 36 to 46 percent of the increase in the 10-year discharge. Since the runoff from the 4 acres of impervious surface (parking area) is not controlled, the 2 and 10 year peak discharges cannot be totally managed without additional stormwater management controls.

5.6 CASE STUDY NO. 5

Porous asphalt pavement will be used to control the increase in the 2 and 10 year frequency storm events on the 5 acre commercial site used in Case Study No. 3. The porous asphalt pavement will be placed on the 4 acre area allotted for parking.

site area = 415 ft. x 525 ft. = 5 acres
building area = 141 ft. x 309 ft. = 1 acre
parking area = 4 acres

5.6.1 Time of Concentration Determination

(Refer to Case Study No. 3)

5.6.2 Peak Discharge Determination

Area = 5 acres = 0.0078 mi^2

	2-Year (P = 3.0 in.)			10-Year (P = 5.0 in.)		
Before Development	A Soil	B	C	A	B	C
CN	30	58	71	30	58	71
Q_b (in.)	0.0	0.27	0.76	0.0	1.17	2.12
q_{ub} (cfs/mi^2/in.)	500	500	500	500	500	500
q_p (cfs)	0.0	1.05	2.97	0.0	4.57	8.28

	2-Year (P = 3.0 in.)			10-Year (P = 5.0 in.)		
After Development	A Soil	B	C	A	B	C
CN	98	98	98	98	98	98
Q_a (in.)	2.77	2.77	2.77	4.76	4.76	4.76
q_{ua} (cfs/mi^2/in.)	990	990	990	990	990	990
q_p (cfs)	21.42	21.42	21.42	36.82	36.82	36.82

Note: The SCS graphical method is used to compute the peak discharge (q_p) from the following equation:

$$q_p = q_u A Q$$

5.6.3 Design Procedure for Porous Asphalt Pavement

(1) Determine the increased contributing area runoff volume (ΔQ_c) by Equation 4-37:

$$\Delta Q_c = Q_a - (q_{ub}/q_{ua})Q_b$$

2-Year Design Storm

A Soil: $\Delta Q_c = 2.77 - (500/990)(0.00 \text{ in.}) = 2.77 \text{ in.}$
B Soil: $\Delta Q_c = 2.77 - (500/990)(0.27 \text{ in.}) = 2.63 \text{ in.}$
C Soil: $\Delta Q_c = 2.77 - (500/990)(0.76 \text{ in.}) = 2.39 \text{ in.}$

10-Year Design Storm

A Soil: $\Delta Q_c = 4.76 - (500/990)(0.00 \text{ in.}) = 4.76 \text{ in.}$
B Soil: $\Delta Q_c = 4.76 - (500/990)(1.17 \text{ in.}) = 4.17 \text{ in.}$
C Soil: $\Delta Q_c = 4.76 - (500/990)(2.12 \text{ in.}) = 3.69 \text{ in.}$

(2) Compute the maximum allowable depth (d_{max}) of the pavement aggregate subbase by the feasibility equation:

$$d_{max} = f\, T_s/V_r$$

Soil	f (in/hr)	T_s (hr)	V_r	d_{max} (in.)	d_{max} (ft.)
A	2.41	72	0.4	434	36.2
B	1.02	72	0.4	184	15.3
C	0.27	72	0.4	49	4.1

The depth to the groundwater table is assumed to be at 15 feet.
The depth to bedrock is assumed to be greater than 15 feet.

(3) Compute the depth of stone subbase (d_p) required to control the increased runoff volumes by:

$$d_p = \frac{\Delta Q_u R + P - fT}{V_r}$$

where $R = A_c/A_p = 1 \text{ ac.}/4 \text{ ac.} = 0.25$;
$T = 2$ hours; and
$V_r = 0.4$

		2 Year (P=3.0 in.)		10 Year (P=5.0 in.)	
Soil	f (in/hr)	ΔQ_u (in)	d_p (in)	ΔQ_u (in)	d_p (in)
A	2.41	2.77	-2.8 (use 0.0)	4.76	3.4 (use 4.0)
B	1.02	2.63	4.0	4.17	10.0
C	0.27	2.39	7.6 (use 8.0)	3.69	13.4 (use 14.0)

Since the design depths of the aggregate subbase (d_p) are less than d_{max} computed in step 2, the porous pavement feasibility criteria is satisfied. The porous pavement will easily control the increase in discharge associated with the 2 and 10 year storms. However, the design depth should also be based upon the required depth of loading conditions and depth below the frost line to allow for adequate stability.

5.7 CASE STUDY NO. 6

A dry well will be designed for a one acre residential lot to capture the rooftop runoff from one inch of rainfall (first flush) as shown in Figure 5-3. Capturing the first flush of runoff will remove some water pollutants, provide groundwater recharge, and reduce runoff during high frequency storm events.

1 acre lot = 43,560 ft² (150 ft. x 290 ft.)
house rooftop = 1,600 ft² (25 ft. x 64 ft.)

5.7.1 Time of Concentration Determination

Before Development

Hydraulic Length (H_L) = 326 ft (diagonal lot length)
Velocity = 0.35 ft/sec (from TR-55, Figure 3-1, assuming a 2% basin slope and meadow landuse)
Time of Concentration:

$$t_c = \frac{326 \text{ ft}}{(0.35 \text{ ft/sec})(60 \text{ sec/min})} = 15.5 \text{ min.} = 0.26 \text{ hrs.}$$

Peak Factor (from TR-55, Figure 5-2):
q_{ub} = 500 cfs/mi²/in.

After Development

Hydraulic Length (H_L) = 238 ft (1/2 lot diagonal + 1/2 lot width)
Velocity - lawn @ 2% slope = 1.0 ft/sec
- roof and driveway @ 2% slope = 2.75 ft/sec
(from TR-55, Figure 3-1)
Time of Concentration:

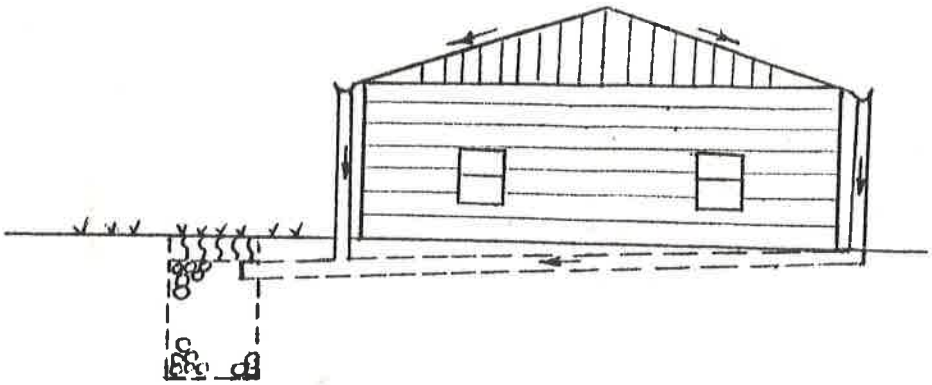
$$t_c = \frac{163 \text{ ft (lawn)}}{1.0 \text{ ft/sec}} + \frac{75 \text{ ft (roof and driveway)}}{2.75 \text{ ft/sec}} \times \frac{1 \text{ hr}}{3600 \text{ sec}}$$

= 0.05 hrs., use a t_c = 0.10 hrs.
Peak Factor (from TR-55, Figure 5-2):
q_{ua} = 990 cfs/mi²/in.

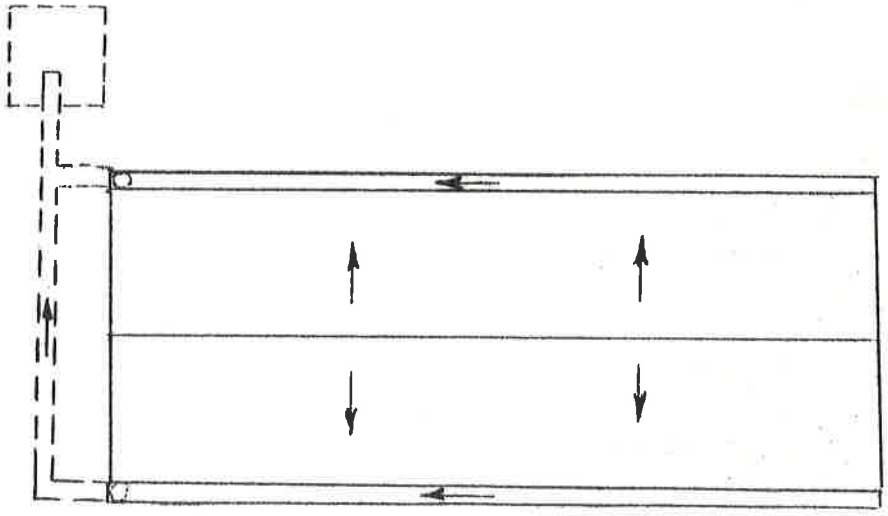
5.7.2 Peak Discharge Determination

Area (A) = 1 acre = 0.0016 mi²

	2-Year (P = 3.0 in.)			10-Year (P = 5.0 in.)		
Before Development	A Soil	B	C	A	B	C
CN	30	58	71	30	58	71
Q_b (in.)	0.0	0.27	0.76	0.0	1.17	2.12
q_{ub} (cfs/mi²/in.)	725	725	725	725	725	725
q_p (cfs)	0.0	0.31	0.86	0.0	1.33	2.40



Profile of House with a Dry Well



Top View of House with a Dry Well

Figure 5-3. Schematic of a House with a Dry Well for Case Study No. 6

After Development	2-Year (P = 3.0 in.) A Soil	B	C	10-Year (P = 5.0 in.) A	B	C
CN	51	68	71	51	68	79
Q_a (in.)	0.11	0.63	0.76	0.75	1.88	2.80
q_{ua} (cfs/mi²/in.)	990	990	725	990	990	990
q_p (cfs)	0.17	0.97	1.84	1.16	2.91	4.33

Note: The SCS graphical method is used to compute the peak discharge (q_p) from the following equation:

$$q_p = q_u A Q$$

5.7.3 Design Procedure for Dry Well

(1) From the selected design rainfall depth (P = 1 in) and runoff curve numbers, compute the runoff depth from the contributing area:

(Q_c, CN_c = 98), and the overlying dry well soil
(Q, based on a grass covered "B" soil, CN = 61).

First Flush Design (P = 1.0 in)

CN = 61
Q = 0.0 in.
CN_c = 98
Q_c = 0.79 in.

(2) Compute the maximum allowable dry well depth (d_{max}) from the feasibility equation:

$$d_{max} = fT_s/V_r$$

Soil	f (in/hr)	T_s (hr)	V_r	d_{max} (in)	d_{max} (ft)
A	2.41	72	0.4	434	36.2
B	1.02	72	0.4	184	15.3
C	0.27	72	0.4	49	4.1

The depth to the groundwater table is assumed to be at 15 feet. The depth to bedrock is assumed to be greater than 15 feet.

(3) Select a dry well design depth greater than d_{max} and at least two feet above the groundwater table (subtract one foot for the overlying soil cover).

Soil	d_w (ft)
A	12.0
B	12.0
C	4.0

(4) Compute the dry well surface area (A_w) from the following equation:

$$A_w = \frac{Q_c A_c}{V_r d_w - (P - Q) + d_o C_w + fT}$$

where A_c = 1600 ft² (roof area);
V_r = 0.40;
d_o = 1.0 ft (soil cover);
T = 1.0 hrs.;
P, f, C_w, Q_c, and d_w are given below.

Convert all parameters from inches to feet. The value $(- P + Q + d_o C_w)$ is set equal to 0.0 since it cannot be less than zero.

Soil	f (in/hr)	C_w (in/in)	d_w (ft)	Q_c (in)	Q (in)	A_w (ft²)
A	2.41	0.31	12.0	0.79	0.0	21.1
B	1.02	0.25	12.0	0.79	0.0	21.6
C	0.27	0.17	4.0	0.79	0.0	64.9

(5) Compute the after development discharges with the dry well by the equation:

$$q_p = q_{ua} (A - A_c)(Q_a - V_w/A)$$

where q_{ua} = 990 (cfs/mi²/in);
A = 1 ac = 0.0016 mi²;
A_c = 1600 ft² = 0.000057 mi²;
Q_c = 0.79 in; and
$V_w/A = Q_c A_c/A$ = 0.029 in.

Soils	q_{ua}	$(A - A_c)$ (mi²)	Q_a (in)	$(Q_a - V_w/A)$ (in)	q_p (cfs)	Q_a (in)	$(Q_a - V_w/A)$ (in)	q_p (cfs)
A	990	0.0015	0.11	0.08	0.12	0.75	0.72	1.07
B	990	0.0015	0.63	0.60	0.89	1.88	1.85	2.75
C	990	0.0015	1.19	1.16	1.72	2.80	2.77	4.11

5.7.4 Discharge Summary

	q_p (cfs)					
	2-Year (P = 2.0 in.)			10-Year (P = 5.0 in.)		
(Soil)	A	B	C	A	B	C
Before Development	0.0	0.31	0.86	0.0	1.33	2.40
After Development	0.17	0.97	1.84	1.16	2.91	4.33
After Development w/Dry Well	0.12	0.89	1.72	1.07	2.75	4.11

Controlling the first one inch of rainfall has little effect on reducing the 2 and 10 year peak discharge values. In fact, less than 30% of the increase in discharge values are managed.

NOT LOADED - A requested rain table is not included in TR-20
es 1 to 6 are included in the TR-20 program. Should the user
i data with these rain table numbers, they will override the
program. Also, tables 7 to 9, if used, must be loaded.

.XSECTION XXX ALREADY LOADED,
???STRUCTURE XX ALREADY LOADED, or
???RAIN TABLE XX ALREADY LOADED - Table data has previously been loaded. The addition of this data will replace the existing information.

???OPERATION XXXXXX MISSPELLED - Operation name may actually be misspelled or there is an error in the data code or operation number.

***ILLEGAL VALUE IN COL. XX - XX - This appears when there is a negative value in a READHD table. It will also appear if there is a value of zero in the first three data fields of a READHD 9 record.

???BANKFULL ELEVATION LESS THAN SECOND POINT - The bankfull elevation is below the first non zero discharge point of rating. The channel segment should be adequately defined to provide accurate rating exponent (M) estimates.

???DIVERTED FLOW XSECTION NO. IS ZERO - If diverted flow will be used later, it is generally referenced by a cross section number (1 to 200). If diverted flow will not be used, a blank or zero section number is acceptable.

>>>TOTAL DRAINAGE AREA IS XXX.XX SQ MI - This appears when an ENDATA record is encountered. It is the sum of the drainage areas found on the runoff records between the JOB and ENDATA records.

>>>No. STORMS = XX
>>>No. ALTERNATES = XX
>>>No. STANDARD CONTROLS = XXX

These messages are printed when the ENDJOB record is enc
number of storms and the number of alternates correspond
numbers referenced on executive control records. The num
controls is the sum of all standard controls including tho
INSERT and ALTER records but not including those following

SUMMARY

The data check program is recommended for use prior to utilizing the TR-20 program. By checking all initial input data, the user will increase the probability of achieving a successful TR-20 run.

Additional data checks that require more complex logic are included in the TR-20 program, however, many of the simpler data errors may only be identified by the data check program.

Water Quality Banking Agreement (1992)

will be required from consultants. Contact R. Beckland with any questions. RGB

Maryland Department of Transportation
State Highway Administration

O. James Lighthizer
Secretary
Hal Kassoff
Administrator

June 2, 1992

MEMORANDUM

TO: All District Engineers
Deputy Chief Engineer-Bridge Development
Assistant District Engineers-Construction
Deputy Chief Engineer-Highway Development
Director, Office of Environmental Design

FROM: Charles R. Olsen
Chief Engineer

HWY. DESIGN DIV.
92 JUN 3 AM 11:22

SUBJECT: Stormwater Management Banking

A Memorandum of Agreement (MOA) has been executed between Maryland Department of Environment's Sediment and Stormwater Administration (SSA) and SHA to establish a banking system for water quality management for SHA projects. This agreement will ensure that SHA meets its responsibility of providing water quality improvements for all projects and yet allow the flexibility of designing the most environmentally effective solution at a reasonable cost. Every effort must still be made to provide water quality measures on each project; however, this agreement allows the latitude to defer water quality treatment in hardship cases.

The highlights of the MOA include:

- Deferral of water quality for new pavement areas up to a total of 5 acres per sub-basin in metropolitan areas and 2 acres in rural areas (A detailed watershed map is attached).
- Credit for treatment of offsite pavement areas (ie., county roads, parking lots) which drain to our facility.
- Credit for wetland mitigation sites designed to MDE criteria which receive pavement runoff.
- Ability to extend use of the bank to other state agencies, subject to approval by the Chief Engineer.
- Establishment of a process to initiate water quality retrofits to clear existing bank debits or create bank credits.

A copy of the agreement is attached, detailing the process and methods of calculating credits and debits.

My telephone number is _____

Teletypewriter for Impaired Hearing or Speech
383-7555 Baltimore Metro - 565-0451 D.C. Metro - 1-800-492-5062 Statewide Toll Free
707 North Calvert St., Baltimore, Maryland 21203-0717

The agreement is effective immediately for all design projects for which SSA has not yet issued a permit. Construction projects which request stormwater management modifications (ie., deletion of infiltration trenches) will be allowed subject to this agreement. The Highway Design Division, Hydraulics Section will be maintaining a record of bank balances in order that water quality retrofit projects can be initiated in a timely manner. To ensure the accuracy of these records a summary of water quality treatment (credit or debit) for each project must be forwarded to MDE and carbon copied to Highway Design, attention: Kirk McClelland. A sample summary form is attached for reference. Should you have any questions about the use of this bank, please contact Kirk McClelland at 333-1274.

CRO/dp
Attachments

cc: Mr. Dan O'Leary
Mr. Edward G. Stein
Mr. Kirk G. McClelland

MEMORANDUM OF AGREEMENT
BETWEEN
THE MARYLAND DEPARTMENT OF THE ENVIRONMENT
AND THE MARYLAND STATE HIGHWAY ADMINISTRATION
CONCERNING
STORMWATER QUALITY MANAGEMENT BANKING

This Memorandum of Agreement (MOA) between the Maryland Department of the Environment (MDE), Sediment and Stormwater Administration (SSA) and the Maryland Department of Transportation, State Highway Administration (SHA) outlines the parameters by which SHA will provide Stormwater Quality Management (Quality Management) on its projects. These projects are reviewed by SSA pursuant to §4-205 of the Environment Article of the Annotated Code of Maryland, State regulations, and Stormwater Management Guidelines for State and Federal Projects. This MOA recognizes that SHA is sometimes unable to provide Quality Management acceptable to SSA on their projects. By this agreement, the parties intend that, where SHA cannot provide acceptable Quality Management on a given project, the "deficit" thus created will be eliminated at another SHA project within the same sub-basin.

1. SCOPE

The terms set forth in this agreement take effect immediately and apply to those projects to be constructed by SHA which have not already received approval from the MDE, Sediment and Stormwater Administration (SSA). This agreement creates a Quality Management "bank" which allows a debit/credit system for stormwater quality management on SHA projects within a given sub-basin. The bank system is to enable SHA to maximize the cost effectiveness of providing Quality Management and keep projects on schedule while meeting or exceeding SSA Quality Management requirements.

2.0 TERMS

2.1 SHA should maximize Stormwater Quality Management on-site to the extent practicable as required by the Stormwater Management Guidelines for State and Federal Projects and agreements thereafter. SSA will make the final determination as to whether off-site Quality Management will be allowed.

2.2 If a Quality Management (credit) project is proposed to reduce the pavement deficit in the bank, the proposed roadway to be treated should be similar to that of the project(s) deferred to the bank. Similar, in this case, means that the roadways at both sites have similar or higher classifications and traffic volumes (A.D.T.), therefore, similar pollutant loadings. Control of rooftop impervious areas will not be considered as water quality treatment.

2.3 When possible, the "banked" pavement areas should be treated off-site by infiltration structures, which is the preferred stormwater management alternative.

2.4 Both credits and debits in the bank will be recorded according to the sub-basin (as defined by DNR's Maryland Watershed Designation) within which they exist. Projects can only deposit or withdraw pavement acreage within their respective sub-basin.

2.5.0 SHA will locate and notify SSA of potential sites for Quality M[m]anagement. SSA will review these sites and participate in the selection process. Then SHA will provide the necessary soils and hydrologic information to develop the plans and finally they will construct the management structure(s).

2.5.1 When a debit of 5 acres is accrued within sub-basins 02-13-07 through 02-13-11 or 02-14-02, SHA will be required to construct Quality Management for at least 5 acres of existing pavement.

2.5.2 All sub-basins except those listed in 2.5.1 are limited to a debit of 2 acres, before a Quality Management project is required.

2.6 Quality management shall be provided through infiltration, retention or extended detention of runoff in accordance with MDE criteria. Infiltration is the most preferred and extended detention is the least preferred means, therefore infiltration must be determined to be infeasible for a site before retention can be tested for feasibility, with extended detention being chosen as a last resort. Credits applied to the bank will be based on the following:

A) Quality management constructed within the same drainage area as the impervious area that it was designed to treat will receive 100% credit, ie., 1 acre of pavement drains to an infiltration trench, retention pond, or extended detention basin that will treat that 1 acre of pavement, therefore 0 acre of pavement gets debited and 0 acre of Quality Management is credited to the bank.

B) Untreated pavement requiring Quality Management in one drainage area (DA 1) may be deferred to excess quality management in another drainage area (DA 2) if:

1) Quantitative control in that drainage area (DA 1) is not required, or the presence of a quality control structure as part of a quantity control structure is infeasible (ie. underground storage), and

2) sufficient hardship exists to render quality management in that drainage area (DA 1) infeasible, and

3) there is sufficient, untreated existing pavement in the drainage area (DA 2) where excess quality management is proposed to warrant the deferment, and

4) through infiltration practices, quality management will be credited at 100% for deferred (DA 1) highway pavement treated as long as the storage volume provided does not exceed 1" of runoff from the contributing impervious area, and

5) through retention pond(s), quality management will be credited at 70% for deferred (DA 1) highway pavement treated, and

6) through extended detention basins, quality management will be credited at 40% for deferred (DA 1) highway pavement treated.

C) Off-site pavement draining to a SHA infiltration or retention structure will be credited as quality management at 50% for infiltration, 35% for retention, and 20% for extended detention to be applied to deferred pavement on the project (as outlined in B above) or, in the cases of infiltration or retention, to the bank as credit. Extended detention quality management cannot be used for bank credit.

D) On a project basis, the total amount of impervious requiring quality management shall be weighed against the quality management provided, within the framework of 2.6 A), B) and C), with untreated impervious applied to the bank as a debit or excess quality management applied to the bank as credit.

Proportion of Contributory Pavement Credited on Project

Best Management Practice	Contributory Pavement from Highway	
	In Drainage Area	Out of Drainage Area
Infiltration	100%	100%
Retention	100%	70%
Extended Detention	100%	40%
Detention	N/A	N/A

Proportion of Contributory Pavement Credited to the Bank

Best Management Practice	Highway Pavement	Off Site Pavement
Infiltration	100%	50%
Retention	70%	35%
Extended Detention *	N/A	N/A
Detention	N/A	N/A

* 80% for Det. w/ marsh if = 3% D.A., 60% for Det w/ marsh if = 2% D.A., 40% otherwise

2.7 Regarding infiltration, an additional ½" of runoff from impervious areas can be stored for extra credit beyond the required ½" (1" total) for use on that project. However, infiltration storage beyond ½" of runoff from the contributory imperviousness cannot be used for off-site bank credit.

2.8 Wetland mitigation sites may be considered for Quality Management credit based on their anticipated pollutant removal efficiencies and the areas that they treat as outlined in 2.6 B) 5) and 2.5 C), as long as they are designed in accordance with MDE publications.

2.9 New soil boring information will be required for all proposed credit projects.

2.10 Removal of existing pavement and replacement with pervious areas will be allowed for credit with respect to Section 2.2 of this MOA.

2.11 State agencies other than SHA will be allowed to withdraw from the bank, but only with the permission of SHA.

2.12 The construction costs of a retrofit project should not exceed $12,000 per acre treated.

3. MAINTENANCE

SHA agrees to inspect yearly and maintain all Quality Management structures built under the terms of this MOA in accordance with Section 26.09.02.10 of State Regulations.

4. MODIFICATIONS

The terms of this MOA may be modified upon written agreement of both parties.

5. TERMINATION

This MOA shall be terminated upon mutual agreement between both parties.

Approved:

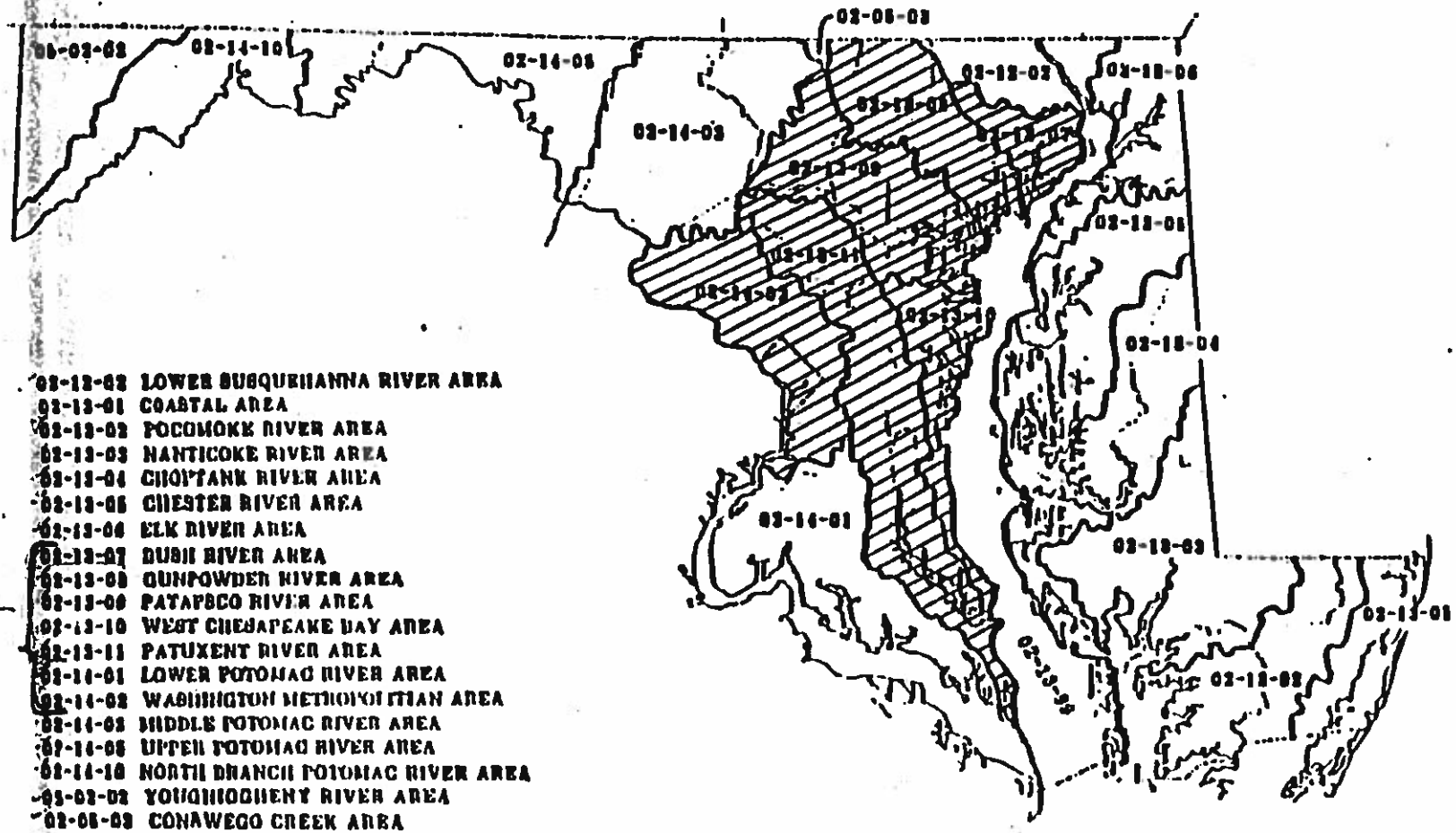
5/14/92
(Date)

Chief Engineer
Maryland State Highway Administration

5/11/92
(Date)

Director
Sediment & Stormwater Administration

MARYLAND WATERSHED DESIGNATIONS



02-12-02 LOWER SUSQUEHANNA RIVER AREA
02-12-01 COASTAL AREA
02-12-02 POCOMOKE RIVER AREA
02-12-03 NANTICOKE RIVER AREA
02-12-04 CHOPTANK RIVER AREA
02-12-05 CHESTER RIVER AREA
02-12-06 ELK RIVER AREA
02-12-07 BUSH RIVER AREA
02-12-08 GUNPOWDER RIVER AREA
02-12-09 PATAPSCO RIVER AREA
02-12-10 WEST CHESAPEAKE BAY AREA
02-12-11 PATUXENT RIVER AREA
02-14-01 LOWER POTOMAC RIVER AREA
02-14-02 WASHINGTON METROPOLITAN AREA
02-14-03 MIDDLE POTOMAC RIVER AREA
02-14-04 UPPER POTOMAC RIVER AREA
02-14-10 NORTH BRANCH POTOMAC RIVER AREA
03-02-02 YOUGHIOGHENY RIVER AREA
02-05-03 CONAWEGO CREEK AREA
02-12-00 CHESAPEAKE BAY

02-12-02
- 02 — FEDERAL MAJOR BASIN DESIGNATOR
- 12 — FEDERAL BASIN DESIGNATOR
- 02 — SUB-BASIN DESIGNATOR (MODIFIED FEDERAL)

Watersheds with 5 acre. maximum water quality deferral.

10.50.01.021

GUIDELINES FOR USING THE STORMWATER MANAGEMENT BANKING AGREEMENT

Maryland State Highway Administration
Highway Design Division

September, 1994

TABLE OF CONTENTS

Page

INTRODUCTION 1

ALLOWABLE WATER QUALITY MEASURES 3

WATER QUALITY SUMMARY SHEET 7

UNUSUAL SITUATIONS IN PREPARING SUMMARY SHEETS 11

APPENDIX A - BLANK SUMMARY SHEET 13

INTRODUCTION

Maryland Department of the Environment (MDE) water quality requirements for added impervious area on SHA projects have become increasingly difficult to meet. In the past, SHA did not have to provide water quality measures where infiltration was infeasible. However, we are now required to provide water quality treatment wherever quantitative management is required and wherever Section B waivers are being granted. This could require SHA to build water quality measures in locations where they would be very expensive or only marginally effective. In order to give the designer the means to meet MDE's water quality requirements in the the most cost-effective manner, the concept of water quality banking has been developed.

A Stormwater Management Banking Agreement was signed between the State Highway Administration and the Maryland Department of the Environment in May 1992. The agreement allows SHA to provide water quality treatment at alternate locations in the same watershed. This extra treatment can be credited toward the water quality requirements in other drainage areas within the same watershed where such measures are not feasible. Figure No. 1 shows the watersheds that the state is divided into for the purposes of this agreement. In order to meet the requirements of the agreement, water quality measures must be investigated in the following order of preference:

1. Within the same drainage area.
2. Within the same project.
3. Within the same watershed. (Stormwater Bank)

Like any solvent "bank", the stormwater bank must be able to cover its debts. It is important, therefore, that every effort be made to provide all reasonable water quality measures on-site. As shown on Figure No. 1, there are limits as to how far in debt SHA may go in each of the watersheds. Most have a 2-acre limit, although the more developed watersheds in Central Maryland have a 5-acre limit. If our debt exceeds those limits, SHA is required to develop a plan to eliminate that debt entirely. Since this situation could make the bank unavailable for additional debit projects in that watershed while the debt is being eliminated, it is in everyone's interest that debiting the stormwater bank is only pursued as a last resort.

In order to ensure the continuing solvency of the stormwater management bank, the Highway Design Hydraulics Section must review and approve all proposed bank debits before submission to MDE.

ALLOWABLE WATER QUALITY MEASURES

This section describes the most commonly used water quality measures and provides general guidance on how to design and locate these measures. Four basic types of water quality measures can currently be used to obtain bank credit on SHA projects. They are, in order of preference, infiltration, extended detention with shallow marsh, retention, and extended detention. This section covers the methods used, and the factors considered, in designing these measures.

Infiltration

The concept behind this measure is that the first half-inch of runoff (first flush) from paved areas contain the bulk of the pollutant load during most storm events. By capturing this first half-inch of runoff and holding it until it infiltrates into the ground, most of the pollutants should theoretically be prevented from running off. The first flush is usually held in either an open basin or a stone-filled trench. The following are some design considerations for these measures:

1. A minimum infiltration rate (as determined by SHA's Geotechnical Explorations Division) of 0.52 inches per hour needs to be present at the bottom of the facility. Higher infiltration rates are preferred. Infiltration is not usually investigated where "D" soils are present.

2. At least 4 feet, and preferrably 6 feet, needs to be between the bottom of the facility and both the seasonally high groundwater table and bedrock.

3. Pre-treatment of runoff to remove sediments prior to entering an infiltration facility will prevent clogging and extend the life of the facility. Pre-treatment can be accomplished by directing roadway runoff through a vegatative filter strip, grassed swale or forebay prior to entering the facility. The use of infiltration is strongly discouraged where pre-treatment of runoff is not possible.

4. The 72-hour maximum allowable runoff storage time controls the design depth of infiltration facilities.

5. Sediment runoff during construction activities can clog infiltration facilities. As a result, infiltration facilities cannot be put into service until all disturbed areas draining toward them are stablized. If the same site is to be used as a sediment basin, the bottom of the proposed infiltration facility must be kept at least two feet below the bottom of the sediment basin.

6. Infiltration facilities need to be at least 100 feet from water supply wells to avoid contamination.

7. Infiltration is the most desirable water quality measure in natural (Class III) and recreational (Class IV) trout waters since it prevents warm roadway runoff from raising stream temperatures to above what trout can tolerate.

8. Additional credit can be given within a project for infiltration of the second half-inch of runoff from paved areas. As a result, infiltrating the first inch of runoff from a one acre paved area could be used to offset two acres of paved area elsewhere on the project. However, infiltration of the second half-inch of runoff from paved areas cannot be credited toward the bank. When infiltrating the first full inch of runoff, the minimum allowable infiltration rate will be 2.41 inches per hour.

Infiltration of the first half-inch of roadway runoff is assigned a banking efficiency of 100 percent. For more detailed information on the design of infiltration facilities, see the latest version of the "Maryland Standards and Specifications for Infiltration Practices".

Extended Detention with Shallow Marsh

This measure combines 24-hour extended detention of the one-year storm event with a shallow marsh designed in accordance with MDE's "Guidelines for Constructing Wetland Stormwater Basins", March 1987. Two different shallow marsh options can be used. The preferred option is creating a marsh area equivalent to at least three percent of the contributing watershed. This is assigned a banking efficiency of 80 percent. If there is not enough space available to do that, a marsh area covering at least two percent of the watershed can be used, but with a reduced banking efficiency of 60 percent. It should be noted that unlike extended detention alone, excess treatment from ED/Marsh can be applied towards the bank and not just to other areas on the same project.

See the section of this paper on "Extended Detention" for how the detention time provided by a particular pond is determined. In natural (Class III) and recreational (Class IV) trout waters the required detention time is reduced to 12 hours to minimize the heating of water detained in the basin during the summer.

Retention

Retention (wet) ponds are designed to have a permanent pool that is large enough to allow incoming suspended pollutants to settle out before they would otherwise leave the facility. Pollutants are also removed by the biological and photo-chemical activity that occurs in the pond. Retentions ponds are to be sized based on procedures in the MDE paper "Feasibility and Design of Wet Ponds to Achieve Water Quality Control". Retention ponds need to have at least a 70 percent pollutant removal rate as determined in that paper. For banking purposes, retention ponds are given a 70 percent efficiency rate, even when the calculated pollutant removal rate is higher. Some factors to consider in locating and designing a wet pond are as follows:

1. Wet ponds should have a minimum 10 foot wide shallow (6 to 12 inch deep) bench around their perimeters. The bench serves as both a safety feature and a location for wetland vegetation to become established. This vegetation helps to stabilize the fringes of the pond and to enhance the water quality benefit of the facility.

2. Seepage from wet ponds must be minimized. Otherwise, pond levels may drop excessively between rainfall events. Excessively low water levels are not only unattractive but can kill off wetland vegetation in the bench area. Seepage losses can be minimized by building the pond on impervious soils, excavating the pond down to (or below) the seasonally low water table, or installing an impervious liner (clay or geotextile) on the bottom of the pond.

3. The distance between the inlet(s) into a wet pond and the outlet structure needs to be maximized. Where the inlet and outlet are close, incoming water may circulate through only a small portion of the pond before exiting. As a result, the water may not stay in the pond long enough for sediments to settle out.

4. Wet ponds cannot be built in natural (Class III) or recreational (Class IV) trout waters due to the the tendency of wet ponds to increase water temperatures.

5. Forebays should be incorporated into the design to provide primary settling and thus extend the useful life of the pond.

Extended Detention

This water quality measure involves providing a very slow release from a detention pond so that the centroid of the outflow hydrograph is delayed a certain amount of time after the centroid of the inflow hydrograph. The long detention time will allow suspended sediment to settle out in the pond. Generally, the storm used is the one-year event and the desired minimum detention time (or centroid delay) is 24 hours. For banking purposes, the efficiency rate for extended detention basins is 40 percent. Since water quality treatment by extended detention alone cannot be credited to the "bank", the use of a shallow marsh with this type of facility is usually desirable. Some factors to consider in locating and designing extended detention basins are as follows:

1. Initial sizing of extended detention basins can be done using procedures in the MDE paper "Design Procedures for Stormwater Management Extended Detention Structures", July 1987, by Bruce W. Harrington. However, this method tends to underestimate the volume and area needed for the facility.

2. The final sizing of an extended detention basin must be verified by using the TR-20 program to check the detention time. Since the centroids of the inflow and outflow hydrographs are difficult to determine, MDE allows us to assume that they are the times at which half of the total runoff volume has occurred on the

two hydrographs. One method of figuring those times is to have the discharge hydrographs printed out and then sum up the volumes of flow for each time increment until half of the total runoff volume has been reached. To get an adequate amount of the outflow hydrograph to print out, a larger than normal time increment (about 0.2 hours) will be needed. The total runoff volume for both the inflow and outflow hydrographs should be taken from the inflow hydrograph since the outflow hydrograph will usually be truncated.

3. In natural (Class III) and recreational (Class IV) trout waters, the maximum allowable detention time is 12 hours. In such a case, incorporating a shallow marsh into the design will help offset the reduction in water quality benefit caused by the reduced detention time.

WATER QUALITY SUMMARY SHEET

The banking agreement encourages on-site water quality measures by giving less than full credit when applying most types of water quality treatment toward pavement added in other drainage areas. The reduction in credit is based on the efficiency applied to the type of practice used. In addition, treatment of non-SHA pavement is given an additional 50% reduction in credit when applied to pavement outside of the drainage area. As a result, keeping track of how pavement added or treated in one drainage area is applied toward other drainage areas on a project can be very complicated.

To standardize and simplify the calculation of a "balance" for SHA projects, a Water Quality Summary Sheet must be filled out for each project and included with the stormwater management report. (If the sheet shows a debit, it must be submitted to Highway Design - Hydraulics for review and approval prior to submission to MDE.) Figure No. 2 is an example of the latest summary sheet.

This version of the sheet requires more information than the last one, but should provide a clearer picture of what is being treated in each drainage area. The following assumptions were made in developing the new sheet:

1. No paved area is transferred to or from drainage areas outside of the limits of the project.
2. Infiltration facilities are designed to infiltrate only the first half-inch of runoff.
3. There is only one type of treatment used in any given drainage area.

If any of the above assumptions are not true on a particular project, see the following section of this paper for additional guidance.

All proposed outfalls where quantitative stormwater management is being done, or where a Section B waiver is being requested, must be included in the summary sheet. In some cases, an existing outfall will be eliminated by diverting its entire flow to another drainage area on the same project. In that case, the outfall must still be shown on the summary sheet, even though there is no proposed outfall left. Otherwise, the sheet will treat the diverted pavement as if it were additional pavement placed by the project and calculate a higher debit (or a smaller credit) than the project warrants.

The following are definitions of the terms used on the new water quality summary sheet shown in Figure No. 2:

(A) - Outfall Number - The number associated with the point of investigation at the SHA right-of-way line.

(B) - Pre-Construction Paved Area - Existing total paved area to point of investigation.

(C) - Post-Construction Paved Area - Proposed total paved area to point of investigation.

NOTE: If there is no water quality treatment being done for the point of investigation, go directly to (M), where (M)=0.

(D) - Total Pavement Treated - The total paved area that drains into the water quality facility.

(E) - New Untreated Pavement - Paved area that did not drain to the point of investigation under existing conditions and that is not contributing to an SHA water quality measure. This can consist of either pre-construction pavement diverted from another point of investigation or additional paved area placed by the contract.

(F) - Treatment Type - The type of water quality treatment used.

(G) - Efficiency - The efficiency given to a particular treatment when applied toward added pavement draining toward other points of investigation within the same project.

(H) - Existing Pavement Treated - The existing paved area within SHA right-of-way that is treated by an SHA water quality facility and that drained toward the treatment site under pre-construction conditions. This can include existing pavement that is resurfaced and existing pavement that is reconstructed in the same location.

(I) - Excess Existing Pavement Treated - This is the existing pavement treated that is not applied toward new untreated pavement draining to the same point of investigation. If the existing pavement treated exceeds the amount of new untreated pavement, then (I) = (H) - (E). If the pavement treated is less than or equal to the amount of new untreated pavement, then (I) = 0.

(J) - Off-Site Pavement Treated - The paved area outside of SHA right-of-way that contributes to an SHA water quality measure.

(K) - Excess Off-Site Pavement Treated - If (H) > (E), then (K) = (J). If off-site and existing pavement treated combined are greater than the amount of new untreated pavement and (H) < (E), then (K) = (J) + (H) - (E). If off-site and existing pavement treated combined are less than or equal to the amount of new untreated pavement, then (K) = 0.

(L) - New Pavement Treated - The paved area that did not drain to the point of investigation under existing conditions and that is within the area contributing to an SHA water quality measure. This can consist of either pre-construction pavement diverted from another point of investigation or additional paved area placed by the contract. This will usually be (D) - (H) - (J).

(M) - Treated Area Applied - (M) = [(H) - (I)] + (G)(I) + [(J) - (K)] + 0.5(G)(K) + (L)

(N) - Net Change In Paved Area For Project - The sum of the post-construction paved areas minus the sum of the pre-construction paved areas.

(O) - Sum of the treated areas applied for the project.

(P) - Net Area Applied to Water Quality Bank - If (O) is less than or equal to (N), then (P) = (O) - (N). If (O) > (N) and there is no extended detention, then (P) also equals (O) - (N). If there is extended detention and (O) > (N), then (P) is calculated in a two step process. First, (G)(I) + 0.5(G)(K) for all entries using extended detention must be subtracted from (O). If (O) is still greater than (N), then (P) equals the modified (O) minus (N). If the modified (O) is less than (N), then (P) = 0.

UNUSUAL SITUATIONS IN PREPARING SUMMARY SHEET

Certain situations may be encountered that are not consistent with assumptions used in developing the summary sheet. This section shows how to deal with these unusual situations.

Pavement Shifted From Outside of Project

The summary sheet assumes that shifts in paved area from one point of investigation to another will balance out over the entire project. This will not be the case if pavement is shifted from a drainage area that is otherwise outside of the limits of the project.

For the summary sheet to calculate this properly, the shifted pavement must not be included as part of the Post-Construction Paved Area unless it is being added as part of a concurrent SHA project. (A concurrent SHA project could be, for example, a different section of work on the same highway that will be done at about the same time.) If paved area shifted into the project drains toward a treatment facility, it must be classified as one of the following: (1) Existing Pavement Treated (if existing and within SHA right-of-way); (2) Off-Site Pavement Treated (if existing and outside of SHA right-of-way); (3) New Pavement Treated (if added as part of a concurrent SHA project). If the shifted paved area does not drain toward a treatment facility, it should not be classified as New Untreated Pavement unless it is being added as part of a concurrent SHA project.

Pavement Shifted Out of Project

If pavement is shifted out of a drainage area on the project and toward a point of investigation on a concurrent SHA project, the shifted paved area should not be reflected in either the Pre-Construction Paved Area or the Post-Construction Paved Area . (In other words, the shifted pavement should either be included in both categories or in neither.) Instead, the shifted pavement should be addressed on the other project.

More Than One Type of Treatment in a Drainage Area

If different types of water quality measures are used in the same drainage area, a multiple line entry for that drainage area is required. The first line is a normal entry except that only paved areas treated by the most efficient type of water quality measure are included. The second entry includes the paved areas treated by the second most efficient measure. The New Untreated Pavement for this entry is only what was not offset by existing pavement treated by the previous water quality measure. (For example, if there were 7.0 acres of new untreated pavement in a drainage area, and an infiltration basin treated runoff from 4.4 acres of existing pavement, 2.6 acres of new untreated pavement would remain.) Following entries (if necessary) deal with the most

efficient measure remaining, and include only whatever new untreated pavement which was not offset by previous entries. Outfalls 8 and 9 in Figure No. 2 are examples of multiple treatment types in the same drainage area.

Providing Infiltration for the Second Half-Inch of Runoff

Infiltration of the second half-inch of runoff from existing paved area can be used to offset new untreated pavement within the same project. However, it cannot be used as bank credit.

To account for this, separate entries for for the first and second half-inch of infiltration are needed, with the first half-inch being the first entry. The second entry should include only the new untreated pavement not offset by the first half-inch of runoff. If there is any Excess Existing Pavement Treated or Excess Off-Site Pavement Treated for the second entry, reduce (J) and then (H) until there there is no excess remaining. (In some cases, doing this may eliminate the need for the second entry altogher.)

A third entry is then needed for the areas taken from (J) and (H) in the second entry. This third entry is any second half-inch infiltration that can be applied to other drainage areas on the project. The new pavement treated with second half-inch infiltration should be included in the third entry by adding it to either (H) or (J). To prevent the "treated area applied" for this area from being applied to the bank, this entry should be treated as if it were extended detention in calculating (P) on the summary sheet. (If you are using the spreadsheet, you can fool it into doing this by giving this entry an efficiency of 0.40 and dividing the area(s) treated by 0.40. The spreadsheet will not apply to the bank any treated area which has an assigned efficiency of less than 0.50)

Outfall 10 in Figure No. 2 is an example of how to address second half-inch infiltration on the summary sheet. In that example, the new pavement treated with second half-inch infiltration was was added to (H) in the third entry. In addition, both (H) and (J) were divided through by 0.4 to offset the 40% efficiency given to it.

17-Sep-94

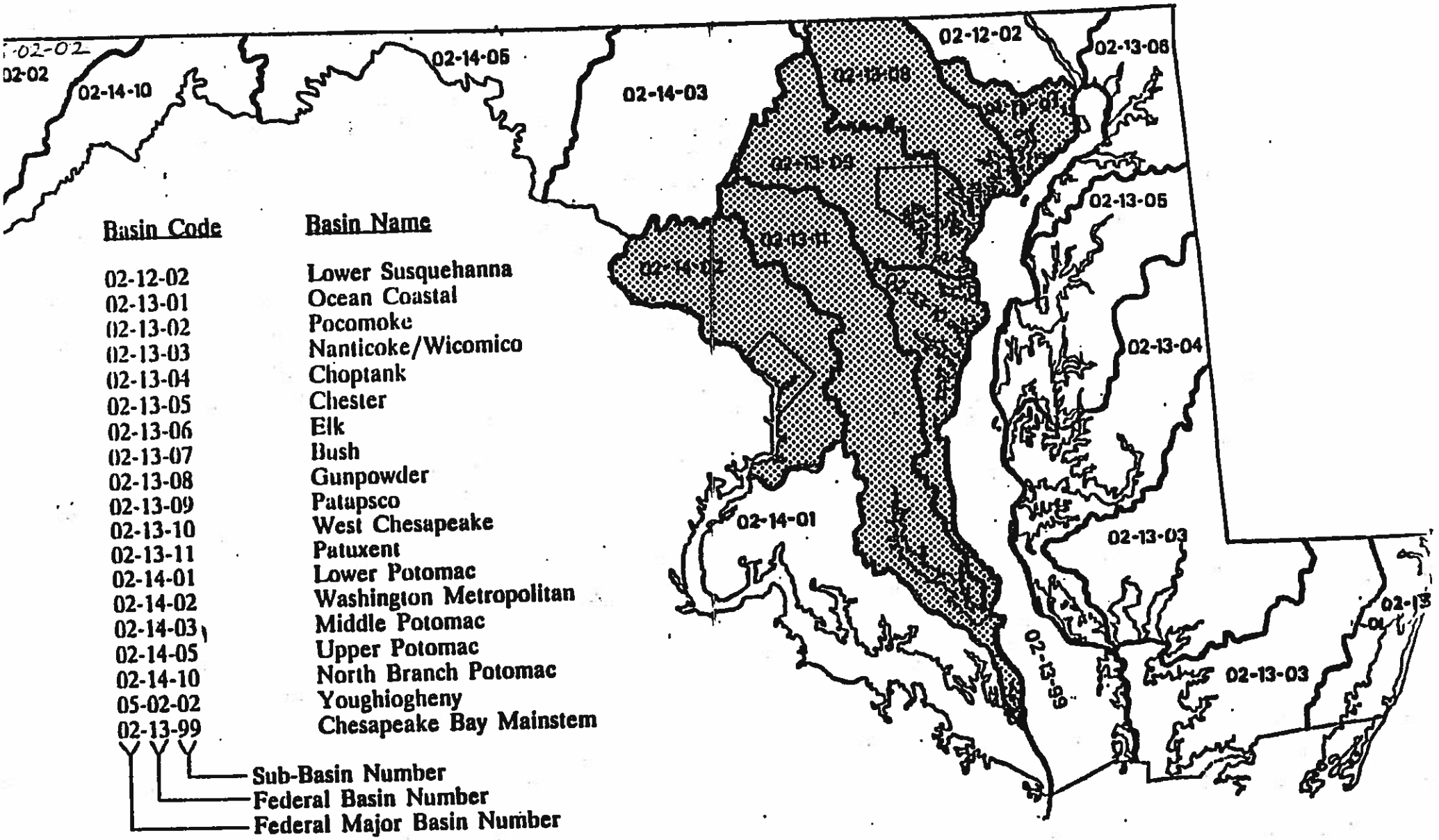
MDE/SHA WATER QUALITY BANK

Watershed Number	Watershed Name	Bank Balance (Acres)	Maximum Debit (Acres)	Mitigation Required?
02-12-02	Lower Susquehanna River Area	-0.59	2.0	No
02-13-01	Coastal Area	0.08	2.0	No
02-13-02	Pocomoke River Area	0.00	2.0	No
02-13-03	Nanticoke River Area	-0.59	2.0	No
02-13-04	Choptank River Area	0.13	2.0	No
02-13-05	Chester River Area	2.76	2.0	No
02-13-06	Elk River Area	0.00	2.0	No
02-13-07	Bush River Area	-6.70	5.0	Yes
02-13-08	Gunpowder River Area	0.93	5.0	No
02-13-09	Patapsco River Area	11.32	5.0	No
02-13-10	West Chesapeake Area	0.86	5.0	No
02-13-11	Patuxent River Area	4.94	5.0	No
02-14-01	Lower Potomac River Area	-2.56	2.0	Yes
02-14-02	Washington Metropolitan Area	0.87	5.0	No
02-14-03	Middle Potomac River	-1.31	2.0	No
02-14-05	Upper Potomac River Area	-0.66	2.0	No
02-14-10	North Branch Potomac River	0.00	2.0	No
05-02-02	Youghiogheny River Area	-1.50	2.0	No

STATEWIDE 7.99 Acres

Figure No. 1

MARYLAND WATERSHED DESIGNATIONS



Basin Code	Basin Name
02-12-02	Lower Susquehanna
02-13-01	Ocean Coastal
02-13-02	Pocomoke
02-13-03	Nanticoke/Wicomico
02-13-04	Choptank
02-13-05	Chester
02-13-06	Elk
02-13-07	Bush
02-13-08	Gunpowder
02-13-09	Patapsco
02-13-10	West Chesapeake
02-13-11	Patuxent
02-14-01	Lower Potomac
02-14-02	Washington Metropolitan
02-14-03	Middle Potomac
02-14-05	Upper Potomac
02-14-10	North Branch Potomac
05-02-02	Youghiogheny
02-13-99	Chesapeake Bay Mainstem

02-13-99
- Sub-Basin Number
- Federal Basin Number
- Federal Major Basin Number

— Watersheds with 5 acre maximum water quality deferral.

FIGURE NO. 2

WATER QUALITY SUMMARY SHEET

ROUTE NUMBER : Examples

DESCRIPTION : _____

CONTRACT NUMBER: _____

WATERSHED NUMBER : 02-13-05

MDE NUMBER: _____

(A) OUTFALL NUMBER	(B) PRE-CONST PAVED AREA (ACRES)	(C) POST-CONST PAVED AREA (ACRES)	(D) TOTAL PAVEMENT TREATED (ACRES)	(E) NEW UNTREATED PAVEMENT (ACRES)	(F) TREATMENT TYPE	(G) EFF	(H) EXISTING PAVEMENT TREATED (ACRES)	(I) EXCESS EXISTING PAVEMENT TREATED	(J) OFF-SITE PAVEMENT TREATED (ACRES)	(K) EXCESS OFF-SITE PAVEMENT TREATED	(L) NEW PAVEMENT TREATED	(M) TREATED AREA APPLIED
1	1.00	3.00	1.50	0.50	Retention	0.70	0.00	0.00	0.00	0.00	1.50	1.50
2	1.00	3.00	3.00	0.00	Retention	0.70	1.00	1.00	0.00	0.00	2.00	2.70
3	1.00	3.00	3.00	0.00	Retention	0.70	0.50	0.50	0.50	0.50	2.00	2.53
4	1.00	3.00	3.00	0.50	Retention	0.70	0.50	0.00	1.00	1.00	1.50	2.35
5	1.00	3.00	3.00	1.20	Retention	0.70	0.50	0.00	1.70	1.00	0.80	2.35
6	1.00	3.00	3.00	1.20	Retention	0.70	1.70	0.50	0.50	0.50	0.80	2.53
7	1.00	3.00	2.50	0.10	Retention	0.70	0.05	0.00	0.55	0.50	1.90	2.18
8	10.00	18.00	5.00	7.00	Infiltration	1.00	3.00	0.00	1.40	0.00	0.60	5.00
8	0.00	0.00	4.00	2.60	Retention	0.70	3.20	0.60	0.40	0.40	0.40	3.56
9	10.00	18.00	8.00	7.00	Infiltration	1.00	5.00	0.00	3.00	1.00	0.00	7.50
9	0.00	0.00	4.00	0.00	Retention	0.70	2.50	2.50	0.50	0.50	1.00	2.93
10	3.00	6.50	3.00	2.00	Infiltration	1.00	1.00	0.00	0.50	0.00	1.50	3.00
10			0.50	0.50	Infiltration	1.00	0.50	0.00	0.00	0.00	0.00	0.50
10			1.50		Infiltration	0.40	5.00	5.00	1.25	1.25	0.00	2.25
TOTAL	30.00	63.50	45.00	22.60			24.45	10.10	11.30	6.65	14.00	(O) 40.88

NET CHANGE IN PAVED AREA FOR PROJECT : (N) 33.50 ACRES

NET AREA APPLIED TO SWM QUALITY BANK: (P) 5.13 ACRES IN CHESTER RIVER AREA

APPENDIX A - BLANK SUMMARY SHEET

WATER QUALITY SUMMARY SHEET

ROUTE NUMBER : _____ WATERSHED NUMBER : _____

DESCRIPTION : _____

CONTRACT NUMBER: _____ MDE NUMBER: _____

(A) OUTFALL NUMBER	(B) PRE-CONST PAVED AREA (ACRES)	(C) POST-CONST PAVED AREA (ACRES)	(D) TOTAL PAVEMENT TREATED (ACRES)	(E) NEW UNTREATED PAVEMENT (ACRES)	(F) TREATMENT TYPE	(G) EFF	(H) EXISTING PAVEMENT TREATED (ACRES)	(I) EXCESS EXISTING PAVEMENT TREATED	(J) OFF-SITE PAVEMENT TREATED (ACRES)	(K) EXCESS OFF-SITE PAVEMENT TREATED	(L) NEW PAVEMENT TREATED	(M) TREATED AREA APPLIED
TOTAL												(O)

NET CHANGE IN PAVED AREA FOR PROJECT : (N) _____ ACRES

NET AREA APPLIED TO SWM QUALITY BANK: (P) _____ ACRES IN _____

Bank form

Water Quality Banking Agreement (2003)

SHA

MDE

August 1, 2003

WATER QUALITY SUMMARY SHEET

The following are definitions of the terms used on the water quality summary sheet. All areas are based on the proposed drainage area boundaries.

(A) – Outfall Number: The number associated with the point of investigation or sub drainage area.

(B) – Pre-Development Impervious Area: The total impervious area that drains to point of investigation or sub drainage area under existing conditions. Note that the drainage area boundaries between pre-development and post-development conditions may differ. In order for the project check (see (R)) to work, the outer most drainage area boundary for the entire project must be the same for pre-development and post-development.

(C) – Post-Development Impervious Area: The total impervious area (new and existing) that drains to the point of investigation or sub drainage area under proposed conditions.

(D) – New Development: The newly added impervious area that is being constructed over existing pervious area within the point of investigation or sub drainage area.

(E) – Re-Constructed Impervious Area: The disturbed existing impervious area as noted here.

Include - existing impervious area that is being reconstructed for functional changes in the same location, such as:

- geometric improvements
- shoulder to travel lane
- sidewalk to travel lane
- driveway to travel lane
- monolithic concrete median to travel lane
- traffic bearing full depth shoulder to travel lane
- (and others that will be listed in the near future)

Exclude - Maintenance activities such as:

- resurfacing
- grinding/milling
- overlay
- full-depth patching
- in-kind replacement of sidewalk
- utility trench patching/resurfacing
- bridge deck replacement (in-kind replacement)
- (and others that will be listed in the near future)

(F) – Existing Impervious Area Removed: The existing impervious area that is being removed and replaced with pervious (grassed) area as part of the project. Note: This does not include any impervious area being removed exclusively as compensation for water quality management and reported in column L.

(G) – Loss of Water Quality: The total existing impervious area that is losing water quality benefits due to the removal of an existing BMP or the conversion of highway from open to closed section.

(H) – Area Requiring Treatment: The amount of impervious area requiring WQv treatment. Equals 100% of the net new development plus 20% of the redevelopment plus 100% of lost water quality.

$$(H) = [(D - F) + 0.2\,(E + F) + (G)]$$

(I) – Impervious Area Treated by Grass Channel or Non-Structural Credit: The total impervious area that will be treated by the proposed grass channels.

(J) – Impervious Area Treated by Structural BMPs: The total impervious area treated by structural Best Management Practices. Include both existing and proposed structures. Do not include impervious area draining to grass channel or other non-structural BMPs.

(K) – BMP Number: The BMP numbers that are assigned by the SHA, Highway Hydraulics Division (HHD). Please contact SHA-HHD Project Engineer to get BMP numbers for the existing and proposed water quality facilities.

(L) – Pavement Removal for Water Quality: The existing impervious area that has been removed and replaced with pervious (grassed) area strictly for water quality purposes. This area (L) is unrelated to column F. (Column F and column L are mutually exclusive.)
Note: Entries to this column must have special approval from SHA and MDE.

(M) – Unadjusted Water Quality Deficit/Credit: A negative number represents a deficit and means that amount of treatment provided is less than the amount required. A positive number represents a credit and means that the amount of treatment provided exceeds the amount required.

$$(M) = [(I) + (J) + (L) - (H)]$$

(N) – Adjustment for Water Quality Pavement Removal: (N) is calculated automatically by the spreadsheet and will be a negative number or 0. For most projects (N) will be zero. The only time (N) will not be zero is when (L) >0 and (D-0.8F) > 0 and a portion of (L) is being applied as treatment for (D). This is to say that at least a portion of the water quality pavement removal (L) is being applied towards a portion of new development (D).

For the most part a 1:1 trade-off is acceptable between WQ required and WQ provided. However, MDE is requiring a 1.2:1 trade-off between water quality pavement removal (L) and net new development (D-0.8F). (See supporting documentation for detailed explanation.) The adjustment (N) is necessary because the spreadsheet calculates everything as a 1:1 trade-off. It was not apparent how the spreadsheet could have otherwise been set up so the adjustment (N) was implemented as a correction factor. In addition, the adjustment implements an order of preference that minimizes the amount of area to which the 1.2 tradeoff factor is applied. Net new development (D-0.8F) will be managed first by grass channel/non-structural credits (I) then by structural BMPs (J) and then by water quality pavement removal (L). To complicate the matter even further there is also an order of preference between new development and redevelopment. For (I) and (J) new development will be managed first then redevelopment, and for (L) redevelopment will be managed first then new development. The adjustment is not easy to follow, but it has been reviewed and checked by both MDE and SHA and example computations demonstrating how and why (N) functions have been developed. Remember that for most projects the adjustment will not be necessary and (N) will be zero.

(O) – Excess Grass Channel Credit: The excess impervious area treated by a grass channel or other non-structural BMP. If the amount of impervious area treated by a grass channel or other non-structural BMP exceeds the amount of treatment required, the excess credit cannot be applied to the water quality bank. (O) will be a positive number or zero.

If (I) > (H), then (O) = [(I) – (H)]
If (I) ≤ (H), then (O) = 0

(P) – 20% Surcharge for Debit: A 20% surcharge is applied by MDE when debiting the Bank as compensation for providing water quality treatment elsewhere in the watershed.

If [(M) + (N)] < 0, then (P) = [0.2(M+N)]
If [(M) + (N)] ≥ 0, then (P) = "N/A"

(Q) – Water Quality Debit/Credit: This is the actual amount that is debited or credited to the bank. A negative number indicates a debit, and a positive number indicates a credit.

If [(M) + (N)] < 0, then Q = [(M) + (N) + (P)] as a debit
If [(M) + (N)] > 0, then Q = [(M) + (N) - (O)] as a credit

(R) – NOTES:

For reviewer/designer quality checks, compute condition of (R)

(R) = Σ(C) – Σ (B) – Σ (D) + Σ (F) + Σ (L) = 0

Implies no change in outer boundary of drainage area for the project

(i.e. Σ(C) – Σ (B) =Σ (D) - Σ (F) - Σ (L))

If R ≠ 0, recheck your computations.

RECEIVED

JUN

Nonpoint Source Permits Program

Directions for Filling Out

Water Quality Summary Sheets

1. For each drainage area or point of investigation (A) determine:

   (B) The added impervious area as a result of this project.

   (C) The type of water quality treatment, if any, used.

   (D) The efficiency of the water quality treatment:

   Infiltration - 1.00

   Retention - 0.70

   Extended Detention - 0.40

   (E) On-site pavement treated, which is defined as pavement within SHA right-of-way. (It does not have to be within the limits of the project).

   (G) Off-site pavement treated, which consists of roadways and parking lots outside of SHA right-of-way.

   [If the Lotus spreadsheet is used, all remaining values on the sheet will automatically be computed for you.]

2. Compute the net on-site pavement treated as follows:

   If (E)-(B) >0, (F) = (E)-(B)

   If (E)-(B) $\leq$0, (F) = 0

3. Compute the net off-site pavement treated as follows:

If $(E)-(B)+(G)>0$, $(H) = (E)-(B)+(G)-(F)$

If $(E)-(B)+(G)\leq 0$, $(H) = 0$

4. Compute the net treated (total) as follows:

If $(E)-(B)+(G)\leq 0$, $(I) = (E)-(B)+(G)$

If $(E)-(B)+(G)>0$, $(I) = [(F)+0.5\ (H)](D)$

5. Sum up column (I) to obtain the net area treated for the entire project.

6. Obtain the net area applied to the bank as follows:

- If the sum of column (I) is less than or equal to zero, use the sum of column (I). This represents the total bank debit for the project.

- If the sum of column (I) is greater than zero, subtract out all of the positive values in column (I) resulting from extended detention (extended detention is not bankable). Use this new value or zero, whichever is greater, as the net area applied to the bank in the form of a credit.

Note: A separate summary sheet will be required for each watershed (ex., 02-13-11) affected by the project.

The summary sheet only applies to drainage areas subject to 2.3 b) waivers. 2.3 a) waivers remain exempt from the banking process.

WATER QUALITY SUMMARY SHEET

ROUTE NUMBER : _____ WATERSHED NUMBER : _____

DESCRIPTION : _____

CONTRACT NUMBER: _____ MDE NUMBER : _____

AREA	ADDED IMPERVIOUS (ACRES)	TREATMENT TYPE	EFF	ON-SITE PAVEMENT TREATED	NET ON-SITE PAVEMENT TREATED	OFF-SITE PAVEMENT TREATED	NET OFF-SITE PAVEMENT TREATED	NET TREATED
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)
TOTAL								

NET AREA APPLIED TO SWM QUALITY BANK: _____ ACRES IN _____

Water Quality Banking Agreement (2002)

DRAFT

WATER QUALITY SUMMARY SHEET

ROUTE NUMBER:
DESCRIPTION:
CONTRACT:
MDE NUMBER:

WATERSHED NUMBER: _____
DATE:

COLUMN D:
REPORT NEWLY ADDED IMPERVIOUS AREA THAT DRAINS TO POI OR SUB DRAINAGE AREA.

COLUMN E:
REPORT THE DISTURBED EXISTING IMPERVIOUS AREA THAT IS RECONSTRUCTED IN THE SAME LOCATION.

COLUMN F:
REPORT THE EXISTING IMPERVIOUS AREA THAT HAS BEEN REMOVED AND REPLACED WITH GRASS AREA.

COLUMN H:
REPORT (H) = [(D) + 0.2(E) +(G) - (F)]

A	B	C	D	E	F	G	H	I	J	K	L
OUTFALL NUMBER	EXISTING IMPERVIOUS AREA (ACRES)	FINAL IMPERVIOUS AREA (ACRES)	NEW DEVELOPMENT (ACRES)	RE-DEVELOPMENT (ACRES)	REDUCTION IN IMPERVIOUS AREA (ACRES)	LOSS OF EXISTING WATER QUALITY (ACRES)	NET AREA TO BE TREATED { (D)+(0.2 * E)-(F)+(G) } (ACRES)	TREATED IMPERVIOUS AREA BY GRASS CHANNEL CREDIT (ACRES)	TREATED IMPERVIOUS AREA BY OTHER BMP'S (ACRES)	BMP NUMBER	WATER QUALITY DEFICIT/ CREDIT (ACRES) (I+J)-(H)
TOTAL											

COLUMN G:
REPORT THE TOTAL EXISTING IMPERVIOUS AREA THAT HAS LOST WATER QUALITY BENEFITS DUE TO THE REMOVAL OF EXISTING BMP OR CONVERSION OF HIGHWAY FROM OPEN TO CLOSED SECTION .

COLUMN A:
REPORT THE NUMBER ASSOCIATED WITH THE POI OR SUB DRAINAGE AREA.

COLUMN B:
REPORT EXISTING IMPERVIOUS AREA THAT DRAINS TO POI OR SUB DRAINAGE AREA.

COLUMN C:
REPORT TOTAL IMPERVIOUS AREA (NEW DEVELOPMENT AND EXISTING) THAT DRAINS TO POI OR SUB DRAINAGE AREA IN THE PROPOSED CONDITION.

COLUMN I:
REPORT THE TOTAL IMPERVIOUS AREA TREATED BY THE PROPOSED GRASS CHANNELS.

COLUMN J:
REPORT TOTAL IMPERVIOUS AREA THAT DRAINS TO VARIOUS BMP EXCEPT GRASS CHANNEL.

COLUMN K:
REPORT BMP NUMBERS THAT WERE ASSIGNED BY SHA/HHD. PLEASE CONTACT SHA/HHD PROJECT ENGINEER TO GET BMP NUMBERS FOR THE EXISTING AND PROPOSED WATER QUALITY FACILITIES.

COLUMN L:
REPORT
(L) = [(I) + (J)] - (H)

ROW M:
REPORT ANY EXCESS GRASS CHANNEL CREDIT.
IF THE SUM OF (I) > SUM OF (H), THEN [SUM OF (I) - SUM OF (H)].
IF THE SUM OF (I) < SUM OF (H), THEN (M) = 0.0

ROW N:
IF THE SUM OF (L) < 0, THEN (N) = 0.2(SUM OF (L)
IF THE SUM OF (L) > 0 OR = 0 THEN (N) = "N/A".

(M) EXCESS GRASS CHANNEL CREDIT _____ ACRES
(N) 20% SURCHARGE FOR DEBIT _____ ACRES
(O) NET WATER QUALITY DEBIT/CREDIT _____ ACRES IN THE _____ WATERSHED

☐ Approved
☐ Pending
☐ Projected

ROW O:
IF THE SUM OF (L) < 0, REPORT [SUM OF (L) +(N)] AS A DEBIT.
IF THE SUM OF (L) > 0, REPORT (SUM OF (L) - (M) AS A CREDIT.

NOTES:

SHA

_____
SHA Highway Hydraulics Division, Chief

MDE

_____
MDE Plan Review Division, Chief

_____
Reviewer's Initial

cc: Sonal Sanghavi,SHA HHD

July 29, 2002 - DRAFT

WATER QUALITY SUMMARY SHEET

The following are definitions of the terms used on the water quality summary sheet as shown in Figure __:

(A) – Outfall Number: The number associated with the point of investigation or sub drainage area.

(B) – Existing Impervious Area: The existing total impervious area that drains to point of investigation or sub drainage area.

(C) – Final Impervious Area: The proposed total impervious area (new and existing) that drains to point of investigation or sub drainage area.

(D) – New Development: The newly added impervious area that drains to point of investigation or sub drainage area.

(E) – Re-Development: The disturbed existing impervious area as noted here.

Include - existing impervious area that is reconstructed for functional changes at the same location, such as:

- geometric improvements
- shoulder to travel lane
- sidewalk to travel lane
- driveway to travel lane
- monolithic concrete median to travel lane
- traffic bearing full depth shoulder to travel lane
- (and others that will be listed in the near future)

Exclude - Maintenance activities such as:

- resurfacing
- grinding/milling
- overlay
- full-depth patching
- in-kind replacement of sidewalk
- utility trench patching/resurfacing
- bridge deck replacement (in-kind replacement)
- travel lane or shoulder to sidewalk
- travel lane to monolithic concrete median
- (and others that will be listed in the near future)

Note: Do not include impervious area that has been removed and replaced with grassed area

(F) – Reduction in Impervious Area: The existing impervious area that has been removed and replaced with grassed area.

(G) – Loss of Water Quality: The total existing impervious area that has lost water quality benefits due to the removal of existing BMP or conversion of highway from open to closed section.

(H) – Net Area to be Treated: $(H) = [(D) + 0.2\ (E) + (G) - (F)]$

(I) – Treated Impervious Area by Grass Channel Credit: The total impervious area that will be treated by the proposed grass channels.

(J) – Treated Impervious Area by other BMPs: The total impervious area treated by Stormwater Best Management Practices.

(K) – BMP Number: The BMP numbers that are assigned by the SHA, Highway Hydraulics Division (HHD). Please contact SHA-HHD Project Engineer to get BMP numbers for the existing and proposed water quality facilities.

(L) – Water Quality Deficit/Credit: $(L) = [(I) + (J)] - (H)$

(M) – Excess Grass Channel Credit: The excess impervious area treated by grass channel that is not applied to water quality bank credit.

If (I) > (H), then (M) = [(I) – (H)]
If (I) < (H), then (M) = 0

(N) – 20% Surcharge for Debit:

If (L) < 0, then (N) = [0.2(L)]
If (L) > 0 or = 0, then (N) = "N/A"

(O) – Net Water Quality Debit/Credit:

If (L) < 0, then (O) = [(L) + (N)]
If (L) > 0, or = 0, then (O) = [(L) – (M)]

(P) – NOTES:

For reviewer/designer quality checks, compute condition of (P)

(P) = (C) – (B) – (D) + (G) = 0	Implies no change in outer boundary of drainage area for the project
(P) = (C) – (B) – (D) + (G) < 0	Implies shift of impervious area out of project under proposed conditions
(P) = (C) – (B) – (D) + (G) > 0	Implies shift of impervious area into project under proposed conditions

State the final check as (P) = or > or < 0

	(1)	(2)	(3)	(3a)	(3b)	(3c)	(4)	(5)	(6)	(7)
POI NUMBER	disturbed area to POI	drainage area to POI	existing imp area to POI	existing imp area being removed	exist imp area being replaced or altered	exist imp area remaining as is	total proposed impervious area	NEW IMP AREA	RE-DEVELOPED AREA	AREA REQUIRING TREATMENT
	(for E&SC purposes)		3=3a+3b+3c					(5)=(4)-(3)	(6)=(3a)+(3b	(7)=(5)+0.20(6)

Note that consultants tend to quantify "newly created impervious area" and/or "net increase in impervious area". Sometimes they're the same; sometimes they equal (5) new impervious area, but usually they're not pertinent to MDE's determination of Area Requiring Treatment.

	(1)	(2)	(3)	(3a)	(3b)	(3c)	(4)	(5)	(6)	(7)	(8)
POI NUMBER	disturbed area to POI (for E&SC purposes)	drainage area to POI	pre-dev'l imp area to POI	existing imp area being removed	exist imp area being replaced or altered	exist imp area remaining as is	post-dev'l impervious area	DEVIL NEW ~~BMP~~ AREA	RE-DEVELOPED AREA	AREA REQUIRING WQv TREATMENT	AREA REQUIRING Rev TREATMENT
			=(3a)+(3b)+(3c)					=(4)-(3)	=(3a)+(3b)	=(5)+0.20x(6)	=(5)

Note that consultants tend to quantify "newly created impervious area" and/or "net increase in impervious area". Sometimes they're the same; sometimes they equal (5) new impervious area, but usually they're not pertinent to MDE's determination of Area Requiring Treatment.

Half Acre Rule (2002)

Staff Meeting- 7/31/02

Attendees- Not recorded

Regarding drawdown requirements for sand filter pretreatment forebays, the Stormwater Design Manual (SDM) does require the forebays to drawdown in 36 hours. This restriction was imposed to limit mosquito breeding habitat. While desirable, this requirement is not mandatory.

A question was raised about the relationship between concentrated inflow points to bioretention facilities and the overflow inlets they contain. Some counties have been requesting that these drainage points be separated as much as possible. After discussion it was decided that this policy would encourage displacement of the 1st flush from the facility, and that positioning inflow and outflow points as close together as possible, to encourage "short-circuiting", would limit this effect.

A question concerning landscaping plans for Stormwater Ponds was raised. The SDM requires such a plan, but it need only assure stabilization against erosion, therefore grass would be acceptable. This is different than the SDM requirements for Stormwater Wetlands, which are much more specific about use of wetland species in the landscaping plan.

An applicant has requested a decision about the use of inlets with depressed inverts as compensatory pretreatment where roadway widening has reduced vegetative filtering of runoff. This is not an acceptable substitute, as resuspension of accumulated sediments would be likely. The use of Gravel Trench Spreaders for the same purpose was also rejected, even in cases where the storage volume in the trenches was .1 inch over the (trench) drainage area.

Additional discussion about the Point of Investigation (PI) for 3.3(B)(3) waivers occurred. The current interpretation is to focus on project runoff, not some point downstream. The project may be broken up into different PI's depending upon proposed drainage patterns. Redevelopment complicates things somewhat, since redevelopment does not require quantitative SWM at all, but projects containing new development and redevelopment will need to separate the two in order to qualify for a 3.3(B)(3) waiver for the new development portion. We adopted a "new ½ acre of imperviousness" variance category to address this redevelopment issue, based on the assumption that ½ acre of pavement will produce about 2 cfs of runoff using 1 year storm precipitation and a .1 hour time of concentration. We can request a downstream investigation where 1 project has a lot of 2 cfs waivers (or ½ acre variances) and their cumulative effect is a concern. It is likely that this policy will ultimately require a tracking system so that the number of waivers/variances an applicant has received in a watershed is easily available to reviewers, allowing consideration of this before granting another. This will become a banking issue, eventually.

When changing gravel road to paved road, this is considered redevelopment for the purposes of qualitative SWM, so the 20% rule would apply. As redevelopment does not require quantitative SWM, only qualitative issues would be pertinent. However, since the RCN of pavement exceeds that of gravel, the Department may require quantitative SWM if the increase in discharge is large enough to merit concern, as discussed in Section 3.5, E, of the Guidelines.

Some confusion was allayed about the applicability of flowsplitters to the various BMP's discussed in the SDM. The flowsplitter requirement is mandatory only for filtering practices, though desirable, and encouraged, for others. This requirement may be met by locating inflow/outflow points close together, to encourage short-circuiting, and minimizing the displacement of the first flush by subsequent runoff.

Revised Water Quality Sheets, provided by Navrang, were handed out at the meeting for review and comment, which should be provided by 8/7/02.

We have been advised to begin looking for a revised standard maintenance note on SHA Title sheets. It should contain phrasing like "SHA's Maintenance Program", or something similar.

Storm Filter Memo (2004)

MDE

MARYLAND DEPARTMENT OF THE ENVIRONMENT
1800 Washington Boulevard • Baltimore MD 21230
410-537-3000 • 1-800-633-6101

Robert L. Ehrlich, Jr., Governor
Michael S. Steele, Lt. Governor

Kendl P. Philbrick, Secretary
Jonas A. Jacobson, Deputy Secretary

October 12, 2004

Ms. Karuna Pujara, Chief
State Highway Administration
Highway Hydraulics Division
707 North Calvert Street
Baltimore, MD 21203-0717

Re: Stormfilter

Dear Ms. Pujara:

In response to your October 1, 2004 letter requesting clarification of MDE's position regarding the use of the Stormfilter System, please be advised that the Water Management Administration (WMA) has approved several State and federal projects utilizing the Stormfilter System as a stand-alone water quality practice. To date, only the use of the "Extra Fine Compost" filter media with a 7.5 gpm flow restricting orifice is approvable for meeting Maryland's pollutant removal rates in accordance with the 2000 Maryland Stormwater Design Manual.

The Stormfilter System, complying with WMA's design criteria, may be incorporated in MSHA stormwater management plans as a stand-alone practice for satisfying water quality requirements.

If you have any questions please do not hesitate to call me at (410) 537-3563.

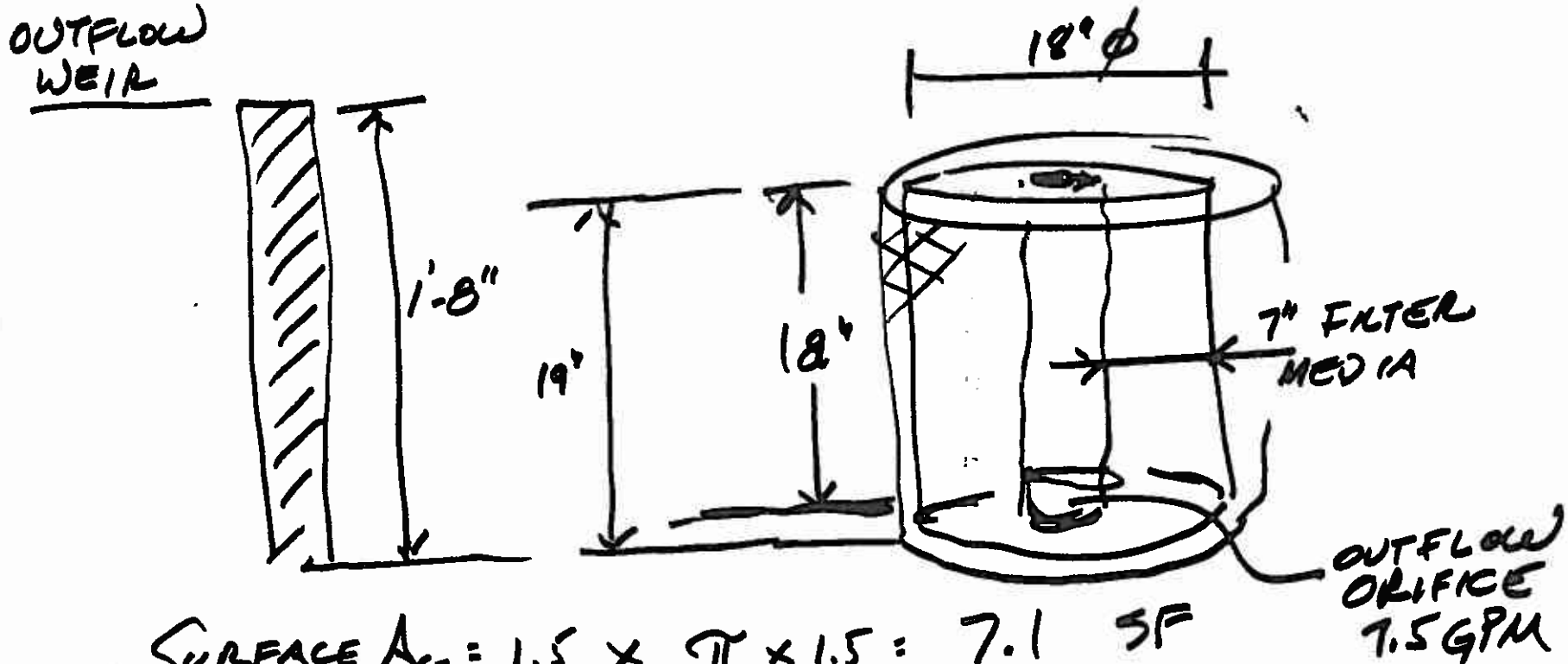
Sincerely,

James K. Tracy, P.E., Chief
Sediment and Stormwater Plan Review Division
Water Management Administration

JKT/

cc: Mr. Ken Pensyl, MDE
Mr. Jim Fritz, MDE
Mr. Brian Clevenger, MDE

SINGLE CARTRIDGE



SURFACE $A_{SF} = 1.5 \times \pi \times 1.5 = 7.1$ SF

FILTER DEPTH = 0.58"

AVERAGE HEAD = $H/2 = (20"-1")/2 = 0.79'$

$K = 8.7'/DAY$ FOR LEAF COMPOST

$$A_{SF} = \frac{(WQV)(d_f)}{(K)(h_f+d_f)(T_f)} = \frac{WQV \times 0.58}{8.7 \times 1.33 \times 1.67} = 0.03 WQV, \quad \#CANISTERS = \frac{0.03 WQV}{7.1} = 0.0042(WQV)$$

Clarification on Submerged Gravel Wetlands (2014)

Clarification on submerged gravel wetland (SGW) design for State and federal projects

Configuration and Function:[1,2,3]

The SGW treats stormwater runoff primarily through filtration but also through sedimentation, physical and chemical sorption, microbially mediated transformation, uptake, and attenuation. Sedimentation occurs in the pretreatment forebay as well as above the wetland surface. Filtration, sorption, and transformation occur as the stormwater passes through the gravel substrate that hosts a microbe rich environment. While some uptake occurs from the wetland vegetation, most of the treatment is within the gravel substrate.

Pretreated runoff is stored on the surface of the wetland. Gravel chimneys or perforated/slotted risers deliver the inflow to the gravel below. The flow passes through the gravel substrate to subdrains on the downstream end. Although the SGW treats stormwater using a "flow through" filtration process, the gravel chamber and soil layer must remain wet between storm events to sustain the microbes as well as the wetland plants. In this regard, the flow configuration also resembles a "plug flow" system.

As the head increases above the surface, the old water retained in the media from the previous storm begins to flow out. The water on the surface drains into the gravel layer below and filters through the media prior to leaving the system. After the surface storage has been drawn down, the water in the gravel substrate remains until it is displaced by runoff from a new storm. To manage channel protection volume (Cp_v), the outlet needs to be designed to slowly release the surface storage over 36 hours. The long residence time also enhances the pollutant removal process. Hydraulic control of the system occurs at the top of the chamber, by an orifice that is sized to discharge the volume over the prescribed 36 hours. The discharge rate needs to be small enough to prevent the volume from discharging too quickly, yet fast enough to empty the system for subsequent storms and to prevent the plants from being submerged too long. To maintain wetland conditions in the soil, the outlet invert is located four inches below the soil surface. Although hydraulic control is just below the wetland surface, the system is configured so that flow exiting the SGW must first traverse the underground gravel substrate.

The conversion and removal of nitrogen is dependent on two conditions: an aerobic sedimentation forebay followed by subsurface anaerobic treatment cells. Aerobic conditions exist in the forebay when it is designed and maintained as a dry area with temporary ponding conditions during storm events. The anaerobic condition in the treatment cells is created by maintaining the high water table within the system as well as the slow flow through the gravel layer. This saturated condition drives the dissolved oxygen level down and creates conditions in which nitrate conversion to nitrogen gas occurs.

DRAFT

Site Conditions:

- The SGW is best suited for areas where a high water table or poorly drained soils are present. However, in areas with excessively high groundwater such as Maryland's Eastern Shore, the design shall assure that groundwater is not siphoned off. The invert of the outlet must be at least 6 inches above the seasonally high groundwater elevation.
- There needs to be sufficient elevation drop to maintain positive drainage through the filter media.
- The hydrologic soil group (HSG) should be C or D. Alternatively, a high groundwater table, hard pan, liner, or other confining layer should be present to maintain submerged flow conditions. (Note that according to new guidance in the National Engineering Handbook 630, Chapter 7, any soil (even sand) with these confining conditions is considered to be HSG C or D.)
- If the drainage area is not large enough to maintain submerged flow conditions (based on Wetland Drawdown Assessment in Appendix D.3 and considering evapo-transpiraton losses as zero), a liner shall be provided. A liner is not necessary if the groundwater elevation is within a foot of the bottom of the SGW.
- To avoid groundwater contamination, a liner shall be used when treating hotspots that generate higher concentrations of hydrocarbons, trace metals, or toxicants than are found in typical stormwater runoff.

Design Criteria

- The SGW should be located offline unless the drainage area to the SGW is less than 20,000 s.f. A flow splitter should be provided to divert the ESD_v to the submerged gravel wetland (see Details No. 5 and No. 6, Appendix D.8. The design of the flow splitter shall be volume based. Discharges that exceed the ESD_v should be directed around the submerged gravel wetland and exit to a stable outfall at non-erosive velocities. The 10-year storm shall be conveyed in a safe, non-erosive manner, either around the SGW (preferred) or above the SGW.

- Effective pretreatment of runoff prior to entering the SGW is especially important because maintenance of a SGW basically involves complete reconstruction. If the drainage area to the SGW is less than 20,000 s.f., pretreatment is not required. For larger drainage areas, pretreatment needs be provided by a forebay or blind swale sized to capture 10% of ESD_v. Runoff may enter the forebay as either concentrated flow or sheet flow. For nitrogen removal, the forebay should be designed to be dry between storm events. Vegetated filters are not a desirable pretreatment option because the tendency is for the runoff to flow along, rather than across, the grass-pavement or grass-gravel interface, thereby causing the flow to concentrate at inevitable low points, compromising the intended sheet flow filtration.

- Stormwater from the forebay to the SGW needs to be uniformly distributed across the width of the SGW. For surface flow, a level edge or spreader for promoting sheetflow is needed between the forebay and the SGW. When flow from the forebay to the SGW is piped, a slotted or perforated pipe (4 to 6-inch) with a

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horizontal distribution system located at the base of the pea gravel layer is needed to promote flow distribution.

- The stormwater being treated gradually (over 36 hours) flows down into the gravel-filled chamber where it is either filtered through or remains until it is pushed up and out by the subsequent storm event. The discharge and control point from the SGW is through an outflow collection system with a small diameter orifice near the surface.

- A wetland soil mix should be used on the surface of the SGW. Even if a soil mix with a high infiltration rate is used, infiltration through the soil layer cannot be the principal path for the ESD_v to flow into the submerged gravel layer. A pipe chimney or rip-rap window must be provided to allow the ESD_v to flow into the submerged gravel layer. Some of the ESD_v may infiltrate through the soil layer, effectively "bypassing" the submerged gravel layer. This is not a concern since the stormwater that does this will be filtered by the soil media.

- The chimney or window into the submerged gravel layer should be a minimum of 15 feet, but no more than 50 feet, from the outlet pipes to maximize the flow path through the submerged gravel layer.

- The flow path through the SGW is referred to as the length. The width of the SGW is the dimension perpendicular to the length and is the distance over which the inflow is dispersed. The recommended length to width ratio (L:W) is between 1:1 to 1:2, thereby encouraging a “stubby” configuration. This is the opposite of what is favored with ponds, basins, and traps. The intent is to spread the flow out along the width of the SGW. This slows the flow, eliminates dead zones, and maximizes the treatment contact area. To ensure a uniform distribution and to prevent short-circuiting, the width should not exceed 100 feet. Studies show that most of the treatment occurs within the first 30% of the flow path where the concentration of microbes is greatest. The flow length along the gravel media should be at least 15 feet.

- Multiple treatment “cells” may be used for meeting the L:W ratio. The “cells” should not necessarily be separated by earth berms or other divides. Their purpose is to provide multiple entry points into the subsurface treatment chamber, not divide the treatment chamber into isolated sections which could be starved of water during the smaller rain events.

- Surface area requirements for stormwater wetlands in Chapter 3 do not apply to this practice because pollutant removal in the SGW primarily takes place within the rock media.

- Geotextile shall be provided along all vertical interfaces between different types of media and in-situ soils to prevent collapse of the layer with smaller particles into the voids of the layer with the larger particles. The use of geotextile is prohibited on horizontal layers except along the very bottom of the facility where it is optional.

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- Liners shall be constructed of 6 – 12 inches of clay or 30 mil polyethylene.

- An observation well consisting of an anchored, six-inch diameter perforated pipe is required. The top of the observation well should be at least six inches above grade.

- The SGW will meet recharge requirements unless a liner has been provided along the bottom.

Sizing Criteria:

- Pre-treatment shall be provided for 10% of the total ESD_v. Typically this is provided in an above ground forebay area.
- Temporary storage for 75% of ESD_v for the drainage area contributing to the wetland shall be provided above the surface of the planting soil and gravel bed.
- Wet storage shall be provided within the soil and gravel substrate. The gravel substrate shall be at least 2 feet thick but no thicker than 4 feet. The substrate should be provided under the full area of the wetland. If for some justifiable reason, the area of the substrate is smaller than the surface area, the substrate shall be sized to store a minimum of 40% of the ESDv.
- The soil layer shall be a minimum of 8 inches thick and shall not be included in either the surface storage or subsurface storage volume computations.
- Storage calculations shall account for the porosity (40%) of the media.
- The recommended length to width ratio (L:W) is between 1:1 to 1:2.
- The control point for the outlet shall be set at 4 inches below the surface of the facility. This keeps the soil saturated enough to sustain the plants but removes the water from the immediate surface where mosquitoes breed. The outlet control shall be at least 6 inches above the seasonally high groundwater elevation to avoid drawing down local groundwater levels. To manage channel protection volume (Cp_v), the orifice outlet needs to be sized to discharge the surface storage volume over 36 hours.
- The maximum allowable ponding depth for the 1 year storm (Cp_v) is 2 feet.
- A P_E value based on the ESD_v captured and treated shall be applied to the contributing drainage area.
- Side slopes shall be 2:1 or flatter.
- For SGWs with drainage areas larger than 20,000 s.f., a minimum of 6 inches of freeboard shall be provided above the design storm.

Landscape Plan:

- A landscape plan showing the location, number, and plant species shall be provided.
- Use of native wetland plant stock obtained from a local aquatic plant nursery is recommended for establishing vegetation. Design variations may use wetland mulch or topsoil on top of the gravel, which may allow for successful seed

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germination. However, use of the rock media for establishing wetland conditions requires specific planting stock. Frequent inspection and maintenance will be necessary until wetland plantings are well established.

- A minimum of three different types of wetland species shall be provided. (Program Review's future guidance can be reference after it is developed.)
- Replacement plantings may be necessary.

[1] University of New Hampshire Stormwater Center, "Subsurface Gravel Wetland Design Specifications," June 2009.

[2] Virginia DCR Stormwater Design Specification No. 13 Constructed Wetland, Version 1.9, March 1, 2011.

[3] New Jersey Stormwater Best Management Practices Manual, Chapter 9.2 Standard for Constructed Stormwater Wetlands, 2011.

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Filterra Bioretention System Memo (2013)

bioretention practice listed in Chapter 5 of the Manual (see p. 5.98). MDE sees no reason to alter this condition.

The analyses, computations, and third-party studies submitted in 2006 and with your recent letter support the high *k* factor used in Filterra®'s design. This *k* factor allows Filterra® to be considerably smaller than other filtering practices and may warrant a reduction in the volume of runoff that must be stored prior to filtering. However, the stormwater modeling submitted with your letter does not support a complete waiver of Maryland's volumetric sizing criterion. Flow-based calculations require estimating parameters like the time of concentration to each practice to determine storage requirements. These parameters are subject to a greater degree of statistical uncertainty and result in designs that do not provide adequate treatment. More complex design parameters do not necessarily translate into improved performance. In contrast, sizing stormwater practices using a volume-based requirement, which is more accurate, is a simpler and more effective approach. Therefore, the Filterra® system must capture and treat a percentage of the WQ_v. However, considering the Filterra® media's higher *k* factor, MDE will reduce the percentage of runoff that must be stored prior to filtering from 75% to 25% of the design volume (e.g., WQ_v).

In new development designs, Re_v must be distributed across a project as much as practical to mimic natural conditions. Some variants of the Filterra® system (the FocalPoint® or boxless system) address the recharge requirement while others (e.g., the standard Filterra® system) do not. Variants that do not provide recharge may be used as part of a systems approach provided that recharge requirements are addressed by the system.

To protect stream channels from erosion, ESD and structural practices must be used to capture, store, and gradually release the Cp_v over an extended interval (e.g., 24 to 36 hours) as determined by the methods found in Appendix D.11 of the Manual. Practices that release runoff over shorter periods of time may not be used for addressing the Cp_v requirement. According to the submitted report and computations, the Filterra® system has an estimated drawdown time between 15 to 18 minutes (0.25 to 0.30 hours). This is significantly less than that required to address Cp_v requirements. Therefore, the Filterra® system does not meet the Cp_v requirements and may not be used as a stand-alone ESD practice. However, practices that do not meet Cp_v requirements may be used provided they are part of a system of practices that captures, stores, and slowly releases the required volume of runoff at rates meeting the channel protection flow criteria.

In summary, MDE approves the Filterra® system as a filtering device that can be used for any redevelopment, retrofitting, or infill application provided it is accepted locally. Additionally, for new development applications, the Filterra® system is approved as an ESD practice for providing water quality treatment and, where the appropriate variant is used, groundwater recharge. This approval is conditioned on limiting the drainage area to 20,000 sq. ft. to a

standard 7 ft x 13 ft. unit; sizing the system to capture and store 25% of the design volume (e.g., WQ_v); and meeting applicable filtering design criteria in the Manual for feasibility, conveyance, and maintenance. Because it does not address Cp_v, the Filterra® may not be used as a stand-alone ESD practice. However, it may be used as part of a system of practices that, as a whole, addresses all of the ESD requirements.

We will remain open to entertaining any future design changes if sufficiently justified. For now, if you have any questions or would like to discuss this further, please call me at (410) 537-3554 or contact Mr. Stewart Comstock at (410) 537-3550 or scomstock@mde.state.md.us.

Sincerely,

Brian S. Clevenger
Program Manager
Sediment, Stormwater & Dam Safety Program

MARYLAND DEPARTMENT OF THE ENVIRONMENT
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410-537-3000 • 1-800-633-6101

Robert L. Ehrlich, Jr., Governor
Michael S. Steele, Lt. Governor

Kendl P. Philbrick, Secretary
Jonas A. Jacobson, Deputy Secretary

June 9, 2006

Mr. Larry S. Coffman
Filterra® Division
Americast, Inc.
11352 Virginia Precast Road
Ashland, VA 23005

Dear Mr. Coffman:

This is in response to your request to approve Americast's Filterra® structure as a stand alone best management practice (BMP) for stormwater quality control. Your February 2, 2006 submittal included a report entitled "State of Maryland, Justification For Stand Alone BMP" dated January 30, 2006 prepared by GeoSyntec Consultants. Provided in this technical support document were field monitoring data from sampled influent and effluent, laboratory results and pollutant removal efficiency analyses, and sizing criteria in conjunction with the Maryland Department of the Environment's (MDE) design requirements. MDE believes that this material bolstering Americast's request is sufficient to conditionally approve Filterra® as a stand alone water quality treatment BMP. Relevant points of discussion follow.

MDE views this to be the natural progression of a process that began nearly four years ago. In an August 5, 2002 letter to Mr. Terry Siviter, MDE determined that Filterra® was classified as a filtering practice and was approved for certain restricted applications that include redevelopment, retrofitting, and infill. It was suggested that should Americast wish to have Filterra® considered as a stand alone water quality BMP, in-field storm event monitoring should be conducted to demonstrate that Maryland's 80% total suspended solids (TSS) and 40% total phosphorus removal rates can be met. MDE believes that this burden of proof has been met provided certain design conditions are applied.

These conditions are a maximum drainage area to each device and meeting the volume holding requirements found in the "2000 Maryland Stormwater Design Manual" (Design Manual). Americast proposes a maximum drainage area of one quarter of an acre to each standard 6' x 8' Filterra® unit. This filter bed size is significantly less than would normally be produced primarily due to this practice's high permeability factor (k).

The storm event monitoring data and pollutant removal efficiency analyses support the high k factor that allows Filterra® units to be considerably smaller than typical filtering practices sized according to Design Manual specifications. However, MDE feels it imperative to hold fast to the remaining Design Manual sizing criteria of pretreating 25% of the water quality volume

(WQ_v) and holding 75% of the WQ_v in the entire system. You have proposed that future maintenance contracts be allowed to supplant some of these holding capacities. Based on what we have experienced over a lengthy period of time regarding BMP maintenance, MDE cannot approve a stormwater device's current design on future activities that may not be sustained. We can revisit this proposal if additional monitoring data are submitted that demonstrates efficiency over a considerable length of time. This will allay concerns that remain over long-term maintenance with this and all structural BMPs.

In summary, MDE approves the Americast Filterra® as a filtering device that can be used for any redevelopment, retrofitting, or infill application. Local stormwater management agencies should be consulted for individual project acceptability. Additionally, the Filterra® filter is approved as a stand alone water quality BMP. This approval is conditioned on limiting the drainage area proportionally to the equivalent of one quarter of an acre to a standard 6' x 8' structure; placing 25% of the WQ_v in pretreatment; sizing the entire system to hold 75% of the WQ_v; and meeting the applicable filtering design criteria in the Design Manual for feasibility, conveyance, and maintenance.

We will remain open to entertaining any design changes in the future if sufficient justification is provided. For now, however, if you have any questions or would like to discuss the above further please call me at 410-537-3554 or email me at bclevenger@mde.state.md.us.

Sincerely,

Brian S. Clevenger
Water Management Administration

cc: Mr. Terry Siviter, Americast, Inc.
Ken Pensyl, WMA
County Stormwater Management Contacts
Municipal Stormwater Management Contacts

Attachment B

Example Calculations

Section 1: RS Calculations

Filters

MARYLAND DEPARTMENT OF TRANSPORTATION

STATE HIGHWAY ADMINISTRATION

Volume Design Computations
Surface Storage Comp
Bioretention/Sand Filter BMP No. 160818
April 26, 2015
Surface Storage

Bioretention Storage

Elevation [ft.]	Area [ft^2]	Area [acre]	Change in Elevation [ft]	Average Area [acre]	Incremental Volume [acre-ft]	Cumulative Volume [acre-ft]	Cumulative Volume [ft^3]
127.00	3156	0.072451791					
128.00	4812.66	0.110483471	1.0	0.091468	0.091467631	0.091467631	3984.33

Wet Volume 3984.33 cf

Media Storage

Af = 3156 sf
H = 4.765 ft
Vol = 6015.34 cf 40% voids

ESDv volume

ESDv= 13332.89 cf

Volume Design Computations
Surface Storage Comp
Mirco Bioretention BMP No. 020603
August 29, 2016
Wet WQv Storage

Forebay

Elevation [ft.]	Area [ft^2]	Area [acre]	Change in Elevation [ft]	Average Area [acre]	Incremental Volume [acre-ft]	Cumulative Volume [acre-ft]	Cumulative Volume [ft^3]
20.00	104	0.002387511					
21.00	236	0.005417815	1.0	0.003903	0.003902663	0.003902663	170
22.00	404	0.009274564	1.0	0.007346	0.007346189	0.011248852	490
22.50	500	0.011478421	0.5	0.010376	0.005188246	0.016437098	716

Micro Bioretention Pool

Elevation [ft.]	Area [ft^2]	Area [acre]	Change in Elevation [ft]	Average Area [acre]	Incremental Volume [acre-ft]	Cumulative Volume [acre-ft]	Cumulative Volume [ft^3]
20.90	1200	0.027548209					
21.90	1620	0.037190083	1.0	0.032369	0.032369146	0.032369146	1410

Media Storage

Area Af = 1200 sf
Depth = 2.59 ft
Volume = 3108 cf

Total WQv volume

WQv= 6978.67 cf

Volume Design Computations
Surface Storage Comp
Surface Sand Filter BMP No. 150625
June 15, 2015

Surface Storage- Sand Filter

Bottom Perimeter (ft)	L =	166	
Facility Bottom Area (sf)	Af =	966	
Side Slope z:1	z =	2	
Height of Weir(ft)	D =	1	
Surface volume		1132	cf

Media Storage

Af	966	sf
H	5	f
Volume	1932	cf

ESDv volume

WQv= 4085.33

Attachment B

Example Calculations

Section 1: RS Calculations

Infiltration

MARYLAND DEPARTMENT OF TRANSPORTATION

STATE HIGHWAY ADMINISTRATION

Volume Design Computations
Surface Storage Comp
Infiltration Basin BMP No. 160128
May 4, 2015

Surface Storage

Length (ft)	L =	150	
Width (ft)	W =	13.75	average width
Depth (ft)	D=	3.80	
Slope 1	s1=	2.00	Slope along width
Slope 2	s2=	3.00	Slope along length
Storage Vol. (cf)	V =	15391.06	
2 Hour infiltration (cf)	V =	178.75	
Total Volume (cf)	V =	15569.81	

WQv volume

WQv= 15569.81

Volume Design Computations
Surface Storage Comp
Infiltration Trench BMP No. 160179
March 31, 2016

Surface Storage

Lenght (ft)	L =	138
Width (ft)	W =	12
Depth (ft)	D=	8
Void Vol. (cf)	V =	5299.2
2 hours infiltration	V =	143.52
Total Volume	V =	5442.72

WQv volume

WQv= 5442.72

Attachment B

Example Calculations

Section 1: RS Calculations

Swales

MARYLAND DEPARTMENT OF TRANSPORTATION™

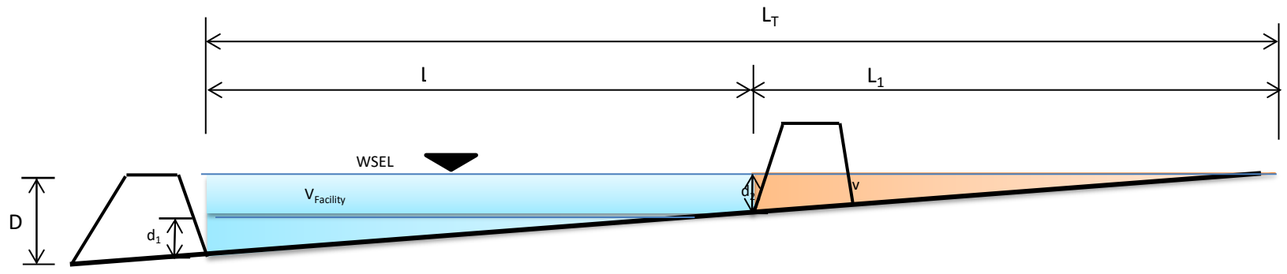
STATE HIGHWAY ADMINISTRATION

Volume Design Computations
Surface Storage Comp
Dry Swale BMP No. 130190
June 7, 2016

Cell 1

Facility Length (ft)	L =	75.00
Facility Bottom Width (ft)	B =	8.0
Lt. Side Slope z:1	z =	2
Rt. Side Slope z:1	z =	2
Slope (ft/ft)	s =	0.04
Height of Check Dam (ft)	D =	1.5

Note, if Pool Length is less than facility then spreadsheet will L_T=Pool Length



Solve for d_1

$d_1 = s * L$

$d_1 =$ 1.5 feet

Solve for d_2

$d_2 = D - d_1$

$d_2 =$ 0 feet

Solve for L_1

$L_1 = d_2 / s$

$L_1 =$ 0 feet

Solve for Pool Length

$L_T = D / s$

$L_T =$ 37.50 feet

Solve for v_1

$v_1 = (d_2^2 L_1(z+z)+3Bd_2L_1)/6$

$v_1 =$ 0.0 cf

Solve for V_{Total}

$V_{Total} = (D^2(L+L_1)(z+z)+3BD(L+L_1))/6$

$V_{Total} =$ 281.3 cf

Solve for $V_{Facility}$

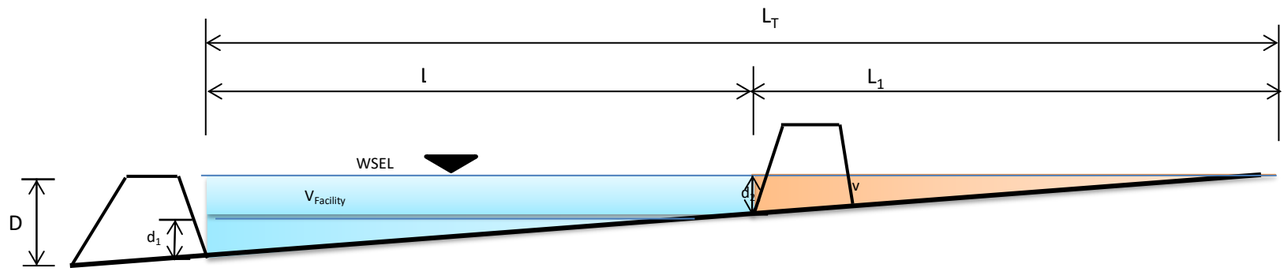
$V_{Facility} = V_{Total} - v_1$

$V_{Facility} =$ 281.3 cf

Cell 2

Facility Length (ft)	L =	70.00
Facility Bottom Width (ft)	B =	8.0
Lt. Side Slope z:1	z =	3
Rt. Side Slope z:1	z =	3
Slope (ft/ft)	s =	0.005
Height of Check Dam (ft)	D =	1.5

Note, if Pool Length is less than facility then spreadsheet will L_T=Pool Length



Solve for d_1

$d_1 = s * L$

$d_1 =$ 0.35 feet

Solve for d_2

$d_2 = D - d_1$

$d_2 =$ 1.15 feet

Solve for L_1

$L_1 = d_2 / s$

$L_1 =$ 230 feet

Solve for Pool Length

$L_T = D / s$

$L_T =$ 300.00 feet

Solve for v_1

$v_1 = (d_2^2 L_1(z+z)+3Bd_2L_1)/6$

$v_1 =$ 1362.2 cf

Solve for V_{Total}

$V_{Total} = (D^2(L+L_1)(z+z)+3BD(L+L_1))/6$

$V_{Total} =$ 2475.0 cf

Solve for $V_{Facility}$

$V_{Facility} = V_{Total} - v_1$

$V_{Facility} =$ 1112.8 cf

ESDv Volume

ESDv= 3327.4 void vol+surf vol

Volume Design Computations
Surface Storage Comp
Grass Swale BMP No. 160256
May 17, 2016

ESDv Volume

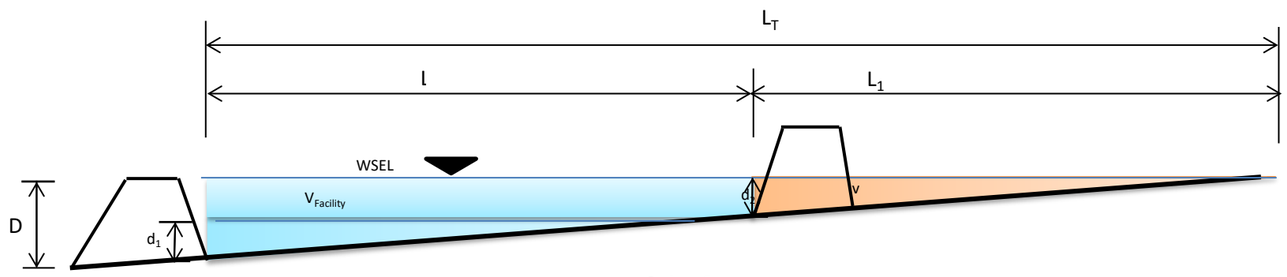
Pe= 1.00 inch

Volume Design Computations
Surface Storage Comp
Wet Swale BMP No. 160187
April 24, 2016

Forebay Volume = **640** cf From Report

Cell 1 & 2 Dimmensions from report and plans

Facility Length (ft)	L =	200.00	Note, if Pool Length is less than facility then spreadsheet will L_T=Pool Length
Facility Bottom Width (ft)	B =	8.0	
Lt. Side Slope z:1	z =	4	
Rt. Side Slope z:1	z =	4	
Slope (ft/ft)	s =	0.005	
Height of Check Dam (ft)	D =	1.5	



Solve for d_1

$d_1 = s * L$

d_1 = 1 feet

Solve for d_2

$d_2 = D - d_1$

d_2 = 0.5 feet

Solve for L_1

$L_1 = d_2 / s$

L_1 = 100 feet

Solve for Pool Length

$L_T = D / s$

L_T = 300.00 feet

Solve for v_1

$v_1 = (d_2^2 L_1(z+z)+3Bd_2L_1)/6$

v_1 = 233.3 cf

Solve for V_{Total}

$V_{Total} = (D^2(L+L_1)(z+z)+3BD(L+L_1))/6$

V_{Total} = 2700.0 cf

Solve for $V_{Facility}$

$V_{Facility} = V_{Total} - v_1$

$V_{Facility}$ = 2466.7 cf

Vt = **4933.3** cf **$V_{Facility}$** x 2

ESDv Volume

ESDv=5573.3 cf

Attachment B

Example Calculations

Section 1: RS Calculations

Wet Ponds

MARYLAND DEPARTMENT OF TRANSPORTATION™

STATE HIGHWAY ADMINISTRATION

Volume Design Computations
Surface Storage Comp
ED Micropool BMP No. 100095
June 30, 2016

Surface Storage-Micropool

Water Surface Perimeter (ft)	L =	394	
Facility Water Surface Area (sf)	Af =	7200	
Side Slope z:1	z =	3	
Height of Weir(ft)	D =	1.5	
Surface volume		9471.94	cf

ESDv volume

WQv= 9471

Volume Design Computations
Surface Storage Comp
Pond/Basin BMP No. 130166
March 11, 2016
Forebay

Elevation [ft.]	Area [ft^2]	Area [acre]	Change in Elevation [ft]	Average Area [acre]	Incremental Volume [acre-ft]	Cumulative Volume [acre-ft]	Cumulative Volume [ft^3]
331.30	0	0					
332.00	3232	0.074196511	0.7	0.037098	0.025968779	0.025968779	1131.2
332.50	3512	0.080624426	0.5	0.07741	0.038705234	0.064674013	2817.2
334.00	4352	0.099908173	1.5	0.090266	0.135399449	0.200073462	8715.2

Total WQv volume

WQv=2817

Volume Design Computations
Storage Comp
Pond/Basin BMP No. 020400
June 23, 2015
Wet Pond

Elevation [ft.]	Area [ft^2]	Area [acre]	Change in Elevation [ft]	Average Area [acre]	Incremental Volume [acre-ft]	Cumulative Volume [acre-ft]	Cumulative Volume [ft^3]
153.35	1421	0.032621671					
154.00	1891	0.043411387	0.7	0.038017	0.024710744	0.024710744	1076.4
155.00	3341	0.076698806	1.0	0.060055	0.060055096	0.08476584	3692.4
155.50	4784	0.109825528	0.5	0.093262	0.046631084	0.131396924	5723.65
156.00	6226	0.142929293	0.5	0.126377	0.063188705	0.194585629	8476.15
156.50	6610	0.15174472	0.5	0.147337	0.073668503	0.268254132	11685.15

Wet Volume

elevation [ft]		volume					
156.25	6418	0.147337006	2.3	0.095374	0.214591942	0.239302686	10424.025

Wet Volume 10424.025 cf

ESDv volume

ESDv= 10424 cf

Attachment B

Example Calculations

Section 2: Sign-Off Sheets

MARYLAND DEPARTMENT OF TRANSPORTATION™

STATE HIGHWAY ADMINISTRATION

Runoff Storage Volume Certification

In support of the latest version of the State Highway Administration MS4 *Impervious Restoration and Coordinated TMDL Implementation Plan*, research was performed to gather and analyze the best available information to compute the Runoff Storage Volume (RS_Volume) for the structural stormwater control facility indicated below (SWM Facility Number). I certify that I used my best professional engineering judgement to determine the RS_Volume for this facility. As part of this certification, the attached documents have been reviewed for accuracy.

This SWM Facility does not provide water quality treatment. Therefore, no RS_Volume was calculated.

SWM Facility Number: 020407

Pe Treated by BMP (in): N/A

RS_Volume (cf): N/A

Facility Type: Dry Pond

Engineer:

Richard Sobbott
Printed Name

Signature

15222
Maryland Registration Number (indicate state if not Maryland)

Daniel Consultants Inc.
Organization

6/20/2017
Date

Runoff Storage Volume Certification

In support of the latest version of the State Highway Administration MS4 *Impervious Restoration and Coordinated TMDL Implementation Plan*, research was performed to gather and analyze the best available information to compute the rainfall inches (PE) treated by the grass swale indicated below (SWM Facility Number). I certify that I used my best professional engineering judgment to determine the PE for this swale. As part of this certification, the attached documents have been reviewed for accuracy.

The PE was then used to automatically calculate the Impervious Area Credit using GIS and available source data..

SWM Facility Number: 030006

PE Value: 0.939

Engineer:

Richard Sobbott
Printed Name

Signature

15222
Maryland Registration Number (indicate state if not Maryland)

Daniel Consultants Inc.
Organization

6/21/2017
Date

Runoff Storage Volume Certification

In support of the latest version of the State Highway Administration MS4 *Impervious Restoration and Coordinated TMDL Implementation Plan*, research was performed to gather and analyze the best available information to compute the Runoff Storage Volume (RS_Volume) for the structural stormwater control facility indicated below (SWM Facility Number). I certify that I used my best professional engineering judgement to determine the RS_Volume for this facility. As part of this certification, the attached documents have been reviewed for accuracy.

This Runoff Storage Volume was used to then automatically calculate the Inches Treated (Pe) and the Impervious Area Credit using GIS and available source data.

SWM Facility Number: _____

RS_Volume (cubic ft): _____

Engineer:

Richard Sobbott
Printed Name

Signature

15222
Maryland Registration Number (indicate state if not Maryland)

Daniel Consultants Inc.
Organization

6/1/2017
Date

Attachment B

Example Calculations

Section 3: Field Report

MARYLAND DEPARTMENT OF TRANSPORTATION

STATE HIGHWAY ADMINISTRATION

BMP ID No. 020800 **Report Date: 08/10/2016** **By: BGA**

GENERAL OBSERVATIONS:

This facility is located along S.B. MD 100/10 in the median area approximately 0.6 miles south of the overpass of MD 100/10 over Jumpers Mill Rd in Anne Arundel County. Construction plans provided and dated in 1992 indicate an infiltration basin to be constructed. An overflow control to the southeast allows the bypass of quantity storms to outfall into a roadside ditch. Runoff is collected from MD 100/10 and conveyed through a grass v-ditch into the basin.

During the subsequent field inspection by CEM on 8/8/16, this facility was verified as an infiltration basin. Bottom dimensions are 70' x 35' and with 0.9 feet of standing water in the basin. The basin depression is bound to the southeast by a cut slope and to the north by a large, flat wooded pine forest. Total water quality storage was calculated from the basin bottom to the edge of the flat wooded forest to the north. Top dimensions measure 110' x 65'.

Ground conditions are stable.

ASSUMPTIONS FOR TREATMENT VOLUME CALCULATIONS:

The following assumptions were made while computing the treated P_E volume:

- Contributing drainage area was determined from existing information in "pilotSWMFACassessment" Access database
- Impervious Acres Credits were determined using the State Highway Administration (SHA) Office of Environmental Design (OED) Water Load Programs Division "Pollutant Load Reductions and Impervious Acres Treated" spreadsheet provided by SHA

SUMMARY OF RESULTS:

BMP 020800

BMP Type	Drainage Area (Ac.)	Imp. Acres to BMP (Ac.)	Total WQv (cu. ft.)	P_E Achieved (in.)	Imp. Acre Credit
Infiltration Basin	---	---	20,969	0	0

VOLUME CALCULATION WORKSHEET:

Enclosed with this report are Volume Design Computations for which the measured in-field conditions were input. The drainage areas were provided by others and were acquired from the GIS database. The computations spreadsheets vary per facility type, and are explained in the "Standard Operating Procedures for Stormwater Management Treatment Determination" by Chesapeake Environmental Management, effective 11/30/2015.

SWM Treatment Determination Field Checklist

BMP SWMFAC: **20800**	Field Crew: BCA / CT		Date: **08/05/16 (Day2) BGA**
Facility Type From Database: **INFBASN**	DCI Grouping: **C**	Road Name:	Boat?
Location Description:			
DCI Work Required: **Complete Class C Field Work for this BMP**			
DCI Comments: **No SWMR and no details in plans. Need field measurement for WQv calculation**			

GIS DA: Ac	GIS Imp Area: Ac	DA match field conditions (Y / N)?	Revised DA:	Revised IMP:

Measurements Needed: **Depth of ponding water; depth from embankment to WSEL; side slopes; control structure; outlet pipe; pretreatment; drawdown device**

Basin/Trench Dimensions

Length: 70'	Width: 35'	Depth:	Side Slopes: 6:1	Geometric Shape: rect.

Check Dams (Y / (N))?	Number of Dams: –	Height of Dams: –	Dist. Between Dams: ~

Pretreatment

Any Pretreatment (Y / (N))?	What Type: –	How Many: –	(dimensions on sketch)

Control Structure

Type: Infiltration Basin	Low-Flow (Y / (N))?	# of Weirs: –	(dimensions on sketch)
	Dist. From Bot. to Low-Flow: –	Dist. From Bot. to Weir: –	

Spillway

Size: –	Material Type: –	Emer. Spillway (Y / (N))?
Dist. From Bot. to Inv. Spillway: –	Dist. From Bot. to Emer. Spillway: –	

Filter Media / Subsurface Storage

Underdrain (Y / (N))?	Obs. Well Present (Y / (N))?	Standing Water ((Y) / N)?	How Much? 0.9' –
Depth from Top of Obs. Well to Fac. Surface Bot: –		Depth from Top of Obs. Well to Bot. of Well: –	

Wet Pools

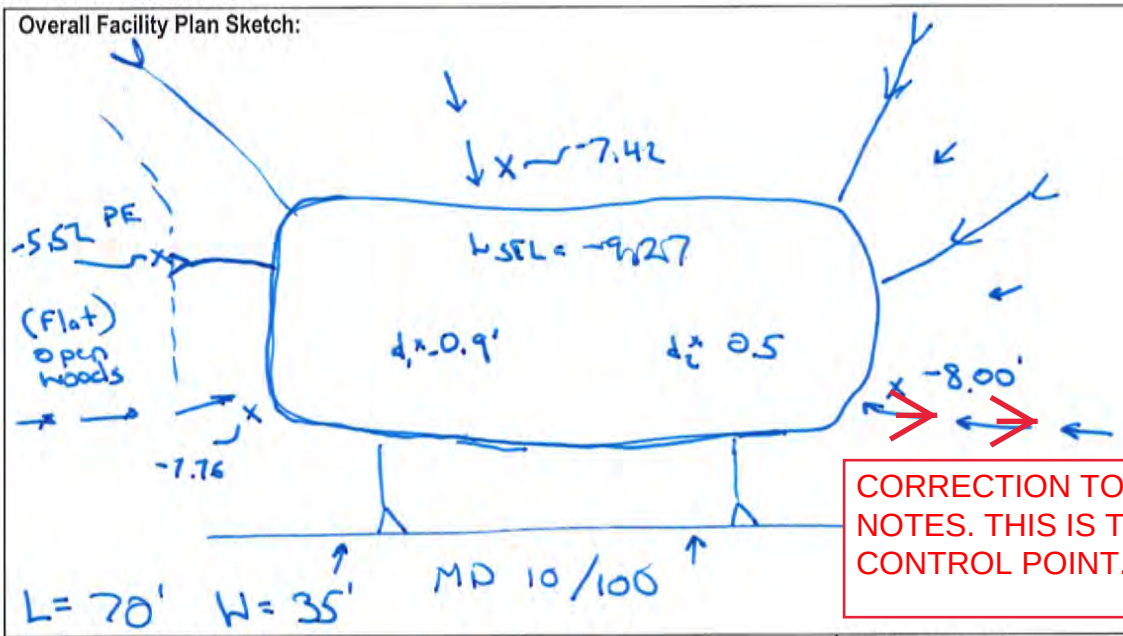
Approx. Top Area (L x W) of Wet Pool:	Average Depth of Wet Pool:	Side Slopes:	(depths and locations on sketch)

Narrative of Any Issues Encountered:

- Infiltration only; no control release structure

BMP SWMFAC: **20800**

Overall Facility Plan Sketch:



CORRECTION TO FIELD NOTES. THIS IS THE CONTROL POINT.

Control Structure Sketch:

Spillway Sketch:

Depth and Location Sketch for Wet Pools or Section Sketch for Filtering Practices:

Volume Design Computations
Surface Storage Comp
Pond/Basin BMP No. 020800
August 10, 2016
Wet WQv Storage

Elevation [ft.]	Area [ft^2]	Area [acre]	Change in Elevation [ft]	Average Area [acre]	Incremental Volume [acre-ft]	Cumulative Volume [acre-ft]	Cumulative Volume [ft^3]
-10.17	1432.6	0.033					
-9.27	2450.0	0.056	0.90	0.045	0.040	0.040	1747.2
-8.00	4282.5	0.098	1.27	0.077	0.098	0.138	6022.3
-7.76	4680.9	0.107	0.24	0.103	0.025	0.163	7097.9
-7.42	5273.8	0.121	0.34	0.114	0.039	0.202	8790.2
-5.52	7546.6	0.173	1.90	0.147	0.280	0.481	20969.6

Interpolated Area Values

elevation [ft]	Area [ft^2]	Inc. Volume [ft^3]	Cum. Vol. [ft^3]
0	7546.6	12179.4	20969.6

Total WQv volume

WQv= 20969 cf

CONVEYANCE DITCH
(FLAT WOODS)
S.B. MD 100/10
+-5.52
+-7.42
+-9.27
+-7.76
020800
+-10.17
+-8.00
CONTROL POINT
(STEEP HILL)
CONVEYANCE DITCH
8/24/2016 2:00:25 PM, 1:30

N
W
E
S
MD 10 ARUNDEL EXPWY
MD 100
Photo 4
Photo 2
020800
EX ST NG
Photo 1
Photo 3
MD 10 ARUNDEL EXPWY
MD 100
Glen Burnie
Solley Rd
Smallwood
10
Green Haven
Duvall Hwy
Paul T Pitcher Memorial Hwy
Arundel E
177
Mountain Rd
South Gate
FACILITY LOCATION
Elvaton Rd
100
ANNE ARUNDEL COUNTY
648
Obrecht Rd
Pasadena
Millersville
Magothy Bridge Rd
Kinder Farm Park
Benfield Blvd
Benfield Rd
2

BMP-020800 Overall A facing northeast, Photo 1

BMP-020800 Overall B facing southeast, Photo 2

BMP-020800 Overall C facing northwest, Photo 3

BMP-020800 Overall D facing north, Photo 4

F. H. WA. REGION NO.	STATE	FED AID PROJ. NO	SHEET NO	TOTAL SHEETS
3	MD.	SEE TITLE SHEET	22	117

To Baltimore

To Annapolis

Ex.Md.Rte.100 W.B.R.
Δ = 37°13'-48"
D = 3°-00'-00"
R = 1909.86'
T = 649.29'
L = 1241.00'
E = 105.43'

MD. RTE. 100, (W.B.R.)

Ex.Md.Rte.100 W.B.

PC 232+83.36

LIMIT OF RESURFACING W.B 100

4' Side Ditch

Type I Check Dam

Tar & Chip Shldr.

42" R.C.P.

Intersecting Slope Ditch

Survey Line & ℄ Constr. Ex. Md. Rte. 100 W.B.R.

Survey Line & ℄ Constr. Md. Rte. 10 N.B.R.

10' Shoulder

Metal Guard Rail

Toe Of Slope

Crown Line

Inv. 86.06

MD. RTE. 10, (N.B.R.)

Earth Berm

Sta. 225+38±, Rt. N.B.R.

Remove Existing Endwall

88 LF 42" RCCP Cl. A

1-Std. Conc. End Section For 42" RCCP

29 SY Class 1 Riprap For Outlet Protection.

See Sheet No. 6

Note:

⚠1 Existing Traffic Barrier W Beam from Sta. 230+30 to Sta 236+50 shall be removed and disposed by the contractor. Payment for this item of work will be considered incidental to the item Clearing and Grubbing.

Md.Rte 10 N.B.R.
Δ = 60°-09'-15.7"
D = 4°-30'-00"
R = 1273.239'
T = 737.398'
L = 1336.762'
E = 198.116'

Type I Check Dam (Typ.)

Traffic Barrier W Beam

Sta. 231+92 To Sta. 233+00, NBR, Lt.
108 LF Traffic Barrier W Beam
1-Trail End Anchorage

Sta. 231+99 To Sta. 233+00 NBR, Rt.
101.25 LF Traffic Barrier W Beam
1-Trail End Anchorage

P.O.T. 222+07.85 Md. Rte. 10 N.B.R. Ah.

P.O.T. 383+55.89 Md. Rte 10 N.B.R. Bk

BORROW AREA No. 1

Approximate Limit of Grading

Woods

Soils Stabilization Matting Over Seed And Mulch SIDE DITCH
Sta. 381+00 To 382+00, (Lt.), NBR.
78 SY - A = 4.0', B = 1.5'
Sta. 231+25 To 235+50, (Lt.), NBR.
543 SY - A = 4.0', B = 3.75'
Sta. 226+50 To 231+50, (Lt.), NBR.
333 SY - A = 4.0', B = 1.0'
Sta. 381+00 To 228+50, (Lt.), SBR. (Side Ditch In Cut)
457 SY - A = 3.0', B = 3.75', B_2 = 2.0'
Sta. 381+00 To 227+00, (Rt.), SBR. (Side Ditch In Cut)
427 SY - A = 4.0', B = 5.25', B_2 = 2.75'
Sta. 227+00 To 235+50, (Rt.), SBR.
850 SY - A = 4.0', B = 2.5'
Sta. 233+00 To 235+50, (Lt.), SBR.
236 SY - A = 4.0', B = 2.25'
Sta. 231+50 To 233+00, (Lt.), NBR
108 SY - A = 2.0', B = 1.25'
Sta. 381+00 To 382+50, (Rt.), NBR. 215 SY - A = 4.0'; B = 4.0'
Sta. 227+00 To 233+00, (Rt.), N.B.R. 544 SY - A = 4.0'; B = 1.5'
Soils Stabilization Matting Over Seed And Mulch SURFACE DRAIN DITCH
Sta. 224+75 To 226+50, (Lt.), NBR.
94 SY - B_1 = 2.4', B_2 = 2.4'
Sta. 230+00 To 233+00, (Lt.), SBR.
150 SY - B_1 = 2.25', B_2 = 2.25'

CHECK DAM
Sta. 223+00 Lt., N.B.R.
Type = I Interval = N/A No = 1 'ds' = 1.75'
Sta. 228+00 To Sta. 233+00 Rt., N.B.R.
Type = I Interval = 100 No = 6 'ds' = 1.0'
Sta. 234+00 Rt., S.B.R.
Type = I Interval = N/A No = 1 'ds' = 1.0'

Sta. 380+70 To Sta. 381+30, (Lt.), Rte. 10 S.B.R.
Construct Infiltration Basin
Bottom Width - 25 Ft.
Bottom Length - 60 Ft.
Bottom Elev. - 81.5
I B # 2

Ex.Md.Rte.100 E.B.R.
Δ = 51°-21'-58"
D = 3°-00'-00"
R = 1909.86'
T = 918.46'
L = 1712.20'
E = 209.36'

LIMIT OF RESURFACING E.B. 100
STA. 231+10

Conc. Flume

48" R.C.P.

Conc.

Grass

Survey Line & ℄ Constr. Ex. Md. Rte. 100 E.B.R.

Survey Line & ℄ Constr. Md. Rte. 10 S.B.R.

Intersecting Slope Ditch

4' Side Ditch

Tar & Chip Shldr.

Crown Line

Ditch

Observation Well I T # 3

10' Shoulder

Infiltration Trench

4' Side Ditch In Cut

3' Side Ditch In Cut

P.C. 226+23.70 Ex. Md. Rte. 100 E.B.R.

T.S.T.

T.S.O.S.

MD. RTE. 10, S.B.R.

Top Of Slope

Right Of Way Line Of Through Highway

Right Of Way Line

Type 1, Check Dam

383+41.17 Md. Rte. 10 S.B.R. Bk

226+23.70 Md. Rte. 10 S.B.R. Ah.

MD. RTE. 10, (S.B.R.)

SEDIMENT CONTROL SCHEDULE
Construct 1935 LF Slope Silt Fence, Rt., Sta. 382+ To 233+10, NBR
Construct Temporary Sediment Trap (90'×18'×4' Depth), Lt., Sta. 226+75, SBR
Construct Temp. Slope Drain S.B.R. Sta. 229+50 (Rt.) 38 L.F. - 18" ϕ
Construct Temp. Slope Drains S.B.R. Sta. 234+50 (Rt.) 38 L.F. - 18" ϕ
Construct Temp. Slope Drains N.B.R. Sta. 225+00 (Rt.) 50 L.F. - 18" ϕ
Construct Temp. Sediment Trap (110'×10'×2.5' Depth), Rt. Sta. 381+50 N.B.R.
Construct Temp. Slope Drain N.B.R. Sta. 229+50 (Rt.) 40 L.F.
Construct 800 L.F. Slope Silt Fence, Lt., Sta. 225+00 To 233+00, N.B.R.
Construct 550 L.F. Slope Silt Fence, Lt., Sta. 230+00 To Sta. 235+50, S.B.R.
Construct 300 L.F. Slope Silt Fence, Lt., Sta. 381+00 To Sta. 222+00, N.B.R.
Construct Temp. Sediment Trap (45'×10'×2.5' Depth) Rt. Sta. 225+00, N.B.R.
Construct Temp. Sediment Trap (40'×20'×2.5' Depth) Rt. Sta. 229+50, N.B.R.
Construct 185 L.F. Slope Silt Fence, Rt. Sta. 382+50, NBR
INFILTRATION TRENCH
Sta. 380+00 To Sta. 226+50 Rt., S.B.R. ⚠1
Lt = 370' Wt = 4.0' Dt = 3.0'

For Details And Locations Of Infiltration Trenches, Check Dams, And Outlet Protection, See Sheet No. 6

For Profile Md. Rte. 10, NBR, See Sheet No. 34
For Profile Md. Rte. 10, SBR, See Sheet No. 34

SCALE { PLAN: 1 IN. = 50 FT.

RUMMEL, KLEPPER & KAHL
CONSULTING ENGINEERS
BALTIMORE, MARYLAND

REVISIONS
⚠1 Addendum No. 1 7-11-89
⚠2 Addendum No. 3 9-6-89

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

ARUNDEL EXPRESSWAY: MD ROUTE 100 TO MD ROUTE 2
PLAN - S.B.R. STA. 381+00 TO 235+50 - N.B.R. STA. 381+00 TO 233+00

CONT NO AA-572-510-570 F A P NO SEE TITLE SHEET SHEET NO 22 OF 117
PREL TRAC BY J.F.L. FINAL TRAC BY

F. H. WA. REGION NO	STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
3	MD.	SEE TITLE SHEET	21	117

BM: Spike In 10" Pine, 100' Rt. Of $\mathbb{Q}$ & Constr. Md. Rte. 100, WBR
Sta. 217+52 Elev. 96.29

2 BM NB-2 SHA SPIKE IN 10" PINE 100' RT OF RTE 10 NBL STA. 368 + 25 ELEVATION 96.29 BK 24014 PG. 99

2 CHECK BM NB-3 SHA SPIKE IN 6" GUM 25° RT OF RTE 10 NBL STA. 376+75 ELEVATION 121.50 BK 24014 PG. 99

2 SET BM # NB-3A SHA SPIKE IN 6" OAK, 170° LT OF RTE 10 NBL STA. 378 + 44 ELEVATION 114.53 BK 24014 PG. 99

2 SET BM # NB-4A SHA SPIKE IN 10" OAK 130° LT OF RTE 10 NBL STA 222 + 79 ELEVATION 103.27 BK 24014 PG. 99

2 CHECK BM # NB-4 SHA SPIKE IN 5" PINE ON $\mathbb{Q}$ AT NBL STA. 224 + 91 ELEVATION 90.18 BK 24014 PG. 98

To Baltimore

To Annapolis

Right Of Way Line
Right Of Way Line Of Through Highway

N.411,500 E.919,800

MD. RTE. 10, (N.B.R.)

Earth Dike
Top Of Slope
Observation Well
S.D.D.
SCE H.P.
Infiltration Trench
BMP 2501
BMP 2503
Toe Of Slope
Ex. Conc. Flume
Type 1, Check Dam (Typ)
4' Side Ditch
10' Shoulder
Tar & Chip Shldr.
Conc. Flume
Survey Line & $\mathbb{Q}$ Constr. Md. Rte. 10 N.B.R.
Survey Line & $\mathbb{Q}$ Constr. Ex. Md. Rte. 100 W.B.R.
Survey Line & $\mathbb{Q}$ Constr. Ex. Md. Rte. 100 E.B.R.
Limit of Borrow Area
Bottom of 4:1 Slope
Woods
T.S.T.
T.O.S.
Approximate Limit of Grading
High Point
BORROW AREA No. 1
LIMIT OF WIDENING (Lt.) STA. 374+00
Exist. 10' Shoulder
Ex. Conc. Flume
S.D.D.
18" CMP
Conc. Flume
Limit of Borrow Area
Right Of Way Line Of Through Highway
Woods
Right Of Way Line
Sheet Match Line
Sheet See Sheet

Borrow Area No. 1
Sta. 368+ Sta. 382 + Lt., S.B.R.
Clear & Grub area, Grade and Seed & Mulch.

Soils Stabilization Matting Over Seed And Mulch SIDE DITCH
Sta. 368+00 To 371+00, (Lt.), N.B.R.
220 S.Y. - A = 4.0', B = 1.75'
Sta. 368+00 To 368+50, (Rt.), S.B.R.
42 S.Y. - A = 4.0', B = 1.75'
Sta. 372+00 To 381+00, (Rt.), S.B.R. (Side Ditch In Cut.)
1200 S.Y. - A = 4.0', B_1 = 5.25', B_2 = 2.75'
Sta. 368+00 To 381+00, (Rt.), N.B.R.
1740 S.Y. - A = 4.0', B = 4.0'

Soils Stabilization Matting Over Seed And Mulch SURFACE DRAIN DITCH
Sta. 371+00 To 381+00, (Lt.), N.B.R.
950 S.Y. - B_1 = 5.5', B_2 = 2.25'
Sta. 374+00 To 381+00, (Lt.), S.B.R.
486 S.Y. - B_1 = 4.0', B_2 = 2.25'
Sta. 368+50 To 372+00, (Rt.), S.B.R.
428 S.Y. - B_1 = 7.75, B_2 = 3.25'
Sta. 368+00 To Sta. 370+00, Lt., N.B.R.
145 S.Y. Earth Dike

Sta. 380+60, Lt., Md. Rte. 10 S.B.R.
45 S.Y. Class I Riprap Ditch Lining

SEDIMENT CONTROL SCHEDULE

Construct 325 L.F. Slope Silt Fence, Rt., Sta. 368+00 N.B.R. To Sta. 369+50 S.B.R.
Construct Temporary Sediment Trap (135' x 20' x 25' Depth), Rt., Sta. 369+50 N.B.R.
Construct 280 L.F. Earth Dike, Lt., Sta. 368+00 To Sta. 370+80, N.B.R.
Construct 250 L.F. Slope Silt Fence, Lt., Sta. 378+50 To 381+00 N.B.R.
Construct 200 L.F. Earth Dike, Lt., Sta. 376+50 To Sta. 378+50, N.B.R.

INFILTRATION TRENCH

Sta. 371+00 To Sta. 375+00 Lt., N.B.R.
L = 400' W = 3.0' D = 4.0'
Sta. 376+80 To Sta. 378+00 Lt., N.B.R.
L = 120' W = 4.0' D = 4.0'
Sta. 372+00 To Sta. 378+00 Rt., S.B.R.
L = 600' W = 4.0' D = 3.5'

CHECK DAM

Sta. 379+20 To Sta. 381+00 Lt., N.B.R.
Type I, Interval = 30', No. = 7, 'ds' = 1.0'
Sta. 368+00 To Sta. 368+50 Rt., S.B.R.
Type I, Interval = 50', No. = 2, 'ds' = 1.0'
Sta. 368+50 To Sta. 369+25, N.B.R.
Type I, Interval = 75', No. = 2, 'ds' = 1.0'

Md. Rte. 10 S.B.R.
$\Delta = 5°-40'-24.7"$
$D = 0°-59'-07.3"$
$R = 5,814.715'$
$T = 288.127'$
$L = 575.782'$
$E = 7.134'$

Ex. Md. Rte. 100 E.B.R.
$\Delta = 8°-17'-14.3"$
$D = 0°-40'-00"$
$R = 8,594.367'$
$T = 622.633'$
$L = 1,243.093'$
$E = 22.524'$

P.T. 370+57.35 Md. Rte. 10 S.B.R.

P.T. 215+92.85 Ex. Md. Rte. 100 E.B.R.

For Details And Locations Of Infilteration Trenches And Check Dams, See Sheet No. 6

For Profile, Md. Rte. 10, NBR, See Sheet No. 33
For Profile, Md. Rte. 10, SBR, See Sheet No. 33

SCALE { PLAN: 1 IN. = 50 FT.

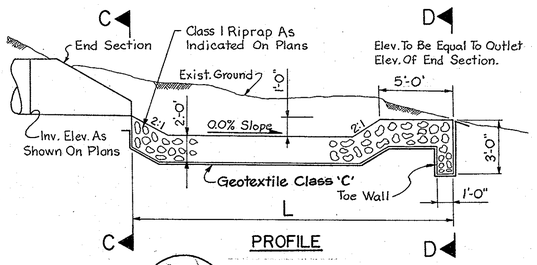
RUMMEL, KLEPPER & KAHL
CONSULTING ENGINEERS
BALTIMORE, MARYLAND

REVISIONS
2 REVISED 7-18-90

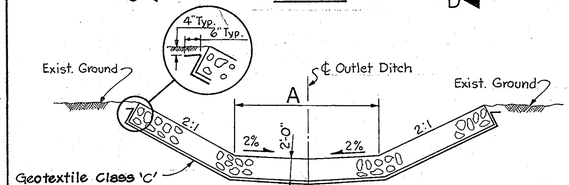
STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION
ARUNDEL EXPRESSWAY: MD. ROUTE 100 TO MD. ROUTE 2
PLAN-S.B.R. & N.B.R. STA. 368+00 TO STA. 381+00

CONT. NO. AA-572-510-570 F. A. P. NO. SEE TITLE SHEET SHEET NO. 21 OF 117
PREL. TRAC. BY FINAL TRAC. BY

F. H. WA. REGION NO.	STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
3	MD.	SEE TITLE SHEET	6	117

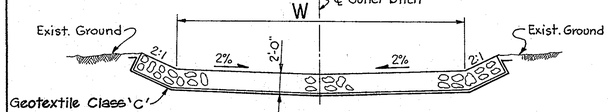


PROFILE



SECTION C-C

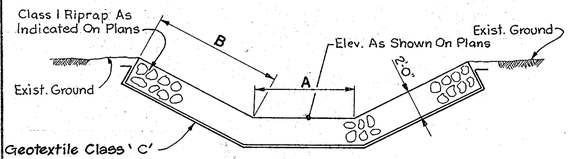
Note: Outlet Channel At Section D-D To Conform To Exist. Ground Configuration



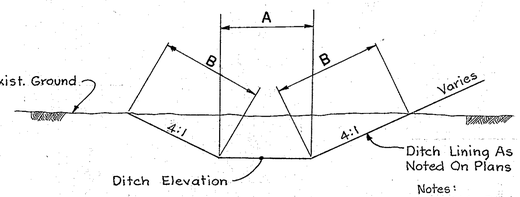
SECTION D-D

LOCATION	A	W	L	NOTES
Sta. 225+65, Rt, NBR	6.5'	20.0'	13.5'	Sht. No. 22
Sta. 364+20, Rt., NBR	6.5'	26.0'	19.0'	Sht. No. 20
Sta. 364+65, Rt., SBR	7.0'	16.0'	9.0'	Sht. No. 20
Sta. 242+50, Rt., SBR	7.0'	4.0'	42.0'	Sht. No. 23
Sta. 3+20.00, Rt. Ramp A	6.5'	4.0'	25.0'	Sht. No. 25
Sta. 27+00, Rt., Ser. Rd.	10.0'	28.0'	18.0'	Sht. No. 28
Sta. 36+60, Rt., Ser. Rd.	5.0'	2.0'	10.0'	Sht. No. 29

DETAIL FOR RIP-RAP OUTLET PROTECTION



DETAIL OF TYPICAL OUTLET DITCH

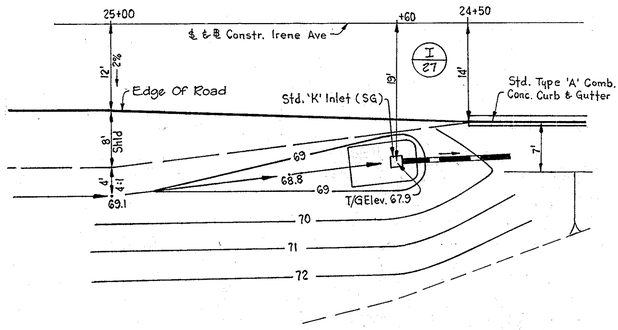


DETAIL OF TYPICAL SIDE DITCH

'TYPE I'

Notes:
1. All Side Ditches Shall Be Type I ' And 4'-0" Wide Unless Otherwise Noted.
2. Type 2 Side Ditches Shall Have 2:1 Side Slopes With Widths As Noted On The Plans.

SCALE: NONE

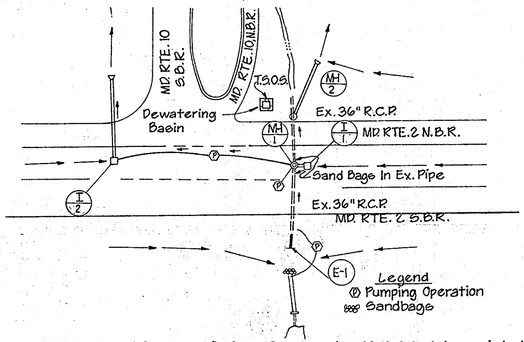


DETAIL

PLACEMENT ST'D. TYPE 'K' INLET (SG)

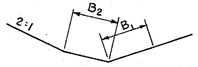
LEFT STA. 24+60

IRENE AVE.

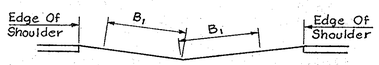


1. Place Sandbag Dike Upstream Of E-1 And Maintain Flows During Construction Of E-1 And Associated Pipes By Pumping To Existing 36" R.C.P.
2. Upon Completion Of E-1 And Associated Pipes Place Sandbags In Existing 36" R.C.P. Upstream Of MH-1 And Maintain Flows During Construction Of MH-1 And I-1 By Pumping Through The MH-1 Work Area.
3. Upon Completion Of MH-1 And I-1 Place Sandbags In Existing 36" R.C.P. Downstream Of MH-1 And Maintain Flows During Construction Of MH-2 And Associated Pipes By Pumping To I-2. Note, I-2 And Associated Pipes Must Be Constructed Prior To Step 2.
4. For General Culvert Construction Notes See Sheet No. 25 Of 107
5. Items Noted For Maintaining Stream Flow At This Location Such As Pumping Operations, Sandbags, Dewatering Basins, And T.S.O.S.'s Shall Be Considered Incidental To The Prices Bid For The Various Drainage Items In The Contract.
6. For Dewatering Basin Details See Sheet No. 43 Of 107

MAINTENANCE OF STREAM FLOWS AT STA. 238+ MD. RTE. 2

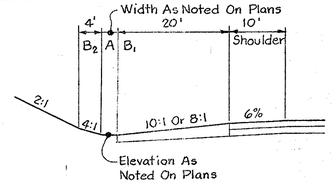


SURFACE DRAIN DITCH



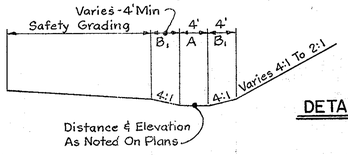
MEDIAN DITCH

DETAIL-DITCH LINING DIMENSIONS



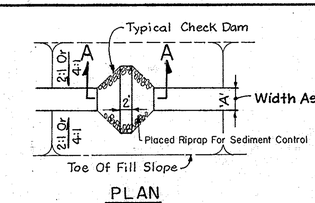
SIDE DITCH IN CUT

STA. 373+ To EQ 383+41.16 = 226+23.70
To STA. 228+, SBR, RTE. 10



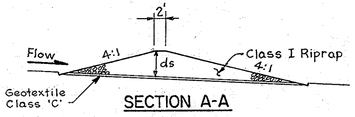
SIDE DITCH IN CUT

STA. 373+ To EQ 383+41.16 = 226+23.70
To STA. 228+, SBR, RTE. 10
STA. 36+00 To STA. 39+00, Service Rd. (Lt.)



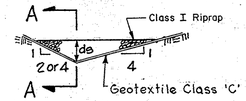
PLAN

Notes: 1. Ditch Side Slopes Are 4:1 For A Type I Check Dam And 2:1 For A Type II Check Dam.



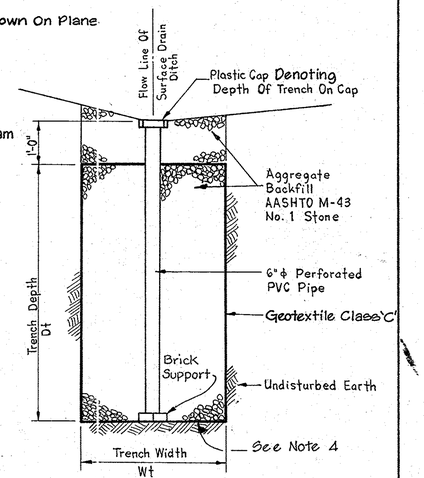
SECTION A-A

DETAIL - TYPICAL CHECK DAM TYPES I and II



DETAIL - TYPICAL CHECK DAM TYPE III

SECTIONAL VIEW



DETAIL - INFILTRATION TRENCH W/ OBSERVATION WELL

N.T.S.

Notes.
1. Perimeter Overlap Of Filter Cloth Shall Be 6"
2. End Of Roll Overlap Of Filter Cloth Shall Be 2'-0" Over The Downstream Roll To Provide A Shingled Effect.
3. Well Cap Shall Be Marked W/Depth Of Trench At Time Of Installation.
4. Bottom Slope Of Trench In A Longitudinal Direction Shall Be 0%.

INFILTRATION SCHEDULE

LOCATION (MD. RTE. 10 N.B.R.)	DEVICE							
	TRENCH				CHECK DAM			
	'Lt'	'Wt'	'Dt'*	CY	TYPE	INTERVAL	No.	'ds'
Sta. 350+00 To Sta. 352+00 Rt.	200	2.0	3.0	59				
Sta. 352+50 To Sta. 354+50 Lt.	200	2.0	4.5	81				
Sta. 354+50 To Sta. 357+50 Lt.	300	3.0	4.0	167				
Sta. 360+00 To Sta. 362+00 Lt.	200	4.0	5.5	198				
Sta. 363+00 To Sta. 364+00 Lt.					I	100	2	1.0
Sta. 364+50 Lt.					I	N/A	1	1.25
Sta. 367+00 To Sta. 369+25 Lt.					I	75	4	1.0
Sta. 371+00 To Sta. 375+00 Lt.	400	3.0	4.0	222				
Sta. 376+80 To Sta. 378+00 Lt.	120	4.0	4.0	89				
Sta. 379+20 To Sta. 381+00 Lt.					I	30	7	1.0
Sta. 223+00 Lt.					I	N/A	1	1.75
Sta. 241+50 To Sta. 246+00 Lt.					I	75	7	1.0
Sta. 246+25 To Sta. 247+00 Lt.					I	25	4	1.0
Sta. 228+00 To Sta. 234+00 Rt.					I	100	7	1.0
Sta. 237+50 To Sta. 240+50 Rt.					II	100	4	1.0
Sta. 252+00 To Sta. 253+50 Lt.					I	150	2	1.0
Sta. 253+00 To Sta. 253+25 Lt.					II	25	2	0.5
Sta. 259+50 Lt.					II	N/A	1	1.0
(RITCHIE HIGHWAY)								
Sta. 227+50 To Sta. 230+50 Rt.	300	2.0	2.5	78				
Sta. 230+50 To Sta. 234+50 Rt.	400	2.0	2.5	104				
(MD. RTE. 10 SBR.)								
Sta. 352+70 To Sta. 357+00 Rt.	430	2.0	3.0	127				
Sta. 372+00 To Sta. 378+00 Rt.	600	4.0	3.5	400				
Sta. 380+00 To Sta. 386+50 Rt.	370	4.0	3.0	219				
Sta. 234+00 Rt.					I	N/A	1	1.0
Sta. 237+50 Rt.					I	N/A	1	1.5
Sta. 239+00 Rt.					I	N/A	1	1.0
Sta. 239+50 Rt.					I	N/A	1	0.5
Sta. 240+00 To Sta. 240+50 Rt.					I	50	2	1.0
Sta. 241+25 To Sta. 242+00 Rt.					II	25	4	1.0
Sta. 244+00 Rt.					II	N/A	1	1.0
Sta. 245+50 Rt.					II	N/A	1	0.5
Sta. 247+50 Rt.					II	N/A	1	1.0
Sta. 252+00 To Sta. 252+50 Rt.					I	50	2	1.0
Sta. 254+50 Rt.					I	N/A	1	1.0
Sta. 257+00 Rt.					I	N/A	1	0.75
Sta. 258+50 To Sta. 260+50 Rt.					I	200	2	1.0
Sta. 250+40 Rt.					I	N/A	1	3.0
Sta. 350+50 Rt.					I	N/A	1	1.0
Sta. 368+00 To Sta. 368+50 Rt.					I	50	2	1.0

*Minimum Depth Of Trench At Most Downstream End. See Note 4 Above.

LOCATION (SERVICE ROAD)	DEVICE							
	TRENCH				CHECK DAM			
	'Lt'	'Wt'	'Dt'	C.Y.	TYPE	INTERVAL	No.	'ds'
STA. 15+50 TO STA. 22+00, LT. & RT.					III	130	10	1.0
STA. 22+00 TO STA. 24+00, RT.					III	N/A	1	1.0
STA. 22+00 TO STA. 25+00, LT.					III	150	2	1.0
STA. 25+00 TO STA. 27+00, LT.					III	100	2	1.0
STA. 27+00 TO STA. 29+50, LT.					III	125	2	0.75
STA. 29+50 TO STA. 32+00, LT.					III	125	3	1.0
STA. 32+00 TO STA. 34+50, LT.					III	125	2	1.0
STA. 34+50 TO STA. 36+00, LT.					III	N/A	1	0.75
STA. 36+50 TO STA. 39+00, LT.					I	N/A	1	0.75
(HUNT ENTRANCE)								
STA. 10+50 TO STA. 13+00, RT.					III	N/A	1	1.0
(IRENE AVENUE)								
STA. 25+00 TO STA. 29+50, RT.					III	50	9	0.85
STA. 25+00 TO STA. 29+50, LT.					III	50	9	0.85

REVISIONS

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CONSULTING ENGINEERS
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STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION
ARUNDEL EXPRESSWAY: MD. ROUTE 100 TO MD. ROUTE 2
DITCH DETAILS

CONT. NO. AA-572-510-570 F. A. P. NO. SEE TITLE SHEET SHEET NO. 6 OF 117
PREL. TRAC. BY FINAL TRAC. BY

Attachment B

Example Calculations

Section 4: P_E Calculator Requirements

MARYLAND DEPARTMENT OF TRANSPORTATION

STATE HIGHWAY ADMINISTRATION

Procedures for performing the amount of rainfall treated (P_E) and Impervious Area Credit (IAC) for Baseline Treatment Determination

The procedures for performing the treatment calculations for stormwater control facilities are below. The process details the initial GIS steps to generate the required data inputs for the calculation of the treatment parameters.

1. **Perform Intersection of Impervious Surface Layer with the SWM BMP Drainage Areas**
   - Obtain the Impervious Surfaces and MDOT SHA Right-of-Way GIS layers and perform the following pre-processing steps:
     - Intersect the impervious surface layer with the right-of-way layer.
     - Calculate the total MDOT SHA-owned acreage (overall property) by using the "Calculate Geometry" function within ArcMap on the right-of-way layer.
     - Calculate the total MDOT SHA-owned impervious surface acreage by intersecting the impervious surface layer with the right-of-way layer, then using the "Calculate Geometry" function within ArcMap.
     - Calculate the "SHA_OWNED" attribute field = "TRUE" (onsite) for impervious surface areas inside the right-of-way layer.
     - Calculate the "SHA_OWNED" attribute field = "FALSE" (offsite) for impervious surface areas outside the right-of-way layer.
   - Obtain the Baseline Stormwater Control Facilities (SWM BMPs) and their associated Drainage Area polygons and perform the following pre-processing steps:
     - Confirm that all drainage areas have impervious surfaces for onsite and offsite areas based on the baseline year imagery.
     - Confirm all SWM BMPs qualify for baseline treatment based on the baseline year and the facility type.
     - Confirm all SWM BMPs have a RS Volume value in the dataset.
     - Intersect the SWM BMP drainage areas with the impervious surface layer to generate the SWM BMP-specific onsite and offsite impervious acreage values.

2. **Perform Baseline Treatment Calculations to Determine the Impervious Area Credit (IAC)**
   - Calculate the Baseline IAC treatment determination, including performing the following pre-processing to the input datasets, including:
     - Confirm all baseline facilities have an assigned RS Volume.
     - Confirm dry facilities were given a P_E treatment factor of 0.
     - Remove any facilities with data inconsistency issues, such as missing RS Volumes to ensure they are omitted from calculations.
     - Parse out the SWM BMPs into three categories to support varying methods of treatment determination, including SWM BMPs, 2A grass swales from the protocol analysis, and Non-2A grass swale BMPs.
   - Calculate the P_E for Baseline SWM BMPs using a modeled P_E treatment calculator.
     - Determine the percent impervious (I) of the drainage area using the sum of onsite and offsite. impervious area. Impervious area is in acres, rounded to two decimals; the resultant I is rounded to the integer.
     - Determine the runoff coefficient (R_v) with the calculated I value using the formula documented in Table 5, Section 5.1.

- Calculate P_E based on the data input of RS volume, the calculated R_v value, and drainage area acres (rounded to two decimals) using the formula documented in Table 5, Section 5.1. The P_E value is rounded to one decimal.
- Calculate the amount of runoff treated (Q) using the RS volume and sum of onsite and offsite impervious area using the formula documented in Table 5, Section 5.1. The Q value is rounded to two decimals, and has a maximum value of 2.50. The value is null if there is no impervious area within the contributing drainage area.
- Calculate the amount of impervious area credit (IAC) provided by the baseline SWM BMP
  - Determine the MDOT SHA-owned impervious areas within the SWM BMP drainage area (SHA_OWNED= TRUE (onsite) impervious area).
  - Calculate the IAC using the MDOT SHA-owned impervious area within the drainage area and the calculated P_E value to obtain the impervious area credit based on the formulas documented in Table 5, Section 5.1. The impervious area credit is rounded to three decimals.

- Calculate the baseline IAC treatment for 2A Grass Swales
  - Assign each 2A Grass Swale an assumed P_E treatment factor of 1.0.
    - Grass swales have no assigned RS volume.
    - Impervious area does not affect the P_E.
  - Calculate the amount of impervious area credit (IAC) provided by the 2A Grass Swale.
    - Determine the total impervious areas within the 2A Grass Swale drainage area (SHA_OWNED= TRUE (onsite) and SHA_OWNED=FALSE (offsite) impervious area).
    - Calculate the IAC using the total sum of the onsite and offsite impervious area multiplied by the P_E (1.0) to obtain impervious area credit. The impervious area credit is rounded to three decimals.

- Calculate the baseline IAC treatment for Non-2A Grass Swales
  - Baseline Grass Swales were given an assumed P_E treatment factor of 1.0.
    - Grass swales have no assigned RS volume.
    - Impervious area does not affect the P_E.
  - Calculate the amount of impervious area credit (IAC) provided by the baseline Non-2A Grass Swale
    - Determine the MDOT SHA-owned impervious areas within the Non-2A Grass Swale drainage area (SHA_OWNED= TRUE (onsite) impervious area).
    - Calculate the IAC using the MDOT SHA-owned impervious area within the drainage area and multiply by the P_E (1.0) to obtain impervious area credit. The impervious area credit is rounded to three decimals.

Attachment B

Examples

Section 5: Full Documentation

MARYLAND DEPARTMENT OF TRANSPORTATION

STATE HIGHWAY ADMINISTRATION

Runoff Storage Volume Certification

In support of the latest version of the State Highway Administration MS4 *Impervious Restoration and Coordinated TMDL Implementation Plan*, research was performed to gather and analyze the best available information to compute the Runoff Storage Volume (RS_Volume) for the structural stormwater control facility indicated below (SWM Facility Number). I certify that I used my best professional engineering judgement to determine the RS_Volume for this facility. As part of this certification, the attached documents have been reviewed for accuracy.

This Runoff Storage Volume was used to then automatically calculate the Inches Treated (Pe) and the Impervious Area Credit using GIS and available source data.

SWM Facility Number: _____

RS_Volume (cubic ft): _____

Engineer:

Richard Sobbott
Printed Name

Signature

15222
Maryland Registration Number (indicate state if not Maryland)

Daniel Consultants Inc.
Organization

6/1/2017
Date

7/29/2017

Pe Addressed Calculation:

$$Pe = \frac{(RS)*12}{(Rv)*A}$$

$$Rv = .05 + .009(I)$$

SWMFAC Number	
Design Sub	INFTREN
Plan Date	1989
GIS Drainage Area (Acres)	0.11
Total Impervious Area (Acres)	
I	18
Rv	0.212
Runnoff Storage Volume (RS)	675
P_E Treated by BMP (inches) (Pe)	

Runoff Depth Treated per Impervious:

$$Q = \frac{(RS)*12}{(IA)}$$

Q	2.5

Impervious Area Treated Calculation:

If P_E is less than or equal to 1, then: $Impervious\ Acres * PE\ Addressed = Impervious\ Acres\ Treated$

I P_E is greater than 1, then: $\left[Impervious\ Acres * \frac{(\text{PE } Addressed - 1)}{.4} * .1\right] + Impervious\ Acres = Impervious\ Acres\ Treated$

Construction Purpose:		Baseline	
P_E Treated by BMP (inches):			
Total Impervious (Acres):		**SHA Owned Impervious (Acres):**	0.02
Impervious Acres Treated[1]:		0.028	

1. For baseline Impervious Acres Treated, 'Impervious Acres' is clipped to the SHA Right-of-Way. For restoration calculations, the full amount of 'Impervious Acres' treated within the drainage area is counted towards credit.

SWM
Existing Impervious Treatment Determination

SWMFAC# 020043

County: Anne Arundel
Type: Infiltration Trench
Watershed: 02131002

N

1 inch = 20 feet

Orthoimagery Source Date: Six inch resolution aerial imagery for the State of Maryland. The imagery for this service is composed of imagery flown in 2010 and 2011. This service in the Maryland State Plane Meters projection.

Legend

- SWMFAC
- Drainage Area
- Right of Way
- Impervious
- Streams
- Unknown
- Capped Inlet
- Manhole
- SWM Structure
- Inlet
- Emergency Spillway
- Unknown End Headwall
- Headwall
- Endwall
- Endsection
- Projecting Pipe
- Junction Box
- Pipe Connection
- Ditch Intersection
- Rip Rap Ditch
- Springhead
- BMP Centroid
- Unknown
- Ditch
- Hydraulic Connector
- Pipe

Export Date: 4/28/2017

SHA State Highway Administration

MDOT MARYLAND DEPARTMENT OF TRANSPORTATION

Volume Design Computations
Surface Storage Comp
Infiltration Trench BMP No. 020043
July 17, 2015

Surface Storage

Length (ft)	L =	100
Width (ft)	W =	4
Depth (ft)	D=	4.00
Void Vol. (cf)	V =	640.00
2 hours infiltration	V =	34.67
Total Volume	V =	674.67

WQv volume

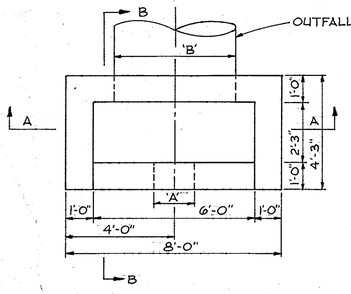
WQv= 675

F. H. WA. REGION NO.	STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
3	MD.	SEE TITLE SHEET	99	365

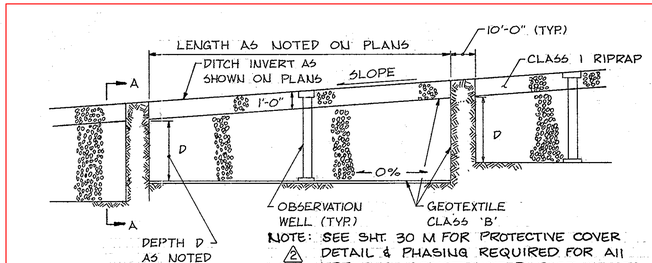
⚠2 GENERAL SWM POND & INFILTRATION NOTES

1.) SWM POND PIPE JOINTS SHALL BE RUBBER GASKETED CONFORMING TO ASTM C-361 OR AWWA C-301. NO GRAVEL BEDDING SHALL BE USED FOR PIPE INSTALLATION.

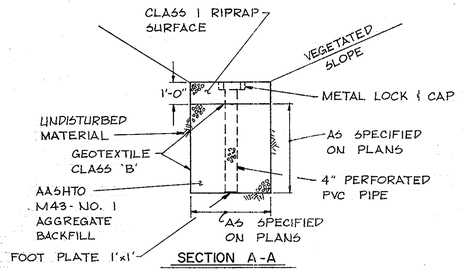
2.) INFILTRATION FACILITIES SHALL BE CONSTRUCTED IN ACCORDANCE WITH "STANDARDS & SPECIFICATIONS FOR INFILTRATION PRACTICES" (MDE, 1984)



PLAN



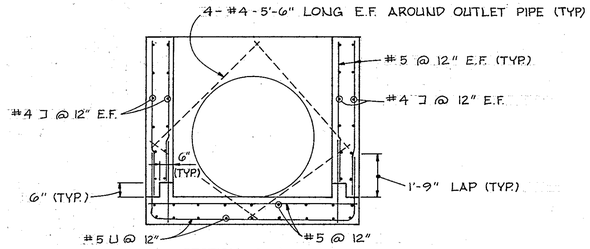
NOTE: SEE SHT. 30 M FOR PROTECTIVE COVER DETAIL & PHASING REQUIRED FOR ALL TRENCHES CONSTRUCTED EAST OF STA. 1660+00, MD. RTE 32.



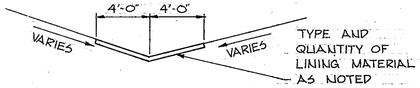
SECTION A-A

INFILTRATION TRENCH TYPICAL DETAIL

N.T.S.

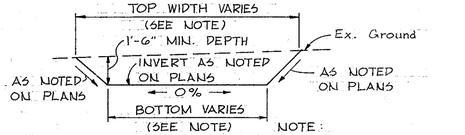


SECTION A-A



MEDIAN AREA DITCH LINING TYPICAL DETAIL

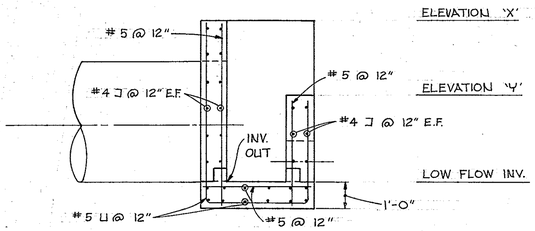
N.T.S.



NOTE: TOP & BOTTOM WIDTH VARY. SEE PLANS FOR STATIONS & OFFSETS OR CONTOUR GRADING TO DETERMINE ACTUAL SIZE

INFILTRATION BASIN TYPICAL DETAIL

N.T.S.



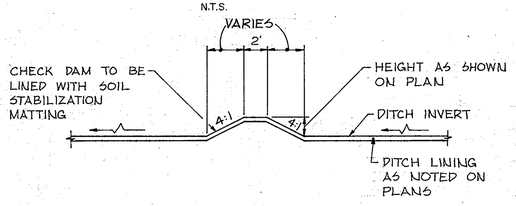
SECTION B-B

STRUCTURE / MD. 32 STA.	'A' (Ø)	'B' (Ø)	LOW FLOW INV.	INV. OUT	'X' (TOP)	'Y' (WEIR)
S-1 / STA. 1613+53, RT.	18"	48"	154.0	153.7	158.7	156.5
⚠2 ✱ S-2 / STA. 1626+15, LT.	12"	36"	185.0	185.0	189.0	186.5
✱ S-3 / STA. 1636+92, RT.	18"	54"	193.0	193.0	199.0	196.2
✱ S-4 / STA. 1658+42, LT.	12"	48"	201.0	200.5	205.5	202.75

✱ SEE DETAIL SHEET 30 L FOR UTILIZING STRUCTURE AS TEMPORARY SED. BASIN RELEASE STRUCTURE

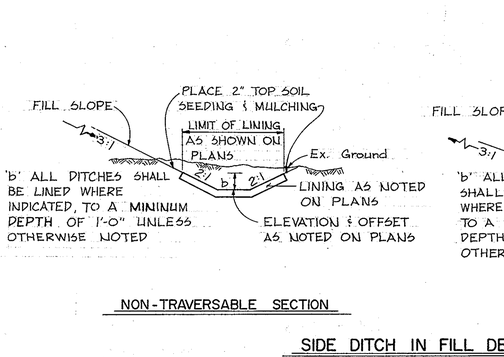
SWM RELEASE STRUCTURE S-1, S-2, S-3, & S-4 PLAN, SECTIONS & DETAILS

N.T.S.



CHECK DAM DETAIL

N.T.S.

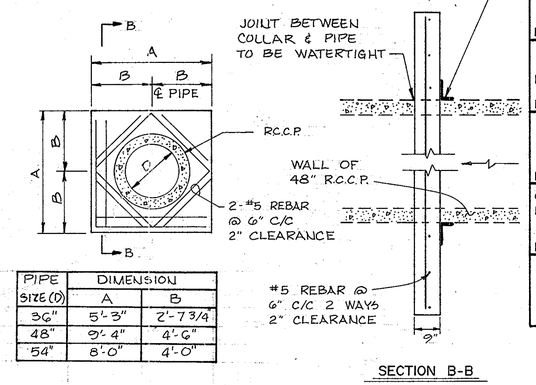


NON-TRAVERSABLE SECTION

TRAVERSABLE SECTION

SIDE DITCH IN FILL DETAILS

N.T.S.

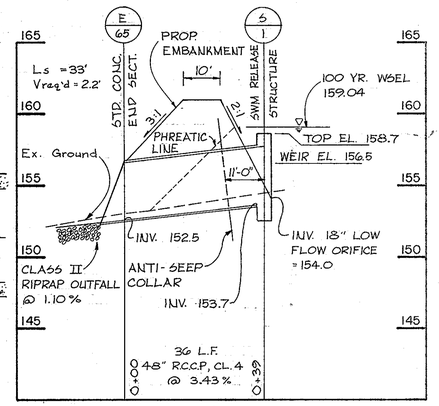


PIPE SIZE (D)	DIMENSION A	DIMENSION B
36"	5'-3"	2'-7 3/4
48"	9'-4"	4'-6"
54"	8'-0"	4'-0"

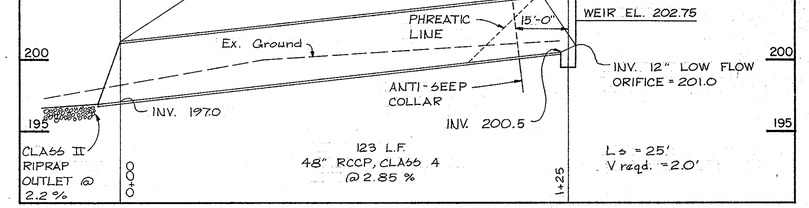
SECTION B-B

⚠2 ANTI-SEEP COLLAR

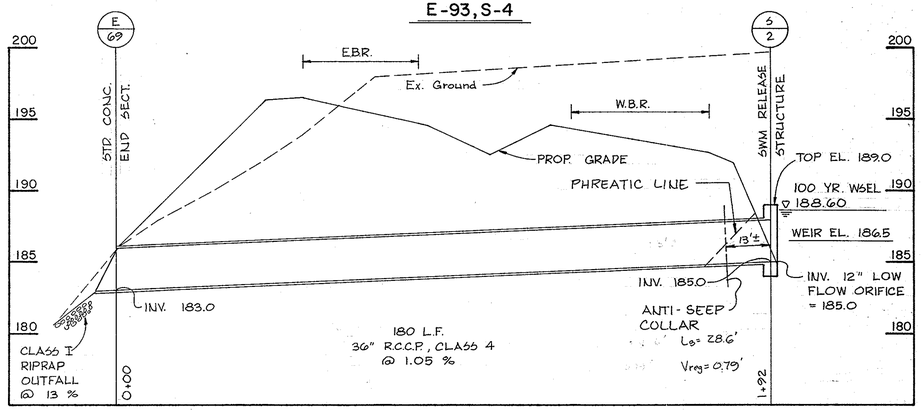
N.T.S.



E-65, S-1



E-93, S-4



⚠2 E-69, S-2

REVISIONS
⚠2 ADDENDUM No. 2 10/20/89

JOHNSON MIRMIRAN & THOMPSON, P.A.
810 GLENEAGLES CT.
BALTIMORE, MARYLAND

NOTE: SCALE FOR PROFILES (TYP.) HORIZ: 1"=20' VERT: 1"=5'

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION
MARYLAND ROUTE 32
EAST OF MD. RTE. 175 TO WEST OF MD. RTE. 3

CONT. NO. AA 739-502-570 F.A.P. NO. SEE TITLE SHEET SHEET NO. 99 OF 365
PREL. TRAC. BY _____ FINAL TRAC. BY _____

F H WA REGION NO	STATE	FED AID PROJ NO	SHEET NO	TOTAL SHEETS
3	MD.	SEE TITLE SHEET	67	365

BENCH MARKS

B.M # 137 ELEV. 196.09
S.H.A. SPIKE IN POWER POLE # G & E 131439
52' LT. OF TRAVERSE LINE, STA. 500+82
BOOK NO. 31354, PAGE 42.

INFILTRATION TRENCH

STA. 1621+50 TO 1622+00,RT
CONSTRUCT 50'L x 4'W x 4'D (MIN)
INFILTRATION TRENCH- 34 C.Y.
BOTTOM ELEV. = 176.0
STA. 1622+50 TO 1623+00,RT
CONSTRUCT 50'L x 4'W x 4'D (MIN)
INFILTRATION TRENCH- 34 C.Y.
BOTTOM ELEV. = 180.5
STA. 1623+80 TO 1624+80,RT
CONSTRUCT 100'L x 4'W x 4'D (MIN) 020043
INFILTRATION TRENCH- 67 C.Y.
BOTTOM ELEV. = 187.0
STA. 1621+00 TO 1622+00,℄
CONSTRUCT 100'L x 6'W x 4'D (MIN) 020038
INFILTRATION TRENCH- 100 C.Y.
BOTTOM ELEV. = 182.0
STA. 1622+25 TO 1623+25,℄
CONSTRUCT 100'L x 6'W x 4'D (MIN) 020039
INFILTRATION TRENCH- 100 C.Y.
BOTTOM ELEV. = 183.0
STA. 1623+50 TO 1624+50,℄
CONSTRUCT 100'L x 6'W x 4'D (MIN) 020040
INFILTRATION TRENCH- 100 C.Y.
BOTTOM ELEV. = 185.0
STA. 1618+05 TO STA. 1619+00, RT
CONSTRUCT 100'L x 4'W x 3'D (MIN.) INFILTRATION TRENCH- 52 C.Y. BOTTOM ELEV.= 178.0

EARTH DIKE FOR SEDIMENT CONTROL

STA. 1615+50 TO STA. 1619+00, LT
350 L.F.- DIVERSION DIKE

TEMPORARY SWALE

STA. 1621+70 TO STA. 1622+75, LT. (TO DIVERT FLOW TO T.ST. 66 PRIOR TO CONSTRUCTION OF INFILTRATION BASIN)

TEMPORARY SEDIMENT BASIN No. 3

SEE NOTE ON SHEET No. 69

STA. 1615+00, RT. TO STA. 1620+54, LT.

CONSTRUCT 2 EA.- STD. TYPE 'K' INLET (STD. NO. MD.- 378.05) 1-45, 1-47
1 EA.- STD. TYPE 'K' INLET DBL. GRATE TANDEM (STD. NO. MD.- 378.02) 1-46
1 EA.- STD. MANNHOLE WITH TYPE A FRAME AND COVER (STD. NOS. MD.- 383.01, 383.31 383.32) M-2
733 L.F. 36" R.C.C.P. CLASS IV
1 EA.- STD. 36" CONC. END SECTION (STD. NO. MD. 368.01) E-66
46 S.Y. CLASS I RIPRAP

STA. 1615+00, RT. TO STA. 1620+80, RT.

CONSTRUCT 1 EA.- STD. TYPE 'K' INLET (STD. NO. MD.-378.05) 1-45
118 L.F. 24" R.C.C.P. CLASS IV
1 EA.- STD. 24" CONC. END SECTION (STD. NO. MD.- 368.01) E-66
46 S.Y. CLASS I RIPRAP

STA. 1620+54, LT. TO STA. 1620+80, RT.

CONSTRUCT 2 EA.- STD. TYPE 'K' INLET DBL. GRATE TANDEM (STD. NO. MD.- 378.02) 1-46,47
163 L.F. 36" R.C.C.P.- CLASS IV
1 EA.- STD. CONC. END SECTION FOR 36" PIPE (STD. NO. MD 368.01)
78 S.Y. CLASS I RIPRAP

BERM DITCH, LT.

STA. 1619+00 TO STA. 1623+00
-70 S.Y. CLASS I RIPRAP
-281 S.Y. SOIL STABILIZATION MATTING

MEDIAN DITCH

STA. 1614+00 TO STA. 1626+00, ℄
-1067 S.Y. SOIL STABILIZATION MATTING

SURFACE DRAIN DITCH

STA. 1614 +00 TO STA. 1620+50, LT.
1211 S.Y. SOIL STABILIZATION MATTING
STA. 1618+50 TO STA. 1619+77, RT.
STA. 1623+76 TO STA. 1625+75, RT.
450 S.Y. SOIL STABILIZATION MATTING
STA. 1622+50, TO 1624+50, LT
1211 S.Y. SOIL STABILIZATION MATTING

SPIRAL № 71

Ls = 730.00'
θs = 9°-07'-30.0"
Lt = 487.32'
St = 243.92'

2' BOTTOM SIDE DITCH, RT.

STA. 1616+00 TO STA. 1618+50
STA. 1619+78 TO STA. 1623+78
STA. 1625+75 TO STA. 1626+00
SIDE SLOPES: VARY
-661 S.Y. SOIL STABILIZATION MATTING

SLOPE SILT FENCE, RT.

STA. 1614+00 TO STA. 1617+30, 350 L.F.
STA. 1619+78 TO STA. 1621 +00,125 L.F.
STA. 1625+50 TO STA. 1626+00, 50 L.F.

INLET SEDIMENT TRAP

90 L.F. CHANNEL SILT FENCE
STA. 1615+00, ℄ STA. 1620+54, LT
STA. 1620+80, ℄
40 [1]

CURVE № 6

Δ = 35°-34'-07"
D = 2°-30'-00"
R = 2291.83'
T = 735.14'
L = 1422.75'
E = 115.02'
S/E = 0.075 ¼

CLASS I RIPRAP

STA. 1615+80 TO STA. 1616+00, RT
35 S.Y. 20'L x 15'W

STONE OUTLET STRUCTURE SEDIMENT TRAP

CONSTRUCT T.ST. No. 15 STA. 1615+85, LT.
CONSTRUCT T.ST. No. 16 STA. 1621+00, RT.
CONSTRUCT T.S.T. No. 66 STA. 1620+95, LT.
CONSTRUCT T.ST. No. 70 STA. 1620+80, ℄
CONSTRUCT T.S.T. No. 105 STA. 1615+20, ℄
12 TONS PLACED RIPRAP FOR SEDIMENT CONTROL
12 SY. GEOTEXTILE CLASS 'B'

INFILTRATION BASIN

STA. 1620+98 TO STA. 1621.+97, LT., MD 32 - CONSTRUCT INFILTRATION BASIN AT INV. 182.0 WITH 2:1 SIDE SLOPES TO LIMITS SHOWN.

TEMPORARY STD. TRAFFIC BARRIER 'W' BEAM BARRICADE

STA. 1617+00, RT.- 12.5 LF, 3 POSTS

CHAIN LINK FENCE - BLACK VINYL COATED

CONSTRUCT 6-FOOT CHAIN LINK FENCE AS DIRECTED BY THE ENGINEER
STA. 1614+00 TO STA. 1626+00, RT.
1390 LF - 6 FOOT FENCE
10 EA.- TERMINAL POSTS

STD. TRAFFIC BARRIER 'W' BEAM

MD.32 E.B.R. - STA. 19+25 TO STA. 24+10
500 L.F. ON RIGHT
BURY ENDS IN CUT SLOPE RIGHT OF STA. 1619+25 & STA. 24+10

STD. TRAFFIC BARRIER 'W' BEAM BARRICADE

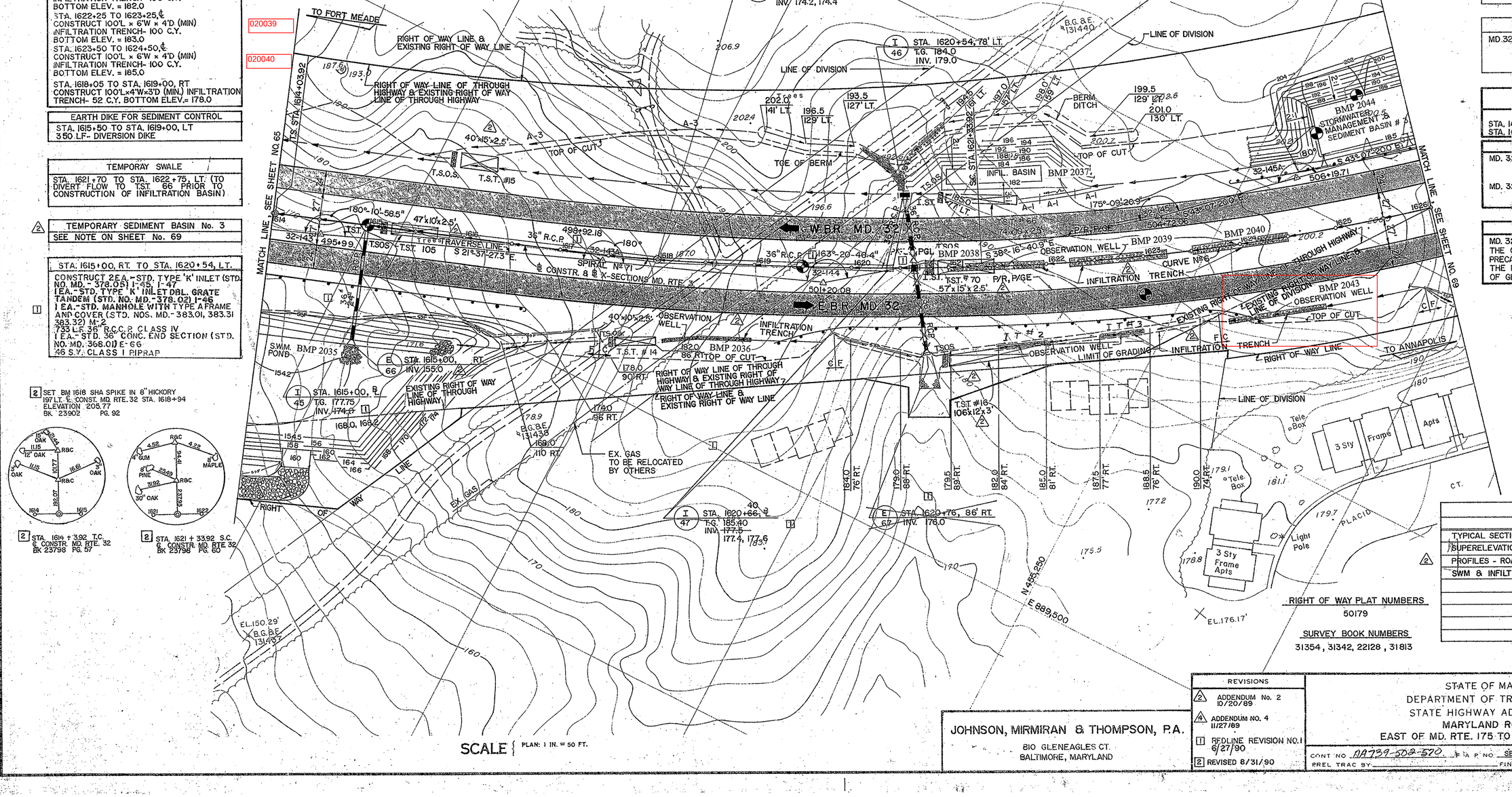
STA. 1617+75, LT. - 12.5 LF, 3 POSTS
STA. 1621+00, LT. - 12.5 LF, 3 POSTS

STD. TRAFFIC BARRIER 'W' BEAM

MD. 32 W.B.R., STA. 1624+00 TO STA. 1626+00
1 EA. -TRAIL END ANCHORAGE
193 LF ON LEFT.
MD. 32 E.B.R., STA. 1614+00 TO STA. 1616+75
1 EA.- TRAIL END ANCHORAGE
275 LF ON RIGHT.

CLEARING & GRUBBING

MD. 32 E.B.R, STA. 1617+00 TO STA. 1626+00 THE CONTRACTOR SHALL TAKE SPECIAL PRECAUTIONS TO NOT CLEAR AND GRUB THE EXISTING WOODS BEYOND THE LIMITS OF GRADING INDICATED ON THE PLAN.



[2] SET BM 1618 SHA SPIKE IN 6" HICKORY 197 LT. ℄ CONST. MD. RTE. 32 STA. 1618+94 ELEVATION 205.77 BK 23902 PG. 92

[2] STA. 1614 + 3.92 T.C. ℄ CONSTR. MD. RTE. 32 BK 23798 PG. 57

[2] STA. 1621 + 33.92 S.C. ℄ CONSTR. MD. RTE 32 BK 23798 PG. 60

CROSS REFERENCES

ITEM	SHEET NO.
TYPICAL SECTIONS	3
SUPERELEVATION DIAGRAMS	20
PROFILES - ROADWAY	68
SWM & INFILTRATION DETAILS	99

RIGHT OF WAY PLAT NUMBERS
50179

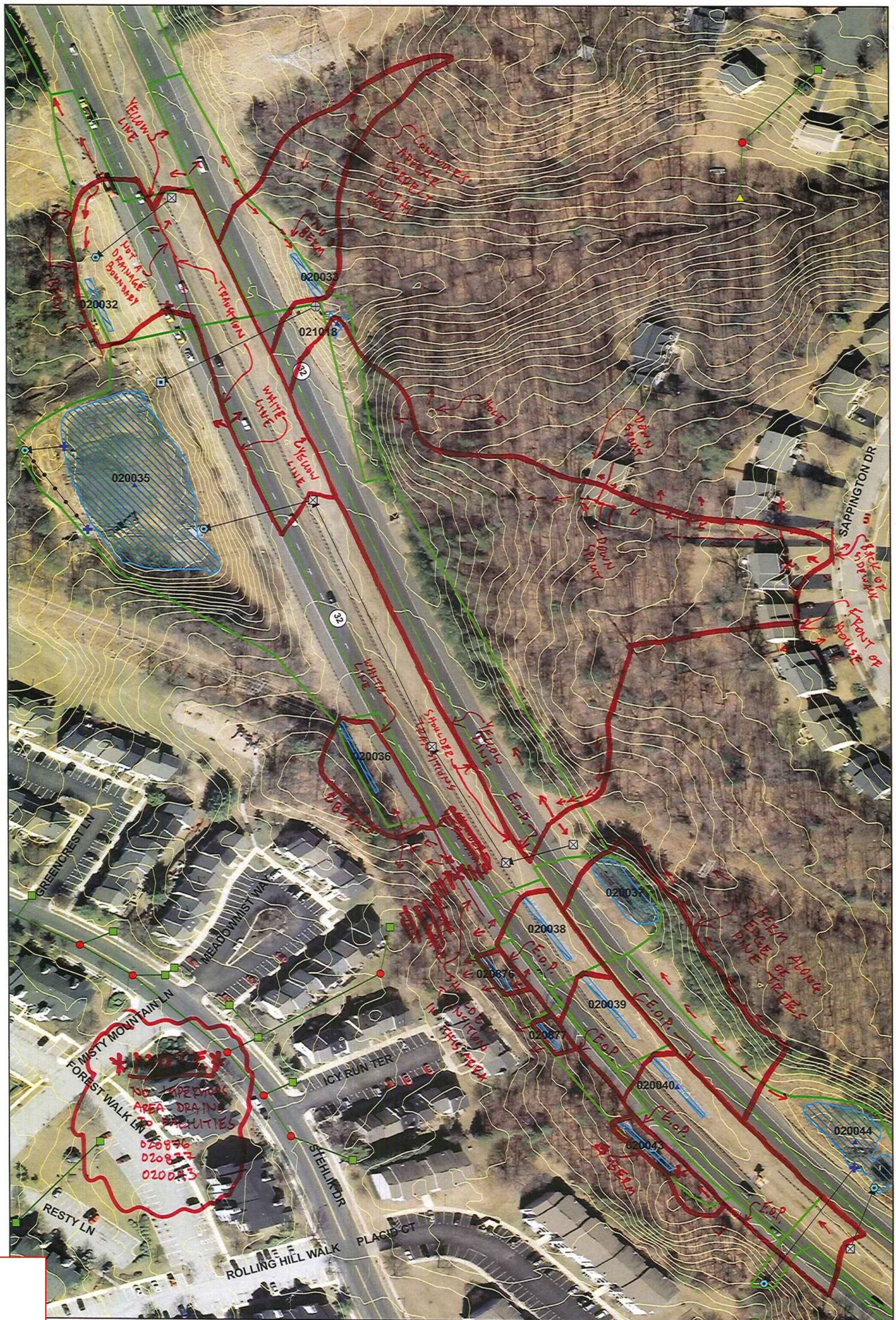
SURVEY BOOK NUMBERS
31354, 31342, 22128, 31813

REVISIONS
[2] ADDENDUM No. 2 10/20/89
[4] ADDENDUM NO. 4 11/27/89
[1] REDLINE REVISION NO.1 6/27/90
[2] REVISED 8/31/90

JOHNSON, MIRMIRAN & THOMPSON, P.A.
810 GLENEAGLES CT.
BALTIMORE, MARYLAND

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION
MARYLAND ROUTE 32
EAST OF MD. RTE. 175 TO WEST OF MD. RTE. 3

CONT NO AA739-503-520 F A P NO SEE TITLE SHEET SHEET NO 67 OF 365
PREL. TRAC BY: FINAL TRAC BY:



Anne Arundel

BMP 020032, 033, 036 thru040, 043, 877, 021018

IFT IFT IFT IFT IFT IFB

N

036 - IFT
037 - IFB
038 - IFT
039 - IFT

Appendix C

MDOT SHA
Plan Review Division -
Annual Report

Appendix C

MDOT SHA Plan Review Division
Annual Report

Note:

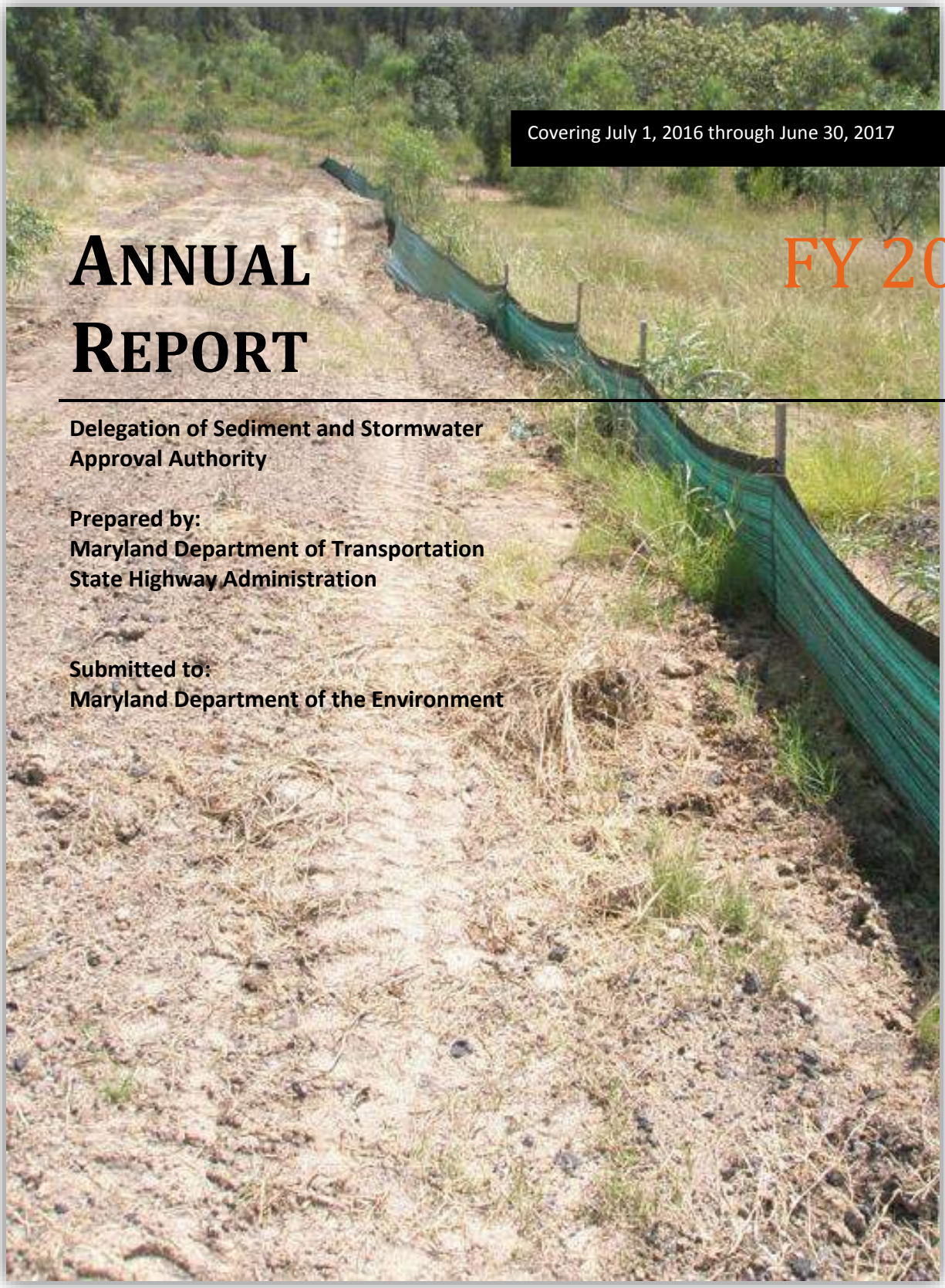
Electronic data, accompanying this MDOT SHA PRD Annual Report has been submitted to MDE via an external hard drive.

The external hard drive includes the following data:

- PRD Data Table That Include Project Data, Approvals, Waivers, And Variances
- Public and Agency Meeting Materials
- Representative Projects
- Guidelines, Administrative Procedures, and Technical Procedures
- Erosion and Sediment Control Inspections, Non-Compliant Inspections, and Enforcement Actions

MARYLAND DEPARTMENT OF TRANSPORTATION

STATE HIGHWAY ADMINISTRATION



Covering July 1, 2016 through June 30, 2017

ANNUAL REPORT

FY 2017

Delegation of Sediment and Stormwater Approval Authority

Prepared by:
Maryland Department of Transportation
State Highway Administration

Submitted to:
Maryland Department of the Environment

MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

Larry Hogan
Governor
Boyd K. Rutherford
Lt. Governor
Pete K. Rahn
Secretary
Gregory Slater
Administrator

October 6, 2017

Jennifer M. Smith, P.E., Manager
Sediment, Stormwater & Dam Safety Program
Maryland Department of the Environment
1800 Washington Boulevard, Suite 400
Baltimore MD 21230

Dear Ms. Smith:

We are pleased to submit our annual report, covering fiscal year 2017. This report is in accordance with our July 8, 2014 Memorandum of Understanding and your February 24, 2015 Letter of Authorization. This program will continue to be funded by MDOT SHA.

We look forward to continuing our collaborative working relationship with the Maryland Department of the Environment (MDE) to successfully and effectively carry out the activities and responsibilities included in our delegated authority agreement. We are committed to working with MDE to ensure that our processes exceed MDE expectations. We welcome your input to modify or expand future reports to meet MDE requirements. If you have any questions or comments regarding this report, please contact Angela Smith, P.E., MDOT SHA Office of Highway Development Deputy Director, at (410) 545-8790, or via email at ASmith@sha.state.md.us.

Sincerely,

Eric Marabello, P.E.
Acting Director, MDOT SHA Office of Highway Development

cc: Laura Ridler, P.E., Chief, Plan Review Division, MDOT SHA
Sonal Ram, P.E., Director, Office of Environmental Design, MDOT SHA
Angela Smith, P.E., Deputy Director, Office of Highway Development, MDOT SHA

TABLE OF CONTENTS

Cover Letter 2

Section 1

1.1 MDOT SHA Response to MDE FY 2016 Review Comments 4
1.2 Introduction 8
1.3 Project Status 8
1.5 Design Elements Not Meeting ESD to the MEP 11
1.6 Significant Staffing Changes 13
1.7 Local Agency Comments and Responses 14
1.8 Summaries of Public Outreach Meetings 14
1.9 Investigations of Citizen Complaints and Inquiries 15
1.10 Plan Review Program Activity Findings 18
1.11 Modifications to the Guidelines and Procedures 18
1.12 Electronic Data 19

SECTION 2

2.1 Project Status Reports 20
2.2 Waivers and Variances 84
2.3 Water Quality Bank Debits 121
2.4 Public and Agency Meeting Summary 123

1.1 MDOT SHA RESPONSE TO MDE FY 2016 REVIEW COMMENTS

Reporting Requirement	MDOT SHA Response
Reporting	This MDOT SHA response covers MDE comment letters dated February 9, 2017 (Field Audit) and March 3, 2017 (Annual Report). The reporting dates, deadlines, and format for future annual reports are noted. This current report covers FY 2017 (July 1, 2016 through June 30, 2017). This report is included as Appendix C of the MDOT SHA MS4 Annual Report. As requested, E&SC and SWM statistics have been included in the MS4 geodatabase.
Project Status Reports	The request for statistics for design and construction activity to be included within the MS4 geodatabase is noted. The PRD MS4 geodatabase is provided on the data drive included with the annual report. Electronic copies of all plans and documents for the representative projects are also included on the data drive. Approved SWM plans will be available on-site during future field audits. Comments regarding the representative projects submitted with the FY 2016 annual report were reviewed and responses are listed below: <u>15-PR-0003</u> This project was granted final approval on June 8, 2015 and there have been no submissions within the reporting period. Project files are not included with this report, since complete files were included with the FY 2016 report. PRD encourages designers to limit calculations to significant digits by providing written comments to that effect. This information has also been included in the Technical Procedures submitted for review and approval with this annual report. <u>15-PR-0023</u> This project was granted final approval on November 14, 2016 and is currently under construction. At the time of final approval, PRD was unaware of the incorrect Use classification for the wet pond receiving stream. MDOT SHA is currently studying available options for modifying the facility and/or mitigating for thermal impacts due to the facility. This project is currently under construction and a study has been initiated to investigate options for mitigating the thermal impacts due to the wet pond. To avoid this issue in the future, a section has been added to the Technical Procedures discussing Use categories and how to determine them. In addition, all reviewers have been reminded that Use categories should be verified during concept review using available MDOT SHA GIS tools. <u>15-PR-0047</u> Your comment regarding water quality credits is noted and PRD will allow Chapter 3 bioretention facilities to credit the WQ Bank. <u>15-PR-0073</u> Bioswales 1-4, 1-5, and 1-6 have been re-designed to eliminate saw tooth steps. The perforated sub-drain for SGW 3-1 was revised to be perpendicular to the flow path prior to Site Development Approval. MDOT SHA designers are reviewing options to reduce the drainage area to rain garden RG 1-1 or split the facility into two smaller ones. The project has an overall water quality credit and it appears that Cpv can still be addressed if the drainage area is reduced. To avoid this

	issue in the future, a cross check will be added to the PRD database that will flag facilities where the maximum drainage area is exceeded. 15-PR-0084 Due to budget constraints, this project has been put on hold indefinitely. No submittals were received during this reporting period, so no electronic files are provided with this current annual report. Regarding tables within the report, currently each consultant has their own method of presenting data within a SWM report. For consistency and ease of review, PRD is developing standard formats for stormwater summary tables to be implemented during FY 2018. 15-PR-0095 This project was placed on the Production schedule due to funding constraints and is expected to be constructed in FY 2020. PRD agrees that a general approval for these types of projects would be beneficial and will continue to work with MDE on an acceptable general approval for safety and resurfacing projects. 15-PR-0097 This design-build project is currently under construction, with the bulk of the design already completed and approved. MDOT SHA is cautious about using a WQ bank when a POI discharges directly to a wetland. Out of 48 identified POI/LOI, two POIs discharge to existing wetlands. POI 4-7B is in the Chester River watershed (02-13-05) and POI 62 is in the Choptank River watershed (02-13-04): • POI 4-7B is an outfall to the south of Access Road 2. This access road is proposed to increase safety on MD 404 by eliminating driveways from individual homes along MD404 and providing access to 4 homes from Dulin Road. A wetland is adjacent to and abutting the south side of Access Road 2, so the roadway is cross-sloped to the north and treatment practices are provided. The access road requires 0.74 acres of treatment and the swales can only treat 0.34 acres because of right-of-way and the proximity of the wetlands. MDE Nontidal Wetlands Division was involved in several iterations of Access Road 2 layouts given the adjacent forested wetland, and eventually approved the final location. • POI 62 is at the extreme eastern end of the project on the north side of existing dualized MD 404. Roadside ditches along existing MD 404 WB are considered wetlands and the ditches being constructed as part of this project tie into them. Treatment falls short by 0.43 acres of impervious because existing wetlands in the roadside ditches would need to be destroyed to create the wet swales needed for treatment. Overall, this project will provide 7.00 acres of excess impervious area treatment for the Choptank River Watershed as a result of the MD 404 construction. 15-PR-0128 A detail of the typical LOD for guardrail end treatments was included in Contract Documents before PRD provided final approval.

QA/QC Activities and Summary of Site Inspections	Regarding the need to improve stabilization due to lack of stabilization, poor coverage of seed and mulch, questionable maintenance of SCE's: Not all stabilization issues found required a programmatic change from the Quality Assurance Program compliance check, but did identify additional improvements to the general program. The QA Program does verify the project record to see if the correct application of amendments has been placed per the contract documents. Program improvements included: • The QA Program continues to meet monthly where discussions, exercises, specification review, lessons learn, etc. are accomplished in effort to build consistency and improve knowledge base. • The QA Program implemented a peer review (of field work) where REC's reviewed, critiqued and documented each other's efforts for group discussion and improvement. Improving stabilization remains a focus item. • The QA Program also implemented an oversight spot check where team leaders review REC's field work with a focus on improving stabilization. • The QA Program participated in specification change to eliminate the stabilization exemption at subgrade, the use of matting in lieu of straw mulch for smaller areas and the increase use of wash racks to prevent tracking onto roadways in 2017. • From November 19, 2016 through August 7, 2017 14 non-compliances ("D" and "F" ratings) were given and 14 of them involved a questionable stabilization practices. The same period also identified 3 with questionable SCE practices. These statistics still demonstrate continuing issues, however, with an increase compliance observation. Regarding the need to reduce offsite impacts due to questionable dewatering activities: Any dewatering failures found are unacceptable and considered non-compliant. Program improvements included: • The QA Program continues to meet monthly where discussions, exercises, specification review, lessons learn, etc. are accomplished in effort to build consistency and improve knowledge base. • The QA Program implemented a peer review (of field work) where REC's reviewed, critiqued and documented other efforts for group discussion and improvement. Reducing offsite impacts due to questionable dewatering activities remains a focus item. • The QA Program implemented an oversight spot check where team leaders review REC's field work with a focus on improving dewatering activities. • From November 19, 2016 through August 7, 2017 14 non-compliances ("D" and "F" ratings) were given and 3 of them involved questionable dewatering practices. Increase compliance observation remains part of the solution to improving dewatering activities.
ESD to the MEP Design Elements	PRD has noted MDE's comments regarding greater detail in the justifications for waivers and variances. Our documentation process for waivers, variances, and WQ bank debits has been implemented in our database and the overall statistics are included in the MS4 geodatabase. Stormwater Project Review Summary Sheets will be provided for field audited projects. PRD will continue to work with MDE on standard design spreadsheets.

Changes to the Approved Standard Operating Procedures (SOPs)	Several changes to the Guidelines and Procedures have been made during this reporting period. Word files are included on the data drive. Changes are tracked in the documents showing revisions since the updates submitted to MDE on 2/22/2016. Technical Procedures have been finalized and are submitted on the data drive with this report for review and approval by MDE.
Changes to Staff	Significant staffing changes during FY 2017 are reported in Section 1.6
Local Agency Comments	MDE comments regarding formal local agency stormwater management comments are noted. Most coordination with local agencies occurs informally through email or phone conversations. During the reporting period, agency meetings were held on 4 projects under review at PRD. Summaries of agency meetings are located in Section 2.4. Copies of the meeting materials are located on the enclosed data drive.
Public Outreach Meetings	During this reporting period, meetings were held on 11 projects under PRD review. Summaries of the projects and the public meetings are located in Section 2.4. Copies of the meeting materials are located on the enclosed data drive.
Citizen Complaints and Inquiries	MDOT SHA will continue to provide specific and focused information of citizen complaints and inquiries in relation to the projects being reviewed by PRD with respect to Sediment and Stormwater topics in the annual reports. The current annual report contains summaries of ten projects in Section 1.9.
Plan Review Program Activity Findings	MDE comments regarding TMDL projects are noted. The TMDL program's default design is per the stormwater manual. Only in instances of hardship will other solutions be accepted for restoration projects. Discussion regarding allowing more than one foot of ponding for the 1" storm in submerged gravel wetlands (SGW) is ongoing and no decision has been made.

1.2 INTRODUCTION

The Maryland Department of Transportation State Highway Administration (MDOT SHA) and the Maryland Department of the Environment (MDE) signed a Memorandum of Understanding (MOU), dated July 8, 2014, designating MDOT SHA as an approving authority for erosion and sediment control and stormwater management plans for MDOT SHA projects in accordance with the applicable sections of the Code of Maryland (COMAR). This authority was given by a letter of authorization from MDE on February 24, 2015. This report serves to satisfy the MOU condition to report on relevant activities on an annual basis after the first year of delegated authority. This report covers fiscal year 2017 (FY 2017) and includes the time period from July 1, 2016 through June 30, 2017. This annual report includes:

- Project status reports detailing the progress of design, review, approval, and construction activity achieved to date
- Findings related to plan review program activities
- Explanations and justifications for any design elements not meeting Environmental Site Design (ESD) to the Maximum Extent Practicable (MEP) according to the Design Manual or the 2011 Standards
- Changes or modifications to the Guidelines and Administrative Procedures
- Significant staffing changes
- Summaries of site inspections conducted
- Comments received and written responses provided to local agencies
- Findings related to quality assurance and quality control activities
- Summaries of public outreach meetings
- Investigations of citizen complaints and inquiries

1.3 PROJECT STATUS

The Plan Review Division maintains a database to track submittals and approval progress on all projects. The majority of the active projects during the reporting period were Design-Bid-Build (89%). The second most common project type was MDE approved projects (10%) submitted to PRD for modifications or for SWM BMP approval. The smallest group of projects, Design-Build, were only 1% of the active projects, however, they represented 12% of the overall submissions. Overall submissions to PRD doubled from FY 2016 to FY 2017.

Project status reports included in Section 2.1 show the progress of design, review, approval, and construction activity achieved during the reporting period. The reports are separated by project type (DBB, DB, MDE). Fifteen of the DBB projects shown below were transferred from MDE to PRD in accordance with a letter from MDE dated December 20, 2016. These projects had been reviewed by MDE but had not yet received final approval when they were transferred

to PRD. All were assigned PR numbers, but reviews continued using the same consultant expedited reviewers and the same review criteria that had been applied to the projects at MDE. These projects were reviewed as concept and final, rather than concept, site development, final. Project Summary Data for all projects is included in a data table on the data drive included with this report. As requested by MDE, this data table replaces the SHA Stormwater Project Review Summary Sheets that were submitted with previous reports. Summaries of Plan Review Division review and approval activity and SWM BMP as-built approvals are included below:

FY 2017 Review and Approval Activity

	Design-Bid- Build Projects (DBB)	Design-Build Projects (DB)	MDE Approved Projects (MDE)	Total
FY 2017 Active Projects	352 (89%)	4 (1%)	38 (10%)	394
Submissions Received	1086 (85%)	148 (12%)	50 (4%)	1284
Comment Letters Issued	599 (85%)	89 (13%)	16 (2%)	704
Concept Approvals	202 (99%)	2 (1%)	0 (0%)	204
Site Development Approvals	140 (99%)	1 (1%)	0 (0%)	141
Final Approvals	120 (99%)	1 (1%)	0 (0%)	121
Modification Approvals	24 (26%)	54 (57%)	16 (17%)	94

FY 2017 SWM BMP As-Built Approvals*

PRD/MDE No.	Contract No.	Action	Date	BMP's Approved*	Total Project BMP's
15-PR-0016	WA2815123	Approved	09/13/2016	1	1
06-SF-0227	CA3255170	Approved	03/10/2017	2	3
08-SF-0234	SO4095171	Approved	05/08/2017	1	1
09-SF-0199	MO5935270	Approved	05/17/2017	1	1
10-SF-0225	HO3785187	Approved	03/22/2017	1	1
11-SF-0138	HA2425180	Approved	05/02/2017	2	2
12-SF-0036	AA2705130	Approved	06/06/2017	5	5
12-SF-0084	CA3825176	Approved	03/08/2017	4	4
12-SF-0093	MO5825180	Approved	03/21/2017	1	1
12-SF-0152	HO4725176	Approved	02/01/2017	20	20
12-SF-0274	WI3835130	Approved	05/17/2017	3	3
12-SF-0326	BA4215180	Approved	02/02/2017	11	11
12-SF-0404	BA6075180	Approved	04/18/2017	1	1
13-SF-0078	PG5435174	Approved	01/20/2017	1	1
13-SF-0313	AL3605180	Approved	03/22/2017	1	1
14-SF-0236	MO1405229	Approved	04/18/2017	1	1
			Total:	56	

***PRD Structural acceptance. Final acceptance by MDOT SHA requires verification of vegetative establishment by Landscape Operations Division (LOD)**

Representative Projects

Electronic copies of submissions, comment letters, and approvals were submitted for twelve representative projects with the FY 2016 annual report. Nine of these projects had activity in FY 2017 and updated electronic data is included on the data drive enclosed with this report. Three of the FY 2016 representative projects had no activity during FY 2017 and no electronic data is provided. As noted below, one project has been delayed until FY 2020 due to budgetary constraints. PRD has selected five additional representative projects to replace the inactive projects. Electronic data for the five additional projects is also included on the data drive. A summary of activity for the representative projects is included in Section 2.1.

- 15-PR-0003, BA7295470, MD 140 Culvert Breakout *(under construction and no submissions were received during FY 2017)* ***No electronic data provided***
- 15-PR-0023, AA4365471, MD 175 from Reece Road to Disney Road
- 15-PR-0047, CL8415184, MD 31 Streetscape
- 15-PR-0073, MO7465171, MD 97 Brookville Bypass
- 15-PR-0084, MO8915270, US 29 from Fairland Road to Musgrove Road *(on hold and no submissions were received during FY 2017)* ***No electronic data provided***
- 15-PR-0095, MO1835177, MD 650 from Milestone Drive to Shaw Avenue *(delayed until FY 2020)*
- 15-PR-0097, AW8965170, MD 404
- 15-PR-0098, AX7665682, TMDL Retrofits in District 3
- 15-PR-0123, MO8695285, MD 185 Signal and ADA Improvements *(approved in FY 2016 and no submissions were received during FY 2017)* ***No electronic data provided***
- 15-PR-0128, HO1775177, I-70 Eastbound Safety and Resurfacing
- 16-PR-0019, AA5105271, MD 198 from Russett Green East to MD 295
- 16-PR-0069, GA6715184, US 219 from MD 135 to East Orchid Street
- 16-PR-0081, AA1795177, MD 295 from MD 175 to MD 100 **(new)**
- 16-PR-0125, AT6885174, Drainage Improvements in Carroll and Frederick Counties **(new)**
- 17-PR-0023, AA4365371, MD 175 from National Business Parkway to McCarron Court **(new)**
- 17-PR-0061, GA4145177, MD 450 from MD 135 to Crabtree Creek **(new)**
- 17-PR-0072 (Formerly 14-SF-0222), MO1505388, MD 124 from Dosh Drive to MD 117 **(new)**

1.4 QA/QC Activities and Summaries of Site Inspections

MDOT SHA ensures quality assurance and quality control (QA/QC) of approved erosion and sediment control plans through inspections of MDOT SHA construction projects for compliance with the approved Erosion and Sediment Control Plans, utilizing a checklist and rating system. MDOT SHA's quality assurance inspections are performed by Regional Environmental Coordinators (REC). MDOT SHA utilizes a real-time inspection and reporting system called the QA Toolkit.

During this period, MDOT SHA performed 3,877 inspections on 382 projects. Twenty-five projects were found to be non-compliant with a grade of D or F during this reporting period. The non-compliances were subsequently corrected. Eleven projects had their grading operations shut down until corrective actions were completed. Fourteen projects were shut down completely until corrective actions were completed. Shutdowns cause significant financial impacts to the contractor as all deployed material, equipment and construction laborers become inactive until the deficiencies are addressed. This is one of the largest sanctions that promotes contractor attention and greatly reduces chances of repeat non-compliance. Additionally, liquidated damages are deployed to recover MDOT SHA's financial impact. Revocation of contractor Erosion Sediment Control Manager (ESCM) and Contractor Superintendent are a separate sanction that impacts the contractor since such certification is a requirement for those personnel to be employed on an MDOT SHA project. Revocation is activated for a period of six months upon two ratings of 'F'. Certification revocations are listed in each project inspection report. There was 1 Yellow Card revocation during this reporting period. Details of the non-compliance findings and the actions taken, a summary of Quality Assurance Inspections by district, and bi-weekly inspection reports for 6 representative projects are included with the electronic data.

During this period, the total number of project inspections stopped or placed on hold was 178. A list of the projects placed on hold and the reasons for the hold status is included with the electronic data.

1.5 Design Elements Not Meeting ESD to the MEP

The Maryland Legislature enacted the Stormwater Management Act of 2007 which established stringent requirements to implement Environmental Site Design (ESD) to the Maximum Extent Practicable (MEP). MDOT SHA's Plan Review Division reviews each project submission in relation to the requirements, Guidelines, and Procedures. Stormwater Management reports are required for each project. The majority of projects include plans. At concept stage, SWM requirements are reviewed for management required and conceptual management provided as well as the appropriateness of any waivers and variances requested. Site development and final stage submissions are reviewed for engineering design, consistency, and completeness.

MDOT SHA-PRD has utilized the language in COMAR Section 26.17.02.06.A(2) as a basis to determine whether a project meets ESD to the MEP:

> "The MEP standard is met when channel stability and 100 percent of the average annual predevelopment groundwater recharge are maintained, nonpoint source pollution is minimized, and structural stormwater management practices are used only if determined to be absolutely necessary."

This statement is further explained in the MDOT SHA Guidelines Section 4.1 and 4.2 as minimum control requirements for new development and redevelopment.

Section 2.2 includes waiver and variance reports that include a breakdown by project of the waivers and variances accepted and granted during FY 2017. PRD considers waivers and variances to be "accepted" with Concept Approval and "granted" with Final Approval.

The majority of waivers and variances accepted by PRD are for maintenance or redevelopment projects (funds 14, 30, 33, 74, 76, 77, 79, 80, 87, 88). Many of these projects are located in developed corridors with limited opportunities for ESD facilities. They often include small amounts of additional impervious scattered throughout the project (funds 76, 77, 80) or narrow strips of additional impervious along the corridor (funds 33, 79). These project types use the Water Quality Bank to meet WQv requirements when ESD facilities are not practicable.

PRD accepted variances at Concept Approval for 61 projects within FY 2017. The majority of variances were for redevelopment projects, such as Bridge Replacement or Rehabilitation (12 projects), Resurfacing and Rehabilitation (10 projects), Crash Prevention (8 projects), and Intersection Capacity (7 projects). The table below shows waivers and variances accepted in FY 2017 by fund type.

FY 2017 Accepted Waivers and Variances by MDOT SHA Fund Type

Fund	Description	No. of Waivers	No. of Projects with Waivers	No. of Variances	No. of Projects with Variances
14	Maintenance	3	2	0	0
26	Noise Barriers	1	1	0	0
29	Facilities & Equipment	0	0	1	1
30	Crash Prevention	7	4	16	8
33	ADA Retrofit	64	7	22	6
49	Environmental Compliance	1	1	0	0
70	Primary	2	1	0	0
71	Secondary	17	3	18	5
72	Interstate	0	0	1	1
74	Drainage	49	24	0	0
76	Safety & Spot Improvements	1	1	4	3
77	Resurfacing & Rehabilitation	163	31	29	10
79	Sidewalks	6	3	11	5
80	Bridge Replacement/Rehabilitation	47	21	27	12
81	Park and Ride	1	1	0	0
82	TMDL Compliance	12	4	0	0
84	Community Safety/Enhancements	9	3	3	2
87	Intersection Capacity	11	4	15	7
88	Bicycle Retrofit	5	1	2	1
99	Billwork (Reimbursement Projects)	2	1	0	0
	Totals	401	113	149	61

The MDOT SHA Office of Highway Development (OHD) process to ensure ESD to the MEP begins with a project concept design presentation to the OHD Director (Director's Review). Any concerns or issues noted during the Director's Review are addressed before the initial concept submission is made to PRD. This process provides leadership-level commitment to project needs and a focus on ESD to the MEP at a very early stage in the design process.

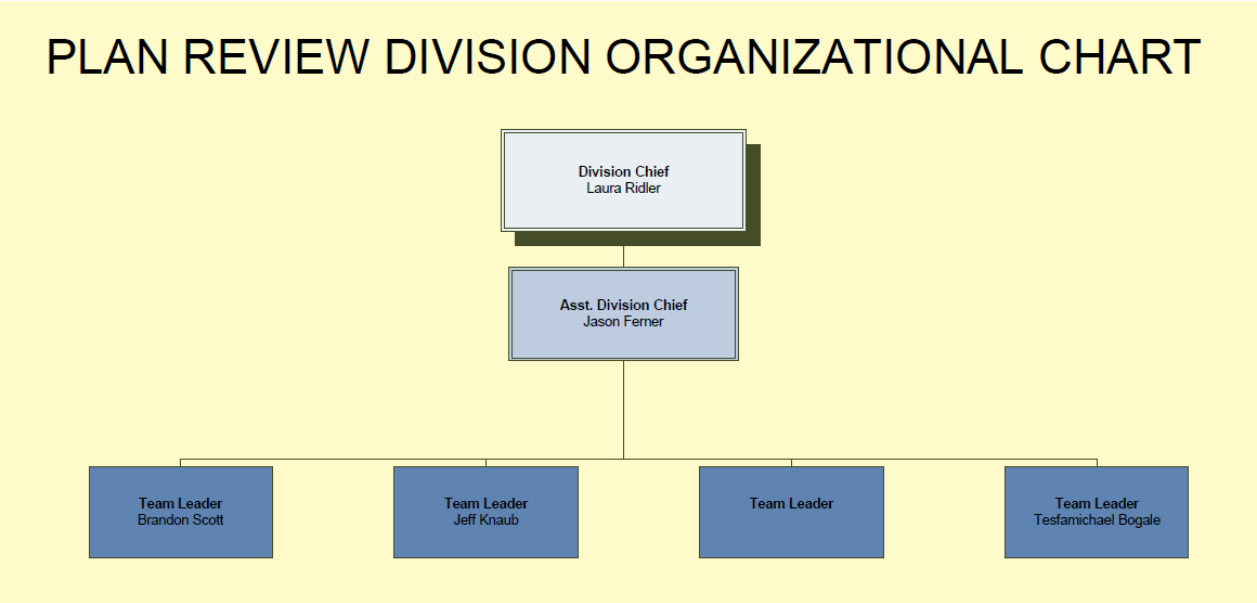
1.6 Significant Staffing Changes

The Plan Review Division had several significant staffing changes during this reporting period. Effective November 23, 2016, Karuna Pujara, PE became Deputy Director of the Office of Materials and Technology, leaving the PRD Division Chief position vacant. Laura Ridler, PE was appointed Division Chief on March 15, 2017.

To fill the vacant Assistant Division Chief position left by Ms. Ridler's promotion, the Office of Highway Development used a competitive selection process including interviews. Jason Ferner, PE was selected to fill the position.

Team Leader Parley Hess, PE left MDOT SHA employment on April 18, 2017. The team leader position was vacant as of the end of this reporting period.

In addition to staffing changes within the Plan Review Division, the Deputy Director overseeing the division also changed. Scott Pomento, PE accepted the position of Director of Planning on December 7, 2016. Angela Smith, PE now oversees the Plan Review Division. The updated organizational chart for the Plan Review Division is included below.



1.7 Local Agency Comments and Responses

No local agencies reached out to PRD during the reporting period. MDE requested examples of comment and response letters with other government agencies. There are no current examples. In relation to specific projects being reviewed by PRD and its coordination with local agencies, MDOT SHA remains committed to being very responsive to requests received. During this reporting period, agency meetings were held for:

- 08-SF-0042, PG6185170, MD 4 at Suitland Parkway
- 16-PR-0047, HO1415170, MD 32 from MD 108 to Linden Church Road (Design Build)
- 17-PR-0075, GA6465270, US 219 from I-68 to Old Salisbury Road (Design Build)
- 17-PR-0088, SM2105171, MD 5 from MD 246 to MD 471

A meeting summary is included in Section 2.4.

1.8 Summaries of Public Outreach Meetings

MDOT SHA values the opinions of the public and holds numerous public outreach meetings to solicit input to add value to our designs and to obtain useful feedback. Typically, a significant public outreach occurs in the planning or design phase before a project is submitted to PRD for review. This early public coordination allows the input to guide and influence design decisions. For public meetings that occur during the design phase of a project under PRD review, we have provided meeting information regarding Sediment and Stormwater topics.

During this reporting period, public meetings were held on eleven projects under PRD review:

- 15-PR-0028, FR3905184, MD 180 from MD 383 to Old Holter Road
- 15-PR-0111, PG0515177, MD 202 from US 50 to MD 450
- 16-PR-0027, PG0465180, MD 381 over Timothy Branch
- 16-PR-0045, FR1115179, MD 17 from B Street to Center Street
- 16-PR-0047, HO1415170, MD 32 from MD 108 to Linden Church Road (Design Build)
- 16-PR-0048, FR1115279, MD 464 from MD 16 to 9th Avenue
- 16-PR-0063, MO5245129, Connecticut Avenue Salt Barn Replacement
- 17-PR-0006, SO2125180, MD 364 over Dividing Creek
- 17-PR-0030, AL2975180, MD 36 over Jennings Run
- 17-PR-0053, AA1245180, MD 468 over Branch of Lerch Creek
- 17-PR-0075, GA6465270, MD 219 from I-68 to Old Salisbury Road

A meeting summary is included in Section 2.4 and meeting materials are included on the enclosed data drive.

1.9 Investigations of Citizen Complaints and Inquiries

MDOT SHA strives to provide outstanding customer service. The Highway Hydraulics Division utilizes a tracking tool to assist in providing this. Additionally, MDOT SHA uses an on-line customer care reporting and communication system. Both systems receive a wide variety of concerns associated with Highway Operations. MDOT SHA will continue to provide specific and focused information of citizen complaints and inquiries related to Sediment and Stormwater topics for projects being reviewed by PRD.

Background information and updates are included below for the projects previously reported on, along with one new project received by PRD during FY 2017:

- 15-PR-0038, XX1605174, MD 28 – 713 W. Montgomery Avenue Drainage Improvement was initiated after a drainage issue was reported by the downstream property owner regarding basement flooding. The property owner contacted Highway Hydraulics Division on April 29, 2013 regarding this drainage issue. No highway improvement work has occurred in this area since 1992. The drainage system relating to this complaint was built in 1992. MDOT SHA designed a storm drain system extension to alleviate this issue. The project received final approval from PRD on March 22, 2016. Construction was completed on October 5, 2016.

- 15-PR-0067, GA1825174, MD 135 Upper Savage Wood Yard, was initiated after a drainage issue was reported by the property owner on July 28, 2015 regarding ponding at their entrance. This roadway was built in 1958 and no major roadway work has been done since that date. It was last resurfaced in 2014. MDOT SHA designed upgrades to the storm drain system and paving to alleviate this issue. The project received final approval from PRD on May 11, 2016 and construction was completed on November 3, 2016.

- 15-PR-0074, BA1445174, I-795 Maintenance Repairs to Painters Mill Levee, was initiated to comply with FEMA requirements for levee certification and involves raising the levee from its original elevation to meet the current regulatory requirements based on the most recent hydraulic models. Due to deficiencies, the levee was decertified, which affected the adjacent property value. The property owner submitted a complaint on September 24, 2012 regarding this issue and brought it to the attention of elected officials. MDOT SHA initiated a design project to mitigate the deficiencies by raising the levee. No highway improvement work has occurred in this area since 1989 and the levee system relating to this complaint was built in 1989. The project received final approval from PRD on August 26, 2016. Construction of the levee was completed and the application to FEMA for final certification was submitted on September 6, 2017.

- 15-PR-0097, AW8965170, MD 404 from US 50 to Holly Road, is a major highway project that involves 9 miles of dualization of MD 404. Due to the significant increase in impervious area, SWM water quantity and quality facilities are being proposed to mitigate the impacts. ESD facilities to maximum extent practicable are proposed. quantity management is provided through stormwater management (SWM) ponds that required right-of-way acquisition. To date, 29 packages have been submitted for PRD approval and construction is expected to be complete by Summer 2018. This project was not directly related to a citizen drainage complaint, but it does alleviate known flooding problems due to undersized culverts along the length of the corridor.

- 15-PR-0100, BA7125174, I-695 at Cromwell Bridge Road Minebank Run Restoration and Water Quality Improvements, was initiated to address public safety concerns. A degrading outfall and a major head cut formed directly adjacent to a townhome community. This issue was reported to MDOT SHA in December 2007, again in April 2008, and then was raised to the elected officials. The original I-695 highway project was built in 1962 with additional improvements in 1987. No highway improvement work has occurred in this area since 1987 and the drainage system relating to the complaint was built in 1962. This project was initiated to address not only the safety issues but also water quality issues in the area. The project includes stormwater management water quality facilities in the interchange in I-695 and Cromwell Bridge Road, stabilization of several drainage outfalls, and restoration of the Minebank Run main channel. The stream restoration portion will be used to meet mitigation requirements for the I-695 Southwest outer loop widening project. The outfall stabilization will address the safety issues as well as provide opportunities for water quality improvement. The stormwater design was initiated to provide water quality treatment of currently untreated impervious surfaces and will provide MS4 TMDL Restoration credit. The project received site development approval on 6/8/17. It is expected to advertise in Fall 2017 with construction beginning in Spring 2018.

- 16-PR-0005, AT6885274, Outfall Stabilization/Restoration at various locations, was initiated after MDOT SHA's District 5 presented eleven sites in need of erosion and drainage remediation/preservation. Three additional sites were later included in the project. Site 6 was removed from the contract due to MEPA approval delays due to the proximity to designated wildlands for wildlife protection. Site 6 design will continue under another contract in the future. The current project includes thirteen outfalls located in Anne Arundel (7), Calvert (1), Charles (4) and St. Mary's County (1). Proposed work includes installing new storm drain pipes with drop manholes, pipe lining, slope stabilization, and outfall stabilization with plunge pools and/or velocity dissipater structures. The sites were reviewed separately and as of the end of this reporting

period, eight of the sites had received site development approval. The project will advertise as a site-by-site contract in July 2017 and construction is expected to begin in November 2017.

- 16-PR-0010, MO2805174, Long Draught Branch between MD 117 and In-Stream SWM Structure was initiated in the early 2000's when MDOT SHA proposed rehabilitating the degraded channel as stormwater management for a MD 117 widening project. That widening project was completed without the need for the stream restoration, and Long Draught Branch (LDB) was not revisited until 2008 when MDOT SHA attempted to restore the reach as a water quality bank project. That iteration of the project was cancelled due tree impacts and the project was placed on hold until the failure of the in-stream SWM structure necessitated removal of the dam. Incorporating the dam removal into a redesign of the stream channel alignment allowed for minimization of tree impacts. The current design involves rehabilitation of approximately 2500 linear feet of stream channel, removal of the in-stream SWM structure, and addressing degraded outfalls entering the stream channel. The project received final approval from PRD on February 10, 2017 and advertised on June 13, 2017. Construction notice to proceed is expected in October 2017. This project was not initiated as a result of a citizen drainage complaint, but it provides stabilization to a very degraded stream channel.

- 16-PR-0039, WA2805174, MD 804 Flood Abatement at Chewsville, was initiated after drainage concerns were raised by residents on January 1, 1999, particularly those living along MD 804. Primarily, two properties have experienced issues. These are located at 21113 and 21223 Twin Springs Drive. MDOT SHA investigated and the issues are a result of undersized and clogged storm drain systems, as well as drainage patterns that carry flow through the town. MDOT SHA is proposing to solve the flooding issue by re-routing flow around the town and upgrading storm drain systems. Stormwater management is needed to meet quantity requirements at the point of investigation as well as at intermediate locations. This will be met by constructing two stormwater management ponds to attenuate peak flows. The project received concept approval from PRD on December 30, 2016 and has made one site development submission with comments issued on April 7, 2017. The project is on the production schedule and has not conducted the preliminary investigation meeting.

- 16-PR-0075, MD 312 Culvert Replacement/Enhancement project was initiated after a drainage issue was reported on March 19, 2013 by the downstream property owner located at 13009 Oakland Road, regarding water failing to drain from his property. The issue was attributed to an undersized MDOT SHA 24" RCP under MD 312 which frequently overtops during storm events. MDOT SHA proposes replacing the existing

culvert with twin 24”x38” HERCP culverts and a 10-foot wide outfall channel with 2:1 side slopes, stabilized with sod. No highway improvement work has occurred in this area since 1967. The drainage system relating to this complaint was built in 1964. The project received two concept reviews but does not have concept approval yet. The last action on this project was concept comments issued on August 12, 2016. MDOT SHA is in the process of easement acquisition. The project is expected to be constructed in summer 2018 using an area wide contract.

- 17-PR-0055, Emergency Culvert Replacement. Flooding was reported on October 19, 2016 by an upstream property owner. The flooding was caused by backwater from undersized pipes located downstream of his property. One of the pipes is proposed to be replaced with a larger diameter pipe. The work was declared an emergency and construction began after PRD granted Concept Approval on April 21, 2017. Work was completed in June and Final Approval was granted on June 21, 2017.

1.10 Plan Review Program Activity Findings

As discussed in the previous annual report, PRD requested resumes in May 2016 for potential consultant reviewers from all consultants who had active design contacts with the Office of Highway Development. PRD received more than 70 resumes from 23 consultant firms and selected 3 reviewers.

The number of submissions to PRD doubled from FY 2016 to FY 2017, necessitating a larger pool of consultant reviewers. PRD interviewed additional candidates from the same resume pool and selected the following eight reviewers to supplement the current pool of MDE/PRD approved reviewers:

- Daniel Plantholt, PE
- Joseph Grant, PE
- Mark Thayer, PE
- Megan Berg, PE
- Nimish Desai, PE
- Saifu Ahmed, PE
- Sonia Hardman, PE
- Wendell Winfield, PE

1.11 Modifications to the Guidelines and Procedures

Changes to the Guidelines and Procedures have been made as a result of:

- Regulatory changes (grading units, expiration of erosion and sediment control plans, and required frequency of ESC inspections)

- Transfer of all MDOT SHA projects remaining at MDE to PRD, except for design-build projects with SF numbers.
- Changes to internal MDOT SHA plan submittal processes
- Changes to internal MDOT SHA QA inspection processes

Copies of the Word documents are included on the data drive transmitted with this report. Changes are tracked in the documents to show what has changed since the last updates were submitted to MDE on 2/22/2016.

The Technical Procedures have been finalized and a copy is included on the data drive for MDE review and approval. This document formalizes PRD current practices.

1.12 ELECTRONIC DATA

As referenced in the previous sections, electronic data is located on the data drive submitted with this report. The following electronic data is included:

- PRD data table that includes project data, approvals, waivers, and variances
- Public and Agency Meeting Materials
- Representative Projects
- Guidelines, Administrative Procedures, and Technical Procedures
- Erosion and sediment control inspections, non-compliant inspections, and enforcement actions:
    - QA Non-compliance Findings (1B.1 QANonComplFind.pdf)
    - Projects on hold (1B.2 QAInspectionHold.pdf)
    - Quality Assurance Inspections by District (1B.3 QA_InspectionPerDistrict.pdf)
    - Representative Projects (1B.4 Representative Projects.pdf)
    - E&S Statistics are included in the MS-4 geodatabase

2.1 PROJECT STATUS REPORTS

Four Project Status Reports are included starting on the following page:

1. MDOT SHA Design-Bid-Build Projects
2. MDOT SHA Design-Build Projects (post award)
3. MDE SF Projects
4. Representative Projects

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
15-PR-0001	1	Tesfamichael Bogale	Patrick Nadeau	Patrick Nadeau	OHD	CE4035174	MD 272	MD 272, North of Rogues Harbor Rd					
						FIN	1	12/15/2015	12/18/2015			12/18/2015	
						SITE	3	11/16/2015	12/04/2015		12/04/2015		
						SITE	2	10/13/2015	10/26/2015				
						SITE	1	09/03/2015	09/16/2015				
						CON	2	04/21/2015	05/14/2015	05/14/2015			
						CON	1	01/07/2015	02/24/2015				
15-PR-0002	1	Sonja Hardman	Glen Helms	Marcus Tadros	OHD	BA5155184	US 1	BALTIMORE CITY LINE TO I-695					
						SITE	2	03/17/2016	04/06/2016				
						SITE	1	01/29/2016	02/04/2016				
						CON	3	05/15/2015	05/21/2015	05/21/2015			
						CON	2	04/22/2015	04/29/2015				
						CON	1	01/21/2015	03/06/2015				
15-PR-0003	1	Tesfamichael Bogale	Polly Solliday	Jason Solicny	OHD	BA7295470	MD 140	MD 140, Culvert Break-out					
						FIN	2	06/05/2015	06/08/2015			06/08/2015	
						FIN	1	05/20/2015	05/28/2015				
						SITE	2	04/30/2015	05/08/2015		05/08/2015		
						SITE	1	04/21/2015	04/27/2015				
						CON	2	03/13/2015	03/19/2015	03/19/2015			
						CON	1	02/13/2015	02/24/2015				
15-PR-0004	1	Tesfamichael Bogale	Junaid Khan	Cecilia Hernandez	OHD	CE2915279	MD 267	MD 267, Market St to W. Old Philadelphia Rd, Sidewalk Retrofit					
						FIN	3	05/31/2016	06/01/2016			06/01/2016	
						FIN	2	05/18/2016	05/23/2016				
						FIN	1	04/05/2016	04/19/2016				
						SITE	5	03/22/2016	03/25/2016		03/25/2016		
						SITE	4	03/15/2016	03/16/2016				
						SITE	3	03/03/2016	03/10/2016				
						SITE	2	02/04/2016	02/25/2016				
						SITE	1	01/12/2016	01/14/2016				
						CON	5	12/16/2015	12/22/2015	12/22/2015			
						CON	4	11/04/2015	11/23/2015				
						CON	3	09/14/2015	09/18/2015				
						CON	2	06/25/2015	07/09/2015				
						CON	1	01/23/2015	02/24/2015				
15-PR-0005	1	Sonja Hardman	Ron Gneo	Sarah Gentner	D3	PG8235177	I 95	From I-495 to 1000' N of Old Gunpowder Road					
						FIN	1	06/18/2015	06/22/2015			06/22/2015	
						SITE	3	06/11/2015	06/12/2015		06/12/2015		
						SITE	2	05/15/2015	05/21/2015				
						SITE	1	03/23/2015	03/25/2015				
						CON	2	03/13/2015	03/13/2015	03/13/2015			
						CON	1	01/30/2015	03/06/2015				
15-PR-0006	1	Tesfamichael Bogale	Craig Lynch	Angela Strevig	D3	PG5115177	MD 210	MD 210, from MD 373 (Livingston Road) to Farmington Road					
						FIN	2	05/20/2015	05/26/2015			05/26/2015	
						FIN	1	04/20/2015	05/06/2015				
						SITE	1	04/14/2015	04/16/2015		04/16/2015		
						CON	2	04/08/2015	04/09/2015	04/09/2015			
						CON	1	01/30/2015	02/24/2015				

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
15-PR-0007	1	Sonja Hardman	Polly Solliday	David Yang	D4	BA5415277	I 695		I-695, W of Stevenson Rd Br to W of Greenspring Ave (withdrawn)				
						CON	1	01/30/2015	02/24/2015				
15-PR-0008	1	Tesfamichael Bogale	Polly Solliday	Kim Livezey	D4	BA0365177	MD 7		MD 7, From Golden Ring Rd to Rossville Blvd				
						FIN	3	07/31/2015	08/03/2015			08/03/2015	
						FIN	2	06/19/2015	06/25/2015				
						FIN	1	06/03/2015	06/15/2015				
						SITE	1	05/21/2015	05/26/2015		05/26/2015		
						CON	2	05/06/2015	05/14/2015	05/14/2015			
						CON	1	01/30/2015	02/24/2015				
15-PR-0009	1	Sonja Hardman	Polly Solliday	James Umekwe	OOTS	PG4675223	I 95		I-95/I-495 College Park Truck Weigh and Inspection Station				
						FIN	2	07/27/2015	07/28/2015			07/28/2015	
						FIN	1	07/14/2015	07/20/2015				
						SITE	2	06/29/2015	07/02/2015		07/02/2015		
						SITE	1	06/05/2015	06/09/2015				
						CON	2	04/27/2015	04/30/2015	04/30/2015			
						CON	1	02/10/2015	03/06/2015				
15-PR-0010	1	Sonja Hardman	Polly Solliday	Sutapa Samanta	D4	BA6855176	US 40		US 40, Chesaco Ave to Todds Lane, Safety & Spot Improvements				
						FIN	2	04/24/2017	04/25/2017			04/25/2017	
						M1	1	06/13/2016	06/16/2016				06/16/2016
						FIN	1	07/17/2015	07/20/2015			07/20/2015	
						SITE	2	07/10/2015	07/10/2015		07/10/2015		
						SITE	1	06/19/2015	07/01/2015				
						CON	2	04/17/2015	04/21/2015	04/21/2015			
						CON	1	02/11/2015	03/06/2015				
15-PR-0011	1	Tesfamichael Bogale	Cornelius Barmer	Steven Collins	OED	AX7665582	VAR VARIES		AT VARIOUS LOCATIONS IN WASHINGTON COUNTY - GROUP 1				
						FIN	1	01/19/2017	01/23/2017			01/23/2017	
						SITE	4	12/22/2016	12/23/2016		12/23/2016		
						SITE	3	11/25/2016	12/08/2016				
						SITE	2	10/31/2016	11/10/2016				
						SITE	1	08/25/2016	09/20/2016				
						CON	3	06/10/2016	06/27/2016	06/27/2016			
						CON	2	04/08/2016	05/06/2016				
						CON	1	02/11/2015	02/24/2015				
15-PR-0013	1	Tesfamichael Bogale	Johathan Brown	Jonathan Brown	OHD	WO1645174	MD 589		MD 346 AND MD 589				
						SITE	2	04/21/2016	05/12/2016		05/12/2016		
						SITE	1	08/26/2015	09/10/2015				
						CON	2	04/27/2015	05/07/2015	05/07/2015			
						CON	1	02/12/2015	02/26/2015				
15-PR-0013	2	Tesfamichael Bogale		Jonathan Brown	OHD	WO1645174	MD 346		MD 346 AND MD 589				
						SITE	2	04/21/2016	05/12/2016		05/12/2016		
						SITE	1	08/26/2015	08/27/2015				
						CON	2	04/24/2015	04/27/2015	04/27/2015			
						CON	1	02/12/2015	03/06/2015				
15-PR-0014	1	Doug Roys	Cornelius Barmer	Karen Coffman	OED	AT0445182	VAR VARIES		TMDL Grass Swales, Anne Arundel Co				
						AB	1	01/13/2017	01/13/2017				
						FIN	2	07/15/2015	07/17/2015			07/17/2015	

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						FIN	1	06/09/2015	06/23/2015				
						SITE	1	05/20/2015	05/26/2015		05/26/2015		
						CON	2	04/08/2015	04/14/2015	04/14/2015			
						CON	1	02/13/2015	02/26/2015				
15-PR-0015	1	Tesfamichael Bogale	Polly Solliday	Wendy Wolcott	D4	HA4265177		MD 924	MD 924, Holly Wreath Drive to St. Clair Dr				
						M1	4	11/30/2015	12/01/2015				12/01/2015
						M1	3	11/16/2015	11/19/2015				
						M1	2	11/04/2015	11/05/2015				
						M1	1	11/02/2015	11/03/2015				
						FIN	3	07/17/2015	07/24/2015			07/24/2015	
						FIN	2	07/02/2015	07/07/2015				
						FIN	1	06/22/2015	06/25/2015				
						SITE	2	06/01/2015	06/12/2015		06/12/2015		
						SITE	1	04/21/2015	05/08/2015				
						CON	4	04/10/2015	04/16/2015	04/16/2015			
						CON	3	03/19/2015	03/25/2015				
						CON	2	03/06/2015	03/09/2015				
						CON	1	02/19/2015	02/24/2015				
15-PR-0016	1	Sonja Hardman	Polly Solliday	James Umekwe	OOTS	WA2815123		I 81	I-81 SB Escort Vehicle Area Geometric Improvements				
						AB	2	08/15/2016	09/13/2016				
						AB	1	04/22/2016	04/25/2016				
						FIN	1	08/14/2015	08/21/2015			08/21/2015	
						SITE	3	07/23/2015	07/24/2015		07/24/2015		
						SITE	2	06/01/2015	06/09/2015				
						SITE	1	05/26/2015	05/26/2015				
						CON	1	02/25/2015	02/26/2015	02/26/2015			
15-PR-0017	1	Tesfamichael Bogale	Glen Helms	Moreshwar Kulkarni	OHD	PG3335172		I 95	IHB - BALTIMORE WASHINGTON PARKWAY TO US 1 (GREENBELT METRO ACCESS)				
						SITE	3	05/17/2017	06/12/2017				
						SITE	2	02/14/2017	03/10/2017				
						SITE	1	03/03/2016	04/26/2016				
						CON	3	08/27/2015	08/28/2015	08/28/2015			
						CON	2	07/08/2015	08/11/2015				
						CON	1	02/25/2015	03/20/2015				
15-PR-0017	2	Tesfamichael Bogale	Glen Helms		OHD	PG3335172		I 95	IHB - BALTIMORE WASHINGTON PARKWAY TO US 1 (GREENBELT METRO ACCESS)				
						SITE	3	05/23/2017	05/31/2017				
						SITE	2	02/01/2017	02/23/2017				
						SITE	1	12/13/2016	12/30/2016				
						CON	1	09/08/2016	09/22/2016	09/22/2016			
15-PR-0018	1	Doug Roys	Craig Lynch	Jim Hade	OED	WO1915174		US 113	Critical Area Mitigation at Firehouse wetland site				
						FIN	1	06/03/2015	06/03/2015			06/03/2015	
						SITE	1	05/28/2015	05/28/2015		05/28/2015		
						CON	2	04/07/2015	04/09/2015	04/09/2015			
						CON	1	03/03/2015	03/06/2015				
15-PR-0019	1	Doug Roys	Joseph Bartell	Jason Alwine	OED	AA7955282		VAR VARIES	AT VARIOUS LOCATIONS - GROUP 1				
						M1	1	05/16/2017	06/16/2017				
						FIN	1	03/06/2017	03/07/2017			03/07/2017	
						SITE	3	02/02/2017	02/07/2017		02/07/2017		

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						SITE	2	12/15/2016	12/29/2016				
						SITE	1	10/06/2016	10/24/2016				
						CON	2	08/05/2016	08/16/2016	08/16/2016			
						CON	1	03/03/2015	03/23/2015				
15-PR-0020	1	Tesfamichael Bogale	Craig Lynch	Sarah Gentner	D3	MO1665187		I 270	SOUTH OF GUDE DRIVE (SPUR FROM C/D LANE SB)				
						CON	2	05/13/2015	06/15/2015				
						CON	1	03/13/2015	04/08/2015				
15-PR-0021	1	Sonja Hardman	Armand de Rosset	Rod Thorton	OOS	XX1115180		MD 950	Emergency Replacement of Str. 16097X0 MD 950 over Beaverdam Cr				
						SITE	2	02/01/2016	02/02/2016		02/02/2016		
						SITE	1	04/23/2015					
						CON	2	03/19/2015	03/19/2015	03/19/2015			
						CON	1	03/13/2015	03/13/2015				
15-PR-0022	1	Tesfamichael Bogale	Craig Lynch	Angela Strevig	D3	PG5105177		MD 210	IHB - FARMINGTON ROAD TO OLD FORT ROAD				
						FIN	3	04/12/2016	04/14/2016			04/14/2016	
						FIN	2	03/29/2016	04/06/2016				
						FIN	1	03/08/2016	03/11/2016				
						SITE	4	02/10/2016	02/26/2016		02/26/2016		
						SITE	3	01/07/2016	01/14/2016				
						SITE	2	12/09/2015	12/23/2015				
						SITE	1	11/04/2015	11/12/2015				
						CON	2	08/26/2015	09/04/2015	09/04/2015			
						CON	1	03/23/2015	03/26/2015				
15-PR-0023	1	Sonja Hardman	Kiona Leah	Chris Weber	OHD	AA4365471		MD 175	WEST OF REECE ROAD TO EAST OF DISNEY ROAD				
						FIN	2	11/10/2016	11/14/2016			11/14/2016	
						FIN	1	10/19/2016	10/25/2016				
						SITE	7	09/16/2016	09/21/2016		09/21/2016		
						SITE	6	08/05/2016	08/19/2016				
						SITE	5	07/12/2016	07/15/2016				
						SITE	4	06/09/2016	07/05/2016				
						SITE	3	04/01/2016	04/04/2016				
						SITE	2	03/04/2016	03/11/2016				
						SITE	1	12/30/2015	01/04/2016				
						CON	4	08/10/2015	08/14/2015	08/14/2015			
						CON	3	06/18/2015	06/23/2015				
						CON	2	05/29/2015	06/04/2015				
						CON	1	03/23/2015	04/08/2015				
15-PR-0024	1	Sonja Hardman	Craig Lynch	Linda Zerbee	D6	WA2515176		I 68	0.9 Miles East of Mountain Rd to Sideling Hill Rest Area				
						SITE	1	11/18/2015	11/23/2015		11/23/2015		
						CON	2	09/18/2015	09/21/2015	09/21/2015			
						CON	1	03/25/2015	03/30/2015				
15-PR-0025	1	Tesfamichael Bogale	Alicia Brandys	Meridith LeDue	OHD	CE3395176		MD 272	IHB - SOUTH OF US 40 TO ROGERS ROAD				
						M2	1	03/21/2017	03/22/2017				
						M1	1	02/27/2017	02/28/2017				02/28/2017
						FIN	2	02/13/2017	02/24/2017			02/24/2017	
						FIN	1	01/31/2017	02/10/2017				
						SITE	5	01/12/2017	01/18/2017		01/18/2017		
						SITE	4	12/23/2016	12/28/2016				

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						SITE	3	11/22/2016	12/08/2016				
						SITE	2	08/26/2016	09/13/2016				
						SITE	1	06/08/2016	06/30/2016				
						CON	4	03/14/2016	03/17/2016	03/17/2016			
						CON	3	01/06/2016	01/14/2016				
						CON	2	07/08/2015	07/30/2015				
						CON	1	03/31/2015	04/22/2015				
15-PR-0026	1	Sonja Hardman	Polly Solliday	David Mitchell	D6	AL2735177		MD 51	Pack Horse Road to Town Creek				
						FIN	1	06/24/2015	06/30/2015			06/30/2015	
						SITE	3	06/11/2015	06/11/2015		06/11/2015		
						SITE	2	05/18/2015	05/26/2015				
						SITE	1	05/11/2015	05/12/2015				
						CON	1	04/06/2015	04/09/2015	04/09/2015			
15-PR-0027	1	Tesfamichael Bogale	Joseph Bartell	Scott Dutrow	D7	CL3045130		MD 26	AT OAKLAND MILLS ROAD				
						FIN	3	06/08/2017	06/09/2017			06/09/2017	
						FIN	2	05/30/2017	06/01/2017				
						FIN	1	05/17/2017	05/23/2017				
						SITE	3	02/13/2017	02/22/2017		02/22/2017		
						SITE	2	01/25/2017	02/07/2017				
						SITE	1	01/17/2017	01/18/2017				
						CON	6	12/13/2016	12/30/2016	12/30/2016			
						CON	5	10/18/2016	11/16/2016				
						CON	4	07/11/2016	08/05/2016				
						CON	3	02/18/2016	03/18/2016				
						CON	2	11/02/2015	11/30/2015				
						CON	1	04/06/2015	04/22/2015				
15-PR-0028	1	Sonja Hardman	Daniel Sharar-Salgado	Huqin Zhang	OHD	FR3905184		MD 180	MD 383 (BROAD RUN ROAD) TO OLD HOLTER ROAD				
						FIN	2	04/21/2017	05/08/2017			05/08/2017	
						FIN	1	04/12/2017	04/12/2017				
						SITE	7	03/27/2017	03/27/2017		03/27/2017		
						SITE	6	03/03/2017	03/10/2017				
						SITE	5	01/17/2017	01/17/2017				
						SITE	4	10/03/2016	10/04/2016				
						SITE	3	05/31/2016	06/07/2016				
						SITE	2	04/25/2016	04/26/2016				
						SITE	1	01/29/2016	02/04/2016				
						CON	4	11/24/2015	11/25/2015	11/25/2015			
						CON	3	09/16/2015	09/18/2015				
						CON	2	07/01/2015	07/15/2015				
						CON	1	04/15/2015	04/17/2015				
15-PR-0029	1		Shreemal Perera	Colbert Stephen	OHD	HO1905181		I 95	Welcome Center Truck Parking Expansion - Project Canceled				
						CON	1	04/17/2015	04/17/2015				
15-PR-0030	1	Doug Roys	Rahul Kesarkar	Barry Ritchie	D6	WA2785187		I 81	IHB- I-70 to Halfway Blvd				
						FIN	2	04/25/2016	04/28/2016			04/28/2016	
						FIN	1	04/04/2016	04/12/2016				
						SITE	2	03/09/2016	03/17/2016		03/17/2016		
						SITE	1	02/24/2016	02/26/2016				
						CON	3	01/13/2016	01/14/2016	01/14/2016			

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						CON	2	11/10/2015	11/16/2015				
						CON	1	04/27/2015	04/30/2015				
15-PR-0031	1	Tesfamichael Bogale	Rahul Kesarkar	Tara Ryan	OED	BA5005249		NA	N/A	Hereford Shop-Storage Tank Removal and Replacement			
						FIN	2	07/21/2015	07/23/2015			07/23/2015	
						FIN	1	07/14/2015	07/17/2015				
						SITE	1	06/25/2015	07/01/2015		07/01/2015		
						CON	1	04/27/2015	05/13/2015	05/13/2015			
15-PR-0032	1	Sonja Hardman	Alicia Brandys	Mike Steiner	D2	CO2795177		MD 404 BU	IHB - 1ST STREET TO 9TH STREET or MD 404 BU from 1st St to 9th St				
						FIN	3	10/03/2016	10/04/2016			10/04/2016	
						FIN	2	09/23/2016					
						FIN	1	09/02/2016	09/06/2016				
						SITE	3	06/03/2016	06/07/2016		06/07/2016		
						SITE	2	02/19/2016	02/26/2016				
						SITE	1	12/08/2015	12/08/2015				
						CON	2	10/02/2015	10/02/2015	10/02/2015			
						CON	1	05/07/2015	05/12/2015				
15-PR-0033	1	Tesfamichael Bogale	Joseph Bartell	Jordan Howard	D3	PG8945177		MD 201	MD 201 from Edmonston Rd to Good Luck Rd				
						FIN	2	05/01/2017	05/02/2017			05/02/2017	
						FIN	1	03/17/2017	03/31/2017				
						SITE	3	08/05/2016	08/25/2016		08/25/2016		
						SITE	2	06/06/2016	06/15/2016				
						SITE	1	04/20/2016	05/10/2016				
						CON	1	05/21/2015	05/27/2015	05/27/2015			
15-PR-0034	1	Dan O'Leary	Armand de Rosset	Yugiong Bai	OHD	PG3645184		MD 500	DC LINE TO MD 208				
						FIN	1	05/30/2017	06/17/2017				
						SITE	5	02/16/2017	02/17/2017		02/17/2017		
						SITE	4	01/17/2017	01/30/2017				
						SITE	3	11/16/2016	11/30/2016				
						SITE	2	09/16/2016	10/13/2016				
						SITE	1	07/05/2016	07/12/2016				
						CON	2	12/15/2015	12/16/2015	12/16/2015			
						CON	1	05/18/2015	05/20/2015				
15-PR-0035	1	Doug Roys	Michael Weber	Steve Collins	OED	AX7665482		VAR VARIES	AT VARIOUS LOCATIONS IN ANNE ARUNDEL COUNTY - GROUP 1				
						SITE	4	03/01/2017	03/09/2017		03/09/2017		
						SITE	3	01/19/2017	02/07/2017				
						SITE	2	10/18/2016	11/17/2016				
						SITE	1	08/26/2016	09/15/2016				
						CON	2	04/28/2016	06/08/2016	06/08/2016			
						CON	1	06/01/2015	07/08/2015				
15-PR-0036	1	Jeff Knaub	Johathan Brown	Jonathan Brown	OHD	XX1605174		I 270	I-270 N prior to MD 28, washout				
						FIN	4	12/15/2016	01/03/2017			01/03/2017	
						FIN	3	09/08/2016	09/19/2016				
						FIN	2	08/10/2015	08/28/2015				
						FIN	1	06/24/2015	06/30/2015				
						CON	1	05/30/2015	06/22/2015	06/22/2015			

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
15-PR-0037	1	Jeff Knaub	Tyler Bazan	Dipa Patel	OOS	GA2085180	MD 546	Bridge 1101200 Over I-68					
						FIN	1	03/14/2016	03/29/2016			03/29/2016	
						SITE	3	03/03/2016	03/08/2016		03/08/2016		
						SITE	2	02/18/2016	02/26/2016				
						SITE	1	12/30/2015	01/11/2016				
						CON	3	11/18/2015	12/01/2015	12/01/2015			
						CON	2	07/29/2015	08/17/2015				
						CON	1	06/05/2015	06/25/2015				
15-PR-0038	1	Sonja Hardman	Johathan Brown	Jonathan Brown	OHD	XX1605174	MD 28	713 W. Montgomery Ave Drainage Improvement					
						FIN	1	03/18/2016	03/22/2016			03/22/2016	
						SITE	2	09/15/2015	09/15/2015		09/15/2015		
						SITE	1	08/10/2015	08/11/2015				
						CON	2	07/08/2015	07/21/2015	07/21/2015			
						CON	1	06/08/2015	06/12/2015				
15-PR-0039	1		Michael Weber	Roger Windschitl	OED	HO1695182	NA N/A	Furnace Ave Tributary					
						M1	1	11/19/2015	11/23/2015				11/23/2015
						FIN	1	09/30/2015	10/01/2015			10/01/2015	
						SITE	2	09/23/2015	09/24/2015		09/24/2015		
						SITE	1	08/05/2015	08/14/2015				
						CON	1	06/25/2015	07/21/2015	07/21/2015			
15-PR-0040	1	Jeff Knaub	Joseph Bartell	Jordan Howard	D3	MO3755277	US 29	MD 384 TO ST ANDREWS WAY					
						SITE	4	12/05/2016	12/22/2016		12/22/2016		
						SITE	3	09/19/2016	09/22/2016				
						SITE	2	05/10/2016	06/29/2016				
						SITE	1	12/22/2015	01/15/2016				
						CON	2	08/24/2015	08/27/2015	08/27/2015			
						CON	1	06/29/2015	07/21/2015				
15-PR-0041	1	Brandon Scott	Rahul Kesarkar	Barry Ritchie	D6	WA2495176	I 81	IHB-MD 58 to US 40					
						FIN	1	06/14/2016	06/16/2016			06/16/2016	
						SITE	2	05/02/2016	05/05/2016		05/05/2016		
						SITE	1	04/04/2016	04/04/2016				
						CON	4	11/16/2015	11/17/2015	11/17/2015			
						CON	3	09/28/2015	09/30/2015				
						CON	2	08/18/2015	08/19/2015				
						CON	1	06/29/2015	07/07/2015				
15-PR-0042	1	Tesfamichael Bogale	Armand de Rosset	Meridith LeDue	OHD	WA1065184	MD 845A	SOUTH CORPORATE LIMITS OF KEEDYSVILLE TO NORTH CORPORATE TOWN LIMITS					
						SITE	4	05/17/2017	05/30/2017				
						SITE	3	12/16/2016	12/30/2016				
						SITE	2	10/24/2016	11/25/2016				
						SITE	1	09/21/2016	09/28/2016				
						CON	6	08/02/2016	08/25/2016	08/25/2016			
						CON	5	07/05/2016	07/20/2016				
						CON	4	06/06/2016	06/16/2016				
						CON	3	01/27/2016	03/03/2016				
						CON	2	10/08/2015	10/22/2015				
						CON	1	07/02/2015	07/13/2015				

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
15-PR-0043	1	Sonja Hardman	Daniel Sharar-Salgado	Vivian Berra-Figuereo	OHD	PG6915170	MD 197	KENHILL DRIVE TO MD 450 (ANNAPOLIS ROAD)					
						CON	3	12/11/2015	12/16/2015	12/16/2015			
						CON	2	11/27/2015	11/30/2015				
						CON	1	07/06/2015	07/10/2015				
15-PR-0044	1	Jeff Knaub	Joseph Bartell	Dana Morse	OOS	QA2405180	US 301	IHB-Bridge 1701101 over MD 290 and Bridge 1701201 over Red Lion					
						FIN	1	01/19/2016	01/21/2016			01/21/2016	
						SITE	2	12/14/2015	01/07/2016		01/07/2016		
						SITE	1	10/16/2015	11/19/2015				
						CON	1	07/09/2015	07/29/2015	07/29/2015			
15-PR-0045	1	Tesfamichael Bogale	Shreemal Perera	Charles Edwards	OOM	AA3925629	NA N/A	HANOVER COMPLEX AREA - PAVEMENT RESURFACING AND DRAINAGE IMPROVEMENTS					
						FIN	3	04/27/2017	05/03/2017			05/03/2017	
						FIN	2	03/01/2017	03/07/2017				
						FIN	1	01/06/2017	01/09/2017				
						SITE	2	08/03/2016	08/18/2016		08/18/2016		
						SITE	1	07/08/2016	07/14/2016				
						CON	3	05/12/2016	05/19/2016	05/19/2016			
						CON	2	01/07/2016	01/28/2016				
						CON	1	07/10/2015	07/28/2015				
15-PR-0046	1	Jeff Knaub	Alicia Brandys	Charlene Thayer	OOM	TA2955129	NA N/A	EASTON MAINTENANCE FACILITY REPLACEMENT					
						FIN	3	08/26/2016	09/01/2016			09/01/2016	
						FIN	2	08/10/2016	08/18/2016				
						FIN	1	06/13/2016	07/12/2016				
						SITE	2	03/18/2016	04/12/2016		04/12/2016		
						SITE	1	12/14/2015	01/13/2016				
						CON	2	10/02/2015	10/20/2015	10/20/2015			
						CON	1	07/23/2015	08/11/2015				
15-PR-0047	1	Tesfamichael Bogale	Gina Goettler	Meridith LeDue	OHD	CL8415184	MD 31	LAMBERT AVENUE TO EAST OF CHURCH STREET					
						SITE	1	05/23/2017	06/02/2017				
						CON	5	01/28/2016	02/12/2016	02/12/2016			
						CON	4	12/17/2015	01/08/2016				
						CON	3	10/28/2015	11/12/2015				
						CON	2	08/21/2015	09/17/2015				
						CON	1	07/27/2015	08/03/2015				
15-PR-0048	1	Jeff Knaub	Rahul Kesarkar	Hicham Baassiri	D1	WI2005176	US 50	WARD STREET TO MAIN STREET or US 50 Business, Ward Street to Main Street					
						FIN	1	11/28/2016	12/02/2016			12/02/2016	
						SITE	3	10/20/2016	10/31/2016		10/31/2016		
						SITE	2	09/23/2016	10/12/2016				
						SITE	1	06/06/2016	07/22/2016				
						CON	3	02/18/2016	03/14/2016	03/14/2016			
						CON	2	11/23/2015	12/22/2015				
						CON	1	07/28/2015	08/14/2015				
15-PR-0049	1	Sonja Hardman	Rahul Kesarkar	Angela Strevig	D3	MO1885177	I 495	IHB-I-270Y to Seminary Road - Inner Loop					
						M1	3	04/12/2017	04/12/2017				04/12/2017
						M1	2	03/17/2017	03/17/2017				
						M1	1	03/09/2017	03/09/2017				
						FIN	2	03/14/2016	03/17/2016			03/17/2016	

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						FIN	1	02/17/2016	02/24/2016				
						SITE	2	02/01/2016	02/02/2016		02/02/2016		
						SITE	1	11/20/2015	11/23/2015				
						CON	1	07/28/2015	07/30/2015	07/30/2015			
15-PR-0050	1	Sonja Hardman	Joseph Bartell	Angela Strevig	D3	PG0525177 MD 410 TO MD 450							
						CON	1	07/28/2015	07/30/2015	07/30/2015			
15-PR-0051	1	Tesfamichael Bogale	Michael Weber	Dorey Uong	D3	MO1655187 I 495 AT MD 190							
						CON	4	05/22/2017	05/23/2017	05/23/2017			
						CON	3	10/26/2016	11/28/2016				
						CON	2	11/12/2015	11/30/2015				
						CON	1	07/28/2015	08/14/2015				
15-PR-0052	1	Jeff Knaub	Joseph Bartell	Karen Fiasco	D5	AA1595177 MD 980B Full Depth Reclamation from WRIGHTON ROAD TO TALBOT ROAD							
						FIN	1	04/14/2016	04/29/2016			04/29/2016	
						SITE	2	02/10/2016	02/12/2016		02/12/2016		
						SITE	1	12/24/2015	01/19/2016				
						CON	1	07/29/2015	08/14/2015	08/14/2015			
15-PR-0053	1	Doug Roys	Michael Weber	Jason Alwine	OED	PG0585182 NA N/A TMDL SWM DNR ROSARYVILLE STATE PARK							
						FIN	2	08/30/2016	09/22/2016			09/22/2016	
						FIN	1	06/23/2016	07/13/2016				
						SITE	3	03/28/2016	04/19/2016		04/19/2016		
						SITE	2	03/08/2016	03/17/2016				
						SITE	1	01/05/2016	02/01/2016				
						CON	2	10/21/2015	11/04/2015	11/04/2015			
						CON	1	07/29/2015	08/18/2015				
15-PR-0054	1	Sonja Hardman	Joseph Bartell	Tara Ryan	OED	CL1895149 NA N/A Westminster Shop-Storage Tank Removal and Replacement							
						FIN	1	08/31/2015	09/02/2015			09/02/2015	
						SITE	1	08/14/2015	08/14/2015		08/14/2015		
						CON	1	07/29/2015	08/03/2015	08/03/2015			
15-PR-0055	1	Jeff Knaub	Junaid Khan	Jeff Robert	OOS	FR1305180 US 15 IHB-Bridge 1616205 and 1616206 over Suitland Road							
						M2	1	06/20/2017	06/28/2017				
						M1	3	02/16/2017	03/02/2017				03/02/2017
						M1	2	01/31/2017	02/10/2017				
						M1	1	12/28/2016	01/06/2017				
						FIN	4	05/12/2016	05/18/2016			05/18/2016	
						FIN	3	04/22/2016	05/02/2016				
						FIN	2	04/15/2016	04/20/2016				
						FIN	1	03/14/2016	03/31/2016				
						SITE	4	02/05/2016	02/08/2016		02/08/2016		
						SITE	3	01/22/2016	02/01/2016				
						SITE	2	01/08/2016	01/14/2016				
						SITE	1	12/09/2015	12/22/2015				
						CON	3	11/02/2015	11/12/2015	11/12/2015			
						CON	2	09/24/2015	10/16/2015				
						CON	1	08/04/2015	08/26/2015				
15-PR-0056	1	Tesfamichael Bogale	Ryan Doheny	Luis Gonzalez	OHD	SM2025171 MD 5 IHB - AT ABELL/MOAKLEY (PHASE 1)							
						CON	5	11/23/2016	12/08/2016	12/08/2016			

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						CON	4	10/06/2016	11/01/2016				
						CON	3	03/31/2016	04/12/2016				
						CON	2	11/10/2015	12/03/2015				
						CON	1	08/05/2015	08/19/2015				
15-PR-0057	1	Sonja Hardman	Joseph Bartell	John Vranish	OHD	AA1805179 MD 424 DUKE OF KENT DRIVE TO MD 450 (DEFENSE HIGHWAY) - PHASE 2							
						SITE	1	03/23/2017	03/31/2017				
						CON	4	02/02/2017	02/08/2017	02/08/2017			
						CON	3	03/18/2016	03/31/2016				
						CON	2	11/02/2015	11/03/2015				
						CON	1	08/06/2015	08/10/2015				
15-PR-0058	1	Jeff Knaub	Joseph Bartell	Chris Strain	OOTS	HO1505185 US 29 IHB-MD 32 to MD 175							
						FIN	2	01/20/2016	02/01/2016			02/01/2016	
						FIN	1	01/11/2016	01/12/2016				
						SITE	2	11/06/2015	11/09/2015		11/09/2015		
						SITE	1	10/19/2015	11/04/2015				
						CON	2	09/22/2015	09/24/2015	09/24/2015			
						CON	1	08/06/2015	08/20/2015				
15-PR-0059	1	Tesfamichael Bogale	Joseph Bartell	Michelle Vrikkis	OOTS	XY2395185 I 70 Partial Interchange Lighting							
						FIN	1	03/04/2016	03/09/2016			03/09/2016	
						SITE	1	01/11/2016	02/02/2016		02/02/2016		
						CON	1	08/07/2015	08/13/2015	08/13/2015			
15-PR-0060	1	Dan O'Leary	Armand de Rosset	Kelvin Saldanha	OHD	CA4135370 MD 2/4 IHB - FOX RUN BOULEVARD TO MD 231 (PHASE 2)							
						SITE	7	06/14/2017	06/21/2017		06/21/2017		
						SITE	6	06/07/2017	06/08/2017				
						SITE	5	05/23/2017	05/30/2017				
						SITE	4	04/11/2017	04/21/2017				
						SITE	3	03/20/2017	03/24/2017				
						SITE	2	09/26/2016	10/13/2016				
						SITE	1	07/20/2016	08/04/2016				
						CON	1	08/10/2015	08/28/2015	08/28/2015			
15-PR-0061	1	Jeff Knaub	Joseph Bartell	Holly Shipley	OOM	AA1025129 NA N/A HANOVER COMPLEX BLDG 1-OOM OOTS SOC ROOF/GUTTER REPAIR REPLACEMENT							
						FIN	2	03/31/2017	04/05/2017			04/05/2017	
						FIN	1	03/09/2017	03/21/2017				
						SITE	3	07/11/2016	07/28/2016		07/28/2016		
						SITE	2	02/22/2016	03/07/2016				
						SITE	1	01/20/2016	02/09/2016				
						CON	1	08/10/2015	09/02/2015	09/02/2015			
15-PR-0062	1	Sonja Hardman	Joseph Bartell	Jay Thaker	OOTS	BA9885285 I 795 IHB-I-795 and Franklin, I-795 at MD 140							
						FIN	1	09/10/2015	09/11/2015			09/11/2015	
						SITE	1	08/24/2015	08/25/2015		08/25/2015		
						CON	1	08/10/2015	08/12/2015	08/12/2015			
15-PR-0063	1	Jeff Knaub	Shreemal Perera	Dipa Patel	OOS	MO5805180 I 495 BRIDGE 1512900 OVER I-495							
						FIN	1	03/01/2017	03/10/2017			03/10/2017	
						SITE	2	02/09/2017	02/16/2017		02/16/2017		
						SITE	1	01/17/2017	02/01/2017				
						CON	3	11/23/2016	12/14/2016	12/14/2016			

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						CON	2	05/12/2016	06/29/2016				
						CON	1	08/10/2015	08/31/2015				
15-PR-0064	1	Sonja Hardman	Joseph Bartell	Sarah Gentner	D3	XX1645176 MD 202 Site 1: Largo Road at Town Farm Road							
						FIN	1	06/06/2016	06/07/2016			06/07/2016	
						SITE	1	10/15/2015	10/15/2015		10/15/2015		
						CON	1	08/10/2015	08/12/2015	08/12/2015			
15-PR-0064	2	Brandon Scott		Dorey Uong	D3	XX1645176 MD 185 Site 2: Knowles Ave to DuPont Ave							
						FIN	1	11/17/2016	11/29/2016			11/29/2016	
						SITE	2	11/17/2016	11/29/2016		11/29/2016		
						SITE	1	10/19/2016	11/10/2016				
						CON	1	08/25/2016	09/22/2016	09/22/2016			
15-PR-0064	3	Sonja Hardman	Joseph Bartell	Dorey Uong	D3	XX1645176 MD 214 MD214 SITE 3: MADISON RD METRO ENTRANCE INTERSECTION IMPROVEMENTS							
						FIN	2	04/11/2017	04/11/2017			04/11/2017	
						FIN	1	03/28/2017	04/05/2017				
						CON	1	03/06/2017	03/07/2017	03/07/2017			
15-PR-0065	1	Jeff Knaub	Joseph Bartell	Jason Pollock	OOS	WA2435180 I 70 Bridge 2112900 over Beaver Creek							
						FIN	1	12/22/2015	12/23/2015			12/23/2015	
						SITE	2	11/23/2015	12/03/2015		12/03/2015		
						SITE	1	10/19/2015	11/04/2015				
						CON	2	09/14/2015	10/01/2015	10/01/2015			
						CON	1	08/10/2015	09/03/2015				
15-PR-0066	1	Tesfamichael Bogale	Joseph Bartell	Andrew Radcliffe	D7	CL2435130 MD 31 AT TAHOMA FARM ROAD							
						FIN	2	12/05/2016	12/19/2016			12/19/2016	
						FIN	1	08/12/2016	09/20/2016				
						SITE	2	04/01/2016	04/14/2016		04/14/2016		
						SITE	1	02/12/2016	03/10/2016				
						CON	4	02/01/2016	02/08/2016	02/08/2016			
						CON	3	12/22/2015	12/23/2015				
						CON	2	11/12/2015	12/04/2015				
						CON	1	08/14/2015	08/31/2015				
15-PR-0067	1	Sonja Hardman	Joseph Bartell	David Mitchell	D6	GA1825174 MD 135 UPPER SAVAGE WOOD YARD ENTRANCE							
						FIN	1	05/06/2016	05/11/2016			05/11/2016	
						SITE	3	04/18/2016	04/19/2016		04/19/2016		
						SITE	2	02/26/2016	03/03/2016				
						SITE	1	11/20/2015	11/23/2015				
						CON	1	08/14/2015	08/17/2015	08/17/2015			
15-PR-0068	1	Jeff Knaub	Jessica Lain	Ralph Manna	OOS	BA0845180 MD 146 03189X0 AND 03190X0 OVER DRAINAGE DITCHES							
						CON	1	08/14/2015	09/03/2015	09/03/2015			
15-PR-0069	1	Tesfamichael Bogale	Gina Goettler	Jared Paper-Evers	OHD	BA5525226 I 695 NOISE BARRIER 03596N0 FROM NOISE BARRIER 03592N0 TO 100 FT NORTH OF DOGWOOD							
						SITE	9	05/19/2017	05/22/2017		05/22/2017		
						SITE	8	04/25/2017	05/11/2017				
						SITE	7	03/30/2017	04/12/2017				
						SITE	6	02/17/2017	03/07/2017				
						SITE	5	08/25/2016					
						SITE	4	07/27/2016	08/11/2016				
						SITE	3	06/13/2016	07/07/2016				

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						SITE	2	05/20/2016	06/01/2016				
						SITE	1	04/08/2016	05/02/2016				
						CON	3	12/17/2015	01/12/2016	01/12/2016			
						CON	2	10/16/2015	10/28/2015				
						CON	1	08/17/2015	09/17/2015				
15-PR-0070	1	Sonja Hardman	Joseph Bartell	Dorey Uong	D3	MO7735177	MD 117	IHB - Longdraft Road to I-279					
						M1	3	01/27/2017	01/30/2017				01/30/2017
						M1	2	01/20/2017	01/23/2017				
						M1	1	01/11/2017					
						FIN	2	03/07/2016	03/10/2016			03/10/2016	
						FIN	1	02/18/2016	03/03/2016				
						SITE	3	02/01/2016	02/03/2016		02/03/2016		
						SITE	2	12/22/2015	12/30/2015				
						SITE	1	11/09/2015	11/12/2015				
						CON	1	08/17/2015	08/18/2015	08/18/2015			
15-PR-0071	1	Tesfamichael Bogale	Joseph Bartell	Dorey Uong	D3	PG0835130	MD 3	IHB - AT FOREST DRIVE					
						CON	4	05/17/2017	05/31/2017	05/31/2017			
						CON	3	04/07/2017	04/19/2017				
						CON	2	12/05/2016	12/23/2016				
						CON	1	08/17/2015	09/01/2015				
15-PR-0072	1	Sonja Hardman	Polly Solliday	Yugiong Bai	OHD	MO5935870	MD 185	AT JONES BRIDGE ROAD/KENSINGTON PARKWAY - PHASE 3					
						SITE	1	11/09/2016	11/18/2016				
						CON	2	09/10/2015	09/14/2015	09/14/2015			
						CON	1	08/19/2015	08/25/2015				
15-PR-0073	1	Sonja Hardman	Christie Minami	Aimee Zhang	OHD	MO7465171	MD 97	IHB - SOUTH OF BROOKEVILLE TO MD 97 NORTH OF BROOKEVILLE					
						SITE	7	06/15/2017	07/07/2017		07/07/2017		
						SITE	6	05/01/2017	05/18/2017				
						SITE	5	03/28/2017	04/06/2017				
						SITE	4	01/25/2017	02/08/2017				
						SITE	3	12/19/2016	01/11/2017				
						SITE	2	08/05/2016	08/26/2016				
						SITE	1	04/08/2016	04/15/2016				
						CON	3	01/07/2016	01/07/2016	01/07/2016			
						CON	2	09/29/2015	10/02/2015				
						CON	1	08/19/2015	08/26/2015				
15-PR-0074	1	Tesfamichael Bogale	Abdul Wakil	AJ de Rosset	OHD	BA1445174	I 795	Maintenance Repairs to Painters Mill Levee at I-795 and Painters Mill Road					
						FIN	1	08/04/2016	08/26/2016			08/26/2016	
						SITE	2	05/04/2016	05/06/2016		05/06/2016		
						SITE	1	03/17/2016	04/11/2016				
						CON	1	08/27/2015	09/09/2015	09/09/2015			
15-PR-0075	1	Brandon Scott	Patrick Nadeau	Chau Chiem	D5	AA1945130	MD 174	1000 FT SOUTH TO 700 FT NORTH OF SEVERN ROAD					
						SITE	3	05/02/2017	05/12/2017		05/12/2017		
						SITE	2	03/06/2017	03/22/2017				
						SITE	1	01/23/2017	02/07/2017				
						CON	4	09/15/2016	10/05/2016	10/05/2016			
						CON	3	06/21/2016	08/01/2016				
						CON	2	04/08/2016	05/02/2016				

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						CON	1	08/28/2015	09/09/2015				
15-PR-0076	1	Brandon Scott	Joseph Bartell	Cathy Spady	D1	DO3025130	MD 16	IHB-At Woods Road					
						FIN	1	03/25/2016	04/11/2016			04/11/2016	
						SITE	2	03/10/2016	03/16/2016		03/16/2016		
						SITE	1	02/01/2016	02/17/2016				
						CON	3	01/06/2016	01/08/2016	01/08/2016			
						CON	2	11/25/2015	12/11/2015				
						CON	1	08/31/2015	09/16/2015				
15-PR-0077	1	Sonja Hardman	Joseph Bartell	Dorey Uong	D3	MO0805177	MD 355	From Hubbard Drive to Templeton Place					
						FIN	1	01/29/2016	02/02/2016			02/02/2016	
						SITE	1	12/14/2015	12/16/2015		12/16/2015		
						CON	2	10/16/2015	10/19/2015	10/19/2015			
						CON	1	09/03/2015	09/08/2015				
15-PR-0078	1	Brandon Scott	Joseph Bartell	Dan Beck	OOS	FR5365180	MD 140	BRIDGE 1006200 REPLACEMENT OVER FLAT RUN					
						M1	1	12/12/2016	12/28/2016				12/28/2016
						FIN	1	08/30/2016	09/02/2016			09/02/2016	
						SITE	2	07/19/2016	08/02/2016		08/02/2016		
						SITE	1	04/25/2016	05/05/2016				
						CON	2	02/12/2016	02/18/2016	02/18/2016			
						CON	1	09/04/2015	09/21/2015				
15-PR-0079	1	Jeff Knaub	Joseph Bartell	Edwin Young	D6	AL2665130	MD 935	IHB - AT RAILROAD STREET or Intersection Improvement at S. Railroad Street					
						FIN	1	01/23/2017	01/30/2017			01/30/2017	
						SITE	3	11/18/2016	12/07/2016		12/07/2016		
						SITE	2	09/23/2016	10/12/2016				
						SITE	1	07/18/2016	08/12/2016				
						CON	2	11/20/2015	12/09/2015	12/09/2015			
						CON	1	09/04/2015	09/18/2015				
15-PR-0080	1	Sonja Hardman	Joseph Bartell	Cathy Spady	D1	SO1925130	MD 413	AT TULLS CORNER ROAD					
						FIN	2	02/10/2017	02/10/2017			02/10/2017	
						FIN	1	01/09/2017	01/11/2017				
						SITE	5	05/16/2016	05/23/2016		05/23/2016		
						SITE	4	04/25/2016	05/02/2016				
						SITE	3	03/11/2016	03/17/2016				
						SITE	2	01/19/2016	01/20/2016				
						SITE	1	12/18/2015	12/21/2015				
						CON	2	11/02/2015	11/02/2015	11/02/2015			
						CON	1	09/04/2015	09/11/2015				
15-PR-0081	1	Tesfamichael Bogale	Joseph Bartell	Richard Wilke	OED	AX0265124R	VAR VARIES	Landscape Sustainability Improvements at Various Locations					
						FIN	2	10/31/2016	11/04/2016			11/04/2016	
						FIN	1	10/04/2016	10/24/2016				
						SITE	3	09/06/2016	09/22/2016		09/22/2016		
						SITE	2	07/11/2016	08/04/2016				
						SITE	1	04/18/2016	05/11/2016				
						CON	1	09/10/2015	09/24/2015	09/24/2015			
15-PR-0082	1	Brandon Scott	Joseph Bartell	Teresa Bondi	D3	MO9445177	MD 185	NORTH OF MD 410 TO MANOR ROAD					
						SITE	1	11/10/2015	11/19/2015				

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						CON	1	09/14/2015	09/24/2015	09/24/2015			
15-PR-0083	1	Tesfamichael Bogale	Glen Helms	Lindsay Bobian	OHD	BA7275572	I 695	SOUTH OF SHADYNOOK AVENUE TO US 40					
						CON	1	09/15/2015	10/05/2015				
15-PR-0084	1	Brandon Scott	Daniel Sharar-Salgado	Marcus Tadros	OHD	MO8915170	US 29	MUSGROVE ROAD TO FAIRLAND ROAD					
						CON	3	11/24/2015	12/03/2015	12/03/2015			
						CON	2	11/03/2015	11/17/2015				
						CON	1	09/16/2015	09/29/2015				
15-PR-0085	1	Doug Roys	Garvin Guide	Colin Hill	OED	AX0335182	NA N/A	PATAPSCO VALLEY STATE PARK (AVALON) - STREAM RESTORATION					
						FIN	1	05/09/2017	06/09/2017			06/09/2017	
						SITE	4	04/04/2017	04/05/2017		04/05/2017		
						SITE	3	03/15/2017	03/23/2017				
						SITE	2	06/13/2016	07/14/2016				
						SITE	1	04/12/2016	05/10/2016				
						CON	3	12/15/2015	12/31/2015	12/31/2015			
						CON	2	11/23/2015	12/11/2015				
						CON	1	09/16/2015	10/09/2015				
15-PR-0086	1	Doug Roys	Michael Weber	Rahul Kesarkar	OED	AX7665282	VAR Varies	SWM AT VARIOUS LOCATIONS IN DISTRICT 7 - GROUP 1					
						SITE	5	03/09/2017	03/09/2017		03/09/2017		
						SITE	4	01/25/2017	02/13/2017				
						SITE	3	11/18/2016	12/05/2016				
						SITE	2	10/18/2016	11/01/2016				
						SITE	1	08/29/2016	09/08/2016				
						CON	2	03/29/2016	04/01/2016	04/01/2016			
						CON	1	09/16/2015	09/22/2015				
15-PR-0087	1	Tesfamichael Bogale	Joseph Bartell	Cathy Spady	D1	AT0245130	US 13	IHB-Jones Road to North of Eden Road					
						FIN	2	05/18/2016	05/20/2016			05/20/2016	
						FIN	1	04/11/2016	04/19/2016				
						SITE	2	03/23/2016	03/31/2016		03/31/2016		
						SITE	1	02/22/2016	03/02/2016				
						CON	3	12/22/2015	12/22/2015	12/22/2015			
						CON	2	11/16/2015	12/11/2015				
						CON	1	09/23/2015	10/06/2015				
15-PR-0088	1	Brandon Scott	Johathan Brown	Jonathan Brown	OHD	XX1605174	I 83	I-83 NB Drainage Issue near Structure 03400X0					
						FIN	1	08/25/2016	09/28/2016			09/28/2016	
						SITE	1	06/02/2016	06/24/2016		06/24/2016		
						CON	1	09/24/2015	10/01/2015	10/01/2015			
15-PR-0089	1	Jeff Knaub	Joseph Bartell	Jim Hade	OED	PG3515224	MD 769D	ANACOSTIA GATEWAY PARK					
						FIN	2	04/14/2016	04/14/2016			04/14/2016	
						FIN	1	03/29/2016	04/13/2016				
						SITE	2	02/10/2016	03/01/2016		03/01/2016		
						SITE	1	11/17/2015	12/01/2015				
						CON	1	09/28/2015	10/06/2015	10/06/2015			
15-PR-0090	1	Sonja Hardman	Joseph Bartell	Teresa Bondi	D3	PG0415177	MD 5	IHB - Surratts Road to MD 223					
						FIN	1	03/14/2016	03/17/2016			03/17/2016	
						SITE	1	02/18/2016	02/23/2016		02/23/2016		
						CON	1	09/28/2015	09/30/2015	09/30/2015			

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
15-PR-0091	1	Tesfamichael Bogale	Joseph Bartell	Dorey Uong	D3	MO0815177	MD 190	MD 614 TO DC LINE					
						M1	1	08/12/2016	08/19/2016				
						FIN	1	07/21/2016	07/25/2016			07/25/2016	
						SITE	2	06/13/2016	06/22/2016		06/22/2016		
						SITE	1	05/31/2016	06/01/2016				
						CON	2	01/04/2016	02/01/2016	02/01/2016			
						CON	1	10/02/2015	10/14/2015				
15-PR-0092	1	Brandon Scott	Joseph Bartell	Cathy Spady	D1	WI1985187	US 13 BU	IHB - Dogwood Drive to West College Avenue					
						FIN	1	04/08/2016	04/15/2016			04/15/2016	
						SITE	3	03/25/2016	03/31/2016		03/31/2016		
						SITE	2	03/04/2016	03/17/2016				
						SITE	1	01/22/2016	02/09/2016				
						CON	3	01/11/2016	01/11/2016	01/11/2016			
						CON	2	12/17/2015	12/24/2015				
						CON	1	10/02/2015	10/08/2015				
15-PR-0093	1	Brandon Scott	Meredith Wilson	Michael Osborne	OOTS	PG3195285	MD 202/21	IHB - MD 202 & MD 214 W/APS/CPS					
						M1	1	02/01/2017	02/10/2017				02/10/2017
						FIN	1	06/20/2016	06/20/2016			06/20/2016	
						SITE	2	04/27/2016	05/19/2016		05/19/2016		
						SITE	1	03/15/2016	04/04/2016				
						CON	4	02/05/2016	02/12/2016	02/12/2016			
						CON	3	01/06/2016	01/22/2016				
						CON	2	11/16/2015	12/03/2015				
						CON	1	10/02/2015	10/29/2015				
15-PR-0094	1	Sonja Hardman	Joseph Bartell	Teresa Bondi	D3	PG0365177	US 301	PEERLESS AVENUE TO MSP WEIGH STATION					
						SITE	1	09/02/2016	09/06/2016		09/06/2016		
						CON	2	05/31/2016	06/01/2016	06/01/2016			
						CON	1	10/02/2015	10/06/2015				
15-PR-0095	1	Tesfamichael Bogale	Joseph Bartell	Angela Strevig	D3	MO1835177	MD 650	MILESTONE DRIVE TO SHAW AVENUE					
						SITE	3	10/17/2016	11/01/2016				
						SITE	2	04/04/2016	05/10/2016				
						SITE	1	03/11/2016	03/17/2016				
						CON	2	11/06/2015	12/07/2015	12/07/2015			
						CON	1	10/05/2015	10/14/2015				
15-PR-0096	1	Brandon Scott	Joseph Bartell	Jordan Howard	D3	PG0395177	MD 5	IHB - MOORES ROAD TO SURRATTS ROAD					
						FIN	1	12/22/2016	01/10/2017			01/10/2017	
						SITE	3	10/31/2016	11/17/2016		11/17/2016		
						SITE	2	09/26/2016	10/06/2016				
						SITE	1	06/20/2016	07/11/2016				
						CON	1	10/05/2015	10/14/2015	10/14/2015			
15-PR-0098	1	Brandon Scott	Kiona Leah	Steve Collins	OED	AX7665682	NA N/A	AT VARIOUS LOCATIONS IN DISTRICT 3 - GROUP 1					
						SITE	1	12/19/2016	12/29/2016		12/29/2016		
						CON	2	05/25/2016	06/21/2016	06/21/2016			
						CON	1	10/06/2015	11/03/2015				
15-PR-0099	1	Tesfamichael Bogale	Joseph Bartell	Sarah Gentner	D3	MO0825177	MD 124	SPUR TO CHRISTOPHER AVENUE TO MIDCOUNTY HIGHWAY					
						CON	1	10/07/2015	10/16/2015	10/16/2015			

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
15-PR-0100	1	Jeff Knaub	Garvin Guide	Jonathan Brown	OHD	BA7125174	I 695	AT CROMWELL BRIDGE ROAD					
						SITE	4	05/26/2017	06/08/2017		06/08/2017		
						SITE	3	05/01/2017	05/10/2017				
						SITE	2	03/31/2017	04/07/2017				
						SITE	1	03/03/2017	03/15/2017				
						CON	3	09/20/2016	10/04/2016	10/04/2016			
						CON	2	08/04/2016	09/06/2016				
						CON	1	10/08/2015	10/30/2015				
15-PR-0101	1	Brandon Scott	Joseph Bartell	Yinka Olagoke	OOS	SO2015180	US 13	Bridge 1900302 over Kings Creek					
						M1	1	07/18/2016	08/02/2016				08/02/2016
						FIN	1	01/20/2016	02/01/2016			02/01/2016	
						SITE	1	11/25/2015	12/03/2015		12/03/2015		
						CON	1	10/09/2015	10/09/2015	10/09/2015			
15-PR-0102	1	Sonja Hardman	Gina Goettler	Lauren Baker	OOM	PG0555129	NA N/A	GREENBELT SALT BARN FACILITY					
						FIN	1	03/10/2017	03/13/2017			03/13/2017	
						SITE	4	12/13/2016	12/16/2016		12/16/2016		
						SITE	3	09/26/2016	09/29/2016				
						SITE	2	06/24/2016	07/01/2016				
						SITE	1	04/15/2016	04/25/2016				
						CON	1	10/16/2015	10/19/2015	10/19/2015			
15-PR-0103	1	Tesfamichael Bogale	Joseph Bartell	Kaitlyn Duncan	OOS	XX1635380	MD 349	EmergencyReplacement of CMP at Tyaskin Creek					
						FIN	1	04/25/2016	05/05/2016				
						CON	1	10/16/2015	10/16/2015	10/16/2015			
15-PR-0104	1	Sonja Hardman	Joseph Bartell	Teresa Bondi	D3	MO9465177	MD 586	IHB - STRUCTURE 15063 TO MD 185 AND MD 193 TO MD 97					
						FIN	1	03/13/2017	03/15/2017			03/15/2017	
						SITE	1	01/27/2017	01/31/2017		01/31/2017		
						CON	1	10/19/2015	10/19/2015	10/19/2015			
15-PR-0105	1	Jeff Knaub	Abdul Wakil	Maurice Agostino	OOS	FR1845180	MD 383	SMALL STRUCTURES 10399X0 AND 10401X0					
						SITE	1	04/26/2016	06/10/2016				
						CON	1	10/26/2015	11/16/2015	11/16/2015			
15-PR-0106	1	Sonja Hardman	Joseph Bartell	Mike Steiner	D2	XY2335277	MD 272	Roney Ave to Cecil Ave - Sidewalk Improvements					
						FIN	1	06/07/2016	06/16/2016			06/16/2016	
						SITE	1	12/15/2015	12/16/2015		12/16/2015		
						CON	2	11/17/2015	11/23/2015	11/23/2015			
						CON	1	10/27/2015	10/28/2015				
15-PR-0106	2	Sonja Hardman	Joseph Bartell	Mike Steiner	D2	XY2335277	MD 314	Granby St to MD 480 - Sidewalk Improvements					
						FIN	1	06/21/2016	06/22/2016			06/22/2016	
						SITE	1	12/17/2015	12/18/2015		12/18/2015		
						CON	2	11/17/2015	11/23/2015	11/23/2015			
						CON	1	10/27/2015	10/28/2015				
15-PR-0106	4	Sonja Hardman	Joseph Bartell	Thomas Revelle	D2	XY2335277	MD 18	Harbor Lane to Wharf Lane					
						FIN	2	08/23/2016	08/24/2016			08/24/2016	
						FIN	1	07/12/2016	07/14/2016				
						SITE	2	06/15/2016	06/21/2016		06/21/2016		
						SITE	1	03/25/2016	03/30/2016				

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						CON	1	02/18/2016	02/22/2016	02/22/2016			
15-PR-0106	5	Sonja Hardman	Joseph Bartell	Thomas Revelle	D2	XY2335277 MD 213 Howard Street to Railroad Ave							
						FIN	1	10/19/2016	10/27/2016			10/27/2016	
						SITE	1	07/19/2016	07/20/2016		07/20/2016		
						CON	2	06/16/2016	07/05/2016				
						CON	1	03/08/2016	03/14/2016	03/14/2016			
15-PR-0106	6	Sonja Hardman	Joseph Bartell	Thomas Revelle	D2	XY2335277 MD 273 Harrington Drive to MD 274							
						FIN	4	09/08/2016	09/08/2016			09/08/2016	
						FIN	3	08/16/2016	08/19/2016				
						FIN	2	07/29/2016	08/01/2016				
						FIN	1	07/12/2016	07/14/2016				
						SITE	1	06/16/2016	06/24/2016		06/24/2016		
						CON	1	03/08/2016	03/14/2016	03/14/2016			
15-PR-0107	1	Sonja Hardman	Meredith Wilson	Jonathan Brown	OHD	AW730A21 US 301 Area 6 Slope Stabilization							
						FIN	1	11/10/2015	11/12/2015			11/12/2015	
						SITE	1	11/02/2015	11/02/2015		11/02/2015		
						CON	1	10/28/2015	10/28/2015	10/28/2015			
15-PR-0108	1	Sonja Hardman	John Vranish	Jason Ferner	OHD	XX3145133 MD 26 Site 1 Frenbrook Drive to North Rolling Road							
						FIN	4	08/26/2016	08/29/2016			08/29/2016	
						FIN	3	08/24/2016	08/25/2016				
						FIN	2	08/16/2016	08/17/2016				
						FIN	1	07/05/2016	07/14/2016				
						SITE	2	05/31/2016	06/02/2016		06/02/2016		
						SITE	1	05/05/2016	05/06/2016				
						CON	3	04/20/2016	04/22/2016	04/22/2016			
						CON	2	03/22/2016	03/31/2016				
						CON	1	10/28/2015	10/28/2015				
15-PR-0108	2	Sonja Hardman	John Vranish	Jason Ferner	OHD	XX3145133 MD 702 Site 2 Southeast Blvd							
						FIN	2	03/17/2016	03/18/2016			03/18/2016	
						FIN	1	03/08/2016	03/10/2016				
						SITE	2	02/10/2016	02/11/2016		02/11/2016		
						SITE	1	01/27/2016	01/29/2016				
						CON	1	01/13/2016	01/19/2016	01/19/2016			
15-PR-0108	3	Sonja Hardman		Jason Ferner	OHD	XX3145133 MD 542 Site 3Loch Hill Road to Yakona Road							
						FIN	1	01/05/2017	01/09/2017			01/09/2017	
						SITE	3	12/12/2016	12/13/2016		12/13/2016		
						SITE	2	11/29/2016	12/01/2016				
						SITE	1	10/18/2016	10/28/2016				
						CON	1	10/03/2016	10/04/2016	10/04/2016			
15-PR-0108	4	Sonja Hardman	John Vranish	Jason Ferner	OHD	XX3145133 MD 26 Site 4 Rolling Road to I-695							
						FIN	1	04/12/2017	04/12/2017			04/12/2017	
						SITE	1	02/08/2017	02/08/2017		02/08/2017		
						CON	1	09/29/2016	10/04/2016	10/04/2016			
15-PR-0108	5	Sonja Hardman		Jason Ferner	OHD	XX3145133 MD 26 Site 5 Deer Park Road to Pikeswood Drive							
						FIN	1	04/24/2017	05/03/2017			05/03/2017	
						SITE	1	02/24/2017	02/28/2017		02/28/2017		

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						CON	1	02/06/2017	02/08/2017	02/08/2017			
15-PR-0109	1	Brandon Scott	Joseph Bartell	Tara Ryan	OED	TA2805149 NA N/A Buried Drum Removal10877 Lewistown Road, Cordova							
						FIN	4	01/12/2017	01/19/2017			01/19/2017	
						FIN	3	09/29/2016	10/18/2016				
						FIN	2	04/20/2016	05/02/2016				
						FIN	1	03/11/2016	03/31/2016				
						SITE	1	12/15/2015	01/07/2016		01/07/2016		
						CON	1	11/02/2015	11/04/2015	11/04/2015			
15-PR-0110	1	Tesfamichael Bogale	Joseph Bartell	Teresa Bondi	D3	MO1575177 MD 187 JOHNSON AVENUE TO I-495							
						SITE	3	09/16/2016	10/04/2016		10/04/2016		
						SITE	2	06/14/2016	07/07/2016				
						SITE	1	04/25/2016	05/13/2016				
						CON	1	11/02/2015	11/17/2015	11/17/2015			
15-PR-0111	1	Jeff Knaub	Joseph Bartell	Dorey Uong	D3	PG0515177 MD 202 US 50 TO MD 450 (ANNAPOLIS ROAD)							
						FIN	2	05/06/2016	05/26/2016			05/26/2016	
						FIN	1	03/25/2016	04/22/2016				
						SITE	1	12/07/2015	12/22/2015		12/22/2015		
						CON	1	11/02/2015	11/16/2015	11/16/2015			
15-PR-0112	1	Sonja Hardman	Tyler Bazan	Joseph Gentile	OHD	FR1715184 US 15 US 15 BU at MD 140							
						M2	1	06/28/2017	06/30/2017				06/30/2017
						M1	4	01/09/2017	01/10/2017				01/10/2017
						M1	3	01/03/2017	01/05/2017				
						M1	2	12/13/2016	12/16/2016				
						M1	1	11/22/2016	12/01/2016				
						FIN	1	10/05/2016	10/24/2016			10/24/2016	
						SITE	2	08/26/2016	08/31/2016		08/31/2016		
						SITE	1	06/09/2016	06/16/2016				
						CON	3	01/13/2016	01/14/2016	01/14/2016			
						CON	2	11/18/2015	11/23/2015				
						CON	1	11/02/2015	11/04/2015				
15-PR-0113	1	Brandon Scott	Joseph Bartell	James Hade	OED	QA1965124 MD 544 0.14 MILES EAST OF JIM JUNGLE ROAD TO JIM JUNGLE ROAD, Jim Jungle Road, Critical Area Mitigation							
						FIN	1	11/01/2016	11/14/2016			11/14/2016	
						SITE	2	10/12/2016	10/19/2016		10/19/2016		
						SITE	1	08/17/2016	08/29/2016				
						CON	1	11/04/2015	11/10/2015	11/10/2015			
15-PR-0114	1	Tesfamichael Bogale	Meredith Wilson	John Narer	OOS	FR1025180 MD 478 BRIDGE 1008900 OVER BRANCH OF POTOMAC RIVER							
						FIN	1	04/21/2017	05/04/2017				
						SITE	5	03/17/2017	03/27/2017		03/27/2017		
						SITE	4	02/14/2017	02/28/2017				
						SITE	3	01/24/2017	02/06/2017				
						SITE	2	10/24/2016	11/14/2016				
						SITE	1	09/06/2016	09/16/2016				
						CON	3	02/26/2016	03/18/2016	03/18/2016			
						CON	2	12/30/2015	01/13/2016				
						CON	1	11/05/2015	11/17/2015				

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
15-PR-0115	1	Jeff Knaub	Joseph Bartell	Yasin Gregg	OED	BA6135149 NA N/A Golden Ring Maintenance Shop - UST System							
						FIN	1	04/08/2016	04/25/2016			04/25/2016	
						SITE	2	02/29/2016	03/17/2016		03/17/2016		
						SITE	1	01/11/2016	02/11/2016				
						CON	1	11/06/2015	12/04/2015	12/04/2015			
15-PR-0116	1	Sonja Hardman	Joseph Bartell	Sarah Gentner	D3	MO1855177 MD 355 MD 28 TO MANNAKEE STREET							
						SITE	2	04/15/2016	04/18/2016		04/18/2016		
						SITE	1	02/19/2016	02/26/2016				
						CON	1	11/09/2015	11/13/2015	11/13/2015			
15-PR-0117	1	Brandon Scott	Joseph Bartell	John Narer	OOS	AL4795180 MD 51 BRIDGE 01092 OVER CSX AND CANAL PARKWAY							
						SITE	1	02/09/2017	03/01/2017				
						CON	3	09/12/2016	09/27/2016	09/27/2016			
						CON	2	06/14/2016	07/15/2016				
						CON	1	11/10/2015	11/23/2015				
15-PR-0118	1	Tesfamichael Bogale	Joseph Bartell	Teresa Bondi	D3	MO9455177 MD 320 MD 193 to MD 650							
						FIN	1	05/19/2016	05/24/2016			05/24/2016	
						SITE	1	04/13/2016	04/26/2016		04/26/2016		
						CON	2	02/09/2016	02/25/2016	02/25/2016			
						CON	1	11/10/2015	11/30/2015				
15-PR-0119	1	Jeff Knaub	Joseph Bartell	Teresa Bondi	D3	PG0355177 US 301 MD 214 TO 45O FEET SOUTH OF EXCALIBUR ROAD							
						SITE	1	06/29/2016	08/04/2016				
						CON	2	01/29/2016	02/17/2016	02/17/2016			
						CON	1	11/10/2015	12/08/2015				
15-PR-0120	1	Sonja Hardman	Joseph Bartell	April Stitt	D7	FR1985177 US 340 IHB - MD 17 to Lander Road							
						FIN	1	06/02/2016	06/07/2016			06/07/2016	
						SITE	2	05/20/2016	05/23/2016		05/23/2016		
						SITE	1	02/02/2016	02/03/2016				
						CON	2	12/09/2015	12/14/2015	12/14/2015			
						CON	1	11/12/2015	11/13/2015				
15-PR-0121	1	Sonja Hardman	Joseph Bartell	Daniel Beck	OOS	PG6985180 I 95/495 IHB - BRIDGE 1616205 AND 1616206 OVER SUITLAND ROAD							
						FIN	2	07/25/2016	07/26/2016			07/26/2016	
						FIN	1	06/17/2016	06/24/2016				
						SITE	2	03/18/2016	03/18/2016		03/18/2016		
						SITE	1	03/10/2016	03/15/2016				
						CON	2	12/04/2015	12/09/2015	12/09/2015			
						CON	1	11/13/2015	11/17/2015				
15-PR-0123	1	Sonja Hardman	Matt Alisch	Derrick Dickerson	OOTS	MO8695285 VAR VARIES IHB - MD 185/MD 187/MD 355 with APS/CPS							
						FIN	4	05/18/2016	05/20/2016			05/20/2016	
						FIN	3	04/20/2016	04/25/2016				
						FIN	2	04/15/2016	04/19/2016				
						FIN	1	04/06/2016	04/12/2016				
						SITE	2	03/22/2016	03/28/2016		03/28/2016		
						SITE	1	03/02/2016	03/03/2016				
						CON	1	11/17/2015	11/23/2015	11/23/2015			

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
15-PR-0124	1	Brandon Scott	Joseph Bartell	David Mitchell	D6	AL2915187	MD 51	IHB - AT VIRGINIA AVENUE					
						M1	1	12/19/2016	12/21/2016				12/21/2016
						FIN	1	07/22/2016	08/04/2016			08/04/2016	
						SITE	2	06/13/2016	06/24/2016		06/24/2016		
						SITE	1	04/29/2016	05/24/2016				
						CON	2	02/26/2016	03/03/2016	03/03/2016			
						CON	1	11/20/2015	12/08/2015				
15-PR-0125	1	Tesfamichael Bogale	Joseph Bartell	Sarah Gentner	D3	MO9475177	MD 124	Orchard Ridge Road to MD 355					
						FIN	2	04/14/2016	04/15/2016			04/15/2016	
						FIN	1	03/31/2016	04/08/2016				
						SITE	2	03/16/2016	03/17/2016		03/17/2016		
						SITE	1	02/16/2016	03/08/2016				
						CON	1	11/24/2015	12/14/2015	12/14/2015			
15-PR-0126	1	Brandon Scott	Johathan Brown	Jonathan Brown	OHD	TBD	US 301	Phase 2 Drainage and Slope Repairs					
						SITE	3	11/03/2016	11/17/2016		11/17/2016		
						SITE	2	09/29/2016	10/13/2016				
						SITE	1	05/12/2016	06/01/2016				
						CON	1	11/25/2015	12/21/2015	12/21/2015			
15-PR-0127	1	Sonja Hardman	Johathan Brown	Jonathan Brown	OHD	TBD	MD 295	Outfall Repair Near MP 11.00					
						FIN	1	09/29/2016	09/29/2016			09/29/2016	
						SITE	2	07/27/2016	07/28/2016		07/28/2016		
						SITE	1	07/12/2016	07/14/2016				
						CON	3	06/16/2016	06/21/2016	06/21/2016			
						CON	2	03/25/2016	03/29/2016				
						CON	1	11/25/2015	11/27/2015				
15-PR-0128	1	Jeff Knaub	Joseph Bartell	John Jenkins	D7	HO1775177	I 70	Marriottsville Road to Baltimore County Line					
						FIN	2	04/08/2016	04/22/2016			04/22/2016	
						FIN	1	02/17/2016	03/09/2016				
						SITE	1	12/30/2015	02/05/2016		02/05/2016		
						CON	1	12/01/2015	12/14/2015	12/14/2015			
15-PR-0129	1	Tesfamichael Bogale	Joseph Bartell	Thomas Revelle	D2	CE2665187	US 40	At Nottingham Road/Old Neck Road					
						CON	5	12/05/2016	12/20/2016				
						CON	4	07/21/2016	08/15/2016				
						CON	3	06/09/2016	06/16/2016				
						CON	2	02/12/2016	03/17/2016				
						CON	1	12/04/2015	12/22/2015				
15-PR-0131	1	Brandon Scott	Michael Weber	Huqin Zhang	OHD	KE4385184	MD 291	WEST OF SCHOOL STREET TO EAST OF CRANE STREET					
						CON	6	05/22/2017	05/26/2017	05/26/2017			
						CON	5	03/23/2017	04/06/2017				
						CON	4	11/09/2016	11/18/2016	11/18/2016			
						CON	3	09/26/2016	10/13/2016				
						CON	2	06/20/2016	07/15/2016				
						CON	1	12/11/2015	01/05/2016				
15-PR-0132	1	Jeff Knaub	Mike Weber	Larry Trout	OED	WA2655282	VAR 70/65	*VOID* Combined with 16-PR-0028 SWM BMPs at Various Locations in Washington Co, Group 2					
						CON	1	12/11/2015	02/03/2016				

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
15-PR-0133	1	Tesfamichael Bogale	Joseph Bartell	Jason Pollock	OOS	BA0805180	MD 137	IHB - BRIDGE 03050 OVER I-83					
						M1	2	06/19/2017	06/23/2017				06/23/2017
						M1	1	06/12/2017	06/14/2017				
						FIN	1	03/13/2017	03/23/2017			03/23/2017	
						SITE	3	03/01/2017	03/07/2017		03/07/2017		
						SITE	2	02/09/2017	02/17/2017				
						SITE	1	01/17/2017	01/31/2017				
						CON	6	01/05/2017	01/05/2017	01/05/2017			
						CON	5	12/08/2016	12/23/2016				
						CON	4	10/03/2016	10/21/2016				
						CON	3	09/28/2016					
						CON	2	06/29/2016	07/22/2016				
						CON	1	12/17/2015	01/12/2016				
15-PR-0134	1	Sonja Hardman	Joseph Bartell	Karen Fiasco	D5	AA1965177	MD 295	Hanover Road to Winterson Road, Hammonds Ferry Road to Baltimore County Line					
						FIN	1	12/08/2016	12/13/2016			12/13/2016	
						SITE	2	10/20/2016	10/24/2016		10/24/2016		
						SITE	1	06/29/2016	06/30/2016				
						CON	1	12/17/2015	12/18/2015	12/18/2015			
15-PR-0136	1	Brandon Scott	Tyler Bazan	Lauren Baker	OOM	HA4605129	MD 152	FALLSTON - SALT BARN REPLACEMENT					
						SITE	2	12/01/2016	12/14/2016		12/14/2016		
						SITE	1	07/28/2016	08/18/2016				
						CON	3	04/21/2016	05/12/2016	05/12/2016			
						CON	2	02/26/2016	03/08/2016				
						CON	1	12/28/2015	01/15/2016				
16-PR-0001	1	Jeff Knaub	Meredith Wilson	Yasin Gregg	OED	FR2595149	NA	N/A	FREDERICK SHOP WASHBAY				
						FIN	1	08/17/2016	08/23/2016			08/23/2016	
						SITE	2	08/05/2016	08/08/2016		08/08/2016		
						SITE	1	07/06/2016	07/28/2016				
						CON	3	05/18/2016	06/20/2016	06/20/2016			
						CON	2	04/11/2016	05/10/2016				
						CON	1	01/04/2016	02/08/2016				
16-PR-0002	1	Tesfamichael Bogale	Regina Kennedy	Regina Kennedy	OHD	MO1065174	I 270	*VOID* Withdrawn and Submitted to MDE Functional Enhancement BMP 150556					
						CON	1	01/11/2016					
16-PR-0003	1	Brandon Scott	Michael Weber	Nimish Desai	OED	BA2015382	VAR VARIES	SWM AT VARIOUS LOCATIONS IN BALTIMORE COUNTY - GROUP 1					
						FIN	1	11/25/2016	12/12/2016			12/12/2016	
						SITE	4	11/03/2016	11/09/2016		11/09/2016		
						SITE	3	10/18/2016	10/28/2016				
						SITE	2	08/24/2016	09/07/2016				
						SITE	1	06/14/2016	06/28/2016				
						CON	1	01/11/2016	02/22/2016	02/22/2016			
16-PR-0004	1	Doug Roys	Michael Weber	Mark Thayer	OED	CH2985182	NA	N/A	DNR Smallwood State Park				
						FIN	1	02/14/2017	02/22/2017			02/22/2017	
						SITE	4	01/17/2017	01/27/2017		01/27/2017		
						SITE	3	12/09/2016	12/22/2016				
						SITE	2	10/26/2016	11/18/2016				
						SITE	1	09/12/2016	09/26/2016				

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						CON	3	04/04/2016	04/11/2016	04/11/2016			
						CON	2	02/25/2016	03/28/2016				
						CON	1	01/14/2016	02/08/2016				
16-PR-0005	1	Tesfamichael Bogale	Junaid Khan	Junaid Kahn	OHD	AT6885274	VAR VARIES	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL CALVERT CHARLES & ST MARY'S COUNTY					
						SITE	5	06/14/2017	06/19/2017		06/19/2017		
						SITE	4	04/18/2017	05/09/2017				
						SITE	3	02/27/2017	03/20/2017				
						SITE	2	02/03/2017	02/17/2017				
						SITE	1	12/14/2016	01/09/2017				
						CON	2	08/02/2016	08/18/2016	08/18/2016			
						CON	1	01/19/2016	02/25/2016				
16-PR-0005	2	Tesfamichael Bogale	Junaid Khan	Junaid Kahn	OHD	AT6885274	VAR VARIES	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL CALVERT CHARLES & ST MARY'S COUNTY					
						SITE	4	04/18/2017	05/09/2017		05/09/2017		
						SITE	3	02/27/2017	03/20/2017				
						SITE	2	02/03/2017	02/17/2017				
						SITE	1	12/14/2016	01/09/2017				
						CON	2	08/02/2016	08/18/2016	08/18/2016			
						CON	1	01/19/2016	02/25/2016				
16-PR-0005	3	Tesfamichael Bogale	Junaid Khan	Junaid Kahn	OHD	AT6885274	VAR VARIES	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL CALVERT CHARLES & ST MARY'S COUNTY					
						SITE	4	04/26/2017	05/04/2017		05/04/2017		
						SITE	3	02/28/2017	03/20/2017				
						SITE	2	02/03/2017	02/17/2017				
						SITE	1	12/22/2016	01/11/2017				
						CON	2	08/29/2016	09/15/2016	09/15/2016			
						CON	1	01/19/2016	02/25/2016				
16-PR-0005	4	Tesfamichael Bogale	Junaid Khan	Junaid Kahn	OHD	AT6885274	VAR VARIES	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL CALVERT CHARLES & ST MARY'S COUNTY					
						SITE	4	04/18/2017	05/09/2017		05/09/2017		
						SITE	3	02/27/2017	03/20/2017				
						SITE	2	02/03/2017	02/17/2017				
						SITE	1	12/14/2016	01/09/2017				
						CON	2	08/02/2016	08/18/2016	08/18/2016			
						CON	1	01/19/2016	02/25/2016				
16-PR-0005	5	Tesfamichael Bogale	Junaid Khan	Junaid Kahn	OHD	AT6885274	VAR VARIES	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL CALVERT CHARLES & ST MARY'S COUNTY					
						SITE	5	06/14/2017	06/19/2017		06/19/2017		
						SITE	4	04/18/2017	05/09/2017				
						SITE	3	02/27/2017	03/20/2017				
						SITE	2	02/03/2017	02/17/2017				
						SITE	1	12/14/2016	01/09/2017				
						CON	2	08/02/2016	08/18/2016	08/18/2016			
						CON	1	01/19/2016	02/25/2016				
16-PR-0005	6	Tesfamichael Bogale	Junaid Khan	Junaid Kahn	OHD	AT6885274	VAR VARIES	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL CALVERT CHARLES & ST MARY'S COUNTY					
						SITE	2	02/03/2017	02/17/2017		02/17/2017		
						SITE	1	12/15/2016	01/02/2017				
						CON	2	07/26/2016	08/09/2016	08/09/2016			
						CON	1	01/19/2016	02/25/2016				

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
16-PR-0005	7	Tesfamichael Bogale	Junaid Khan	Junaid Kahn	OHD	AT6885274 VAR VARIES			IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL CALVERT CHARLES & ST MARY'S COUNTY				
						SITE	4	04/26/2017	05/04/2017		05/04/2017		
						SITE	3	02/28/2017	03/20/2017				
						SITE	2	02/03/2017	02/17/2017				
						SITE	1	12/22/2016	01/11/2017				
						CON	1	09/12/2016	09/22/2016	09/22/2016			
16-PR-0005	8	Tesfamichael Bogale	Junaid Khan	Junaid Kahn	OHD	AT6885274 VAR VARIES			IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL CALVERT CHARLES & ST MARY'S COUNTY				
						SITE	6	06/28/2017	07/10/2017				
						SITE	5	06/07/2017	06/19/2017				
						SITE	4	04/17/2017	04/27/2017				
						SITE	3	02/27/2017	03/20/2017				
						SITE	2	02/03/2017	02/17/2017				
						SITE	1	12/15/2016	01/02/2017				
						CON	2	07/27/2016	08/09/2016	08/09/2016			
						CON	1	01/19/2016	02/25/2016				
16-PR-0005	9	Tesfamichael Bogale	Junaid Khan	Junaid Kahn	OHD	AT6885274 VAR VARIES			IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL CALVERT CHARLES & ST MARY'S COUNTY				
						SITE	6	06/28/2017	07/10/2017		07/10/2017		
						SITE	5	06/07/2017	06/19/2017				
						SITE	4	04/17/2017	04/27/2017				
						SITE	3	02/27/2017	03/20/2017				
						SITE	2	02/03/2017	02/17/2017				
						SITE	1	12/15/2016	01/02/2017				
						CON	2	07/27/2016	08/09/2016	08/09/2016			
						CON	1	01/19/2016	02/25/2016				
16-PR-0005	10	Tesfamichael Bogale	Junaid Khan	Junaid Kahn	OHD	AT6885274 VAR VARIES			IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL CALVERT CHARLES & ST MARY'S COUNTY				
						SITE	6	06/28/2017	07/10/2017				
						SITE	5	06/07/2017	06/19/2017				
						SITE	4	04/17/2017	04/27/2017				
						SITE	3	02/27/2017	03/20/2017				
						SITE	2	02/03/2017	02/17/2017				
						SITE	1	12/15/2016	01/02/2017				
						CON	2	07/27/2016	08/09/2016	08/09/2016			
						CON	1	01/19/2016	02/25/2016				
16-PR-0005	11	Tesfamichael Bogale	Junaid Khan	Junaid Kahn	OHD	AT6885274 VAR VARIES			IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL CALVERT CHARLES & ST MARY'S COUNTY				
						SITE	6	06/28/2017	07/10/2017		07/10/2017		
						SITE	5	06/07/2017	06/19/2017				
						SITE	4	04/17/2017	04/27/2017				
						SITE	3	02/27/2017	03/20/2017				
						SITE	2	02/03/2017	02/17/2017				
						SITE	1	12/15/2016	01/02/2017				
						CON	2	07/27/2016	08/09/2016	08/09/2016			
						CON	1	01/19/2016	02/25/2016				
16-PR-0005	12	Tesfamichael Bogale		Junaid Kahn	OHD	AT6885274 VAR VARIES			IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL CALVERT CHARLES & ST MARY'S COUNTY				
						SITE	6	06/28/2017	07/10/2017		07/10/2017		
						SITE	5	06/15/2017	06/19/2017				
						SITE	4	04/26/2017	05/05/2017				
						SITE	3	02/28/2017	03/20/2017				

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						SITE	2	02/03/2017	02/17/2017				
						SITE	1	12/22/2016	01/11/2017				
						CON	2	08/29/2016	09/15/2016	09/15/2016			
						CON	1	01/19/2016	02/25/2016				
16-PR-0005	13	Tesfamichael Bogale	Junaid Khan	Junaid Kahn	OHD	AT6885274	VAR VARIES	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL CALVERT CHARLES & ST MARY'S COUNTY					
						SITE	2	02/03/2017	02/17/2017		02/17/2017		
						SITE	1	12/22/2016	01/11/2017				
						CON	2	08/29/2016	09/15/2016	09/15/2016			
						CON	1	01/19/2016	02/25/2016				
16-PR-0005	14	Tesfamichael Bogale	Junaid Khan	Junaid Kahn	OHD	AT6885274	VAR VARIES	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL CALVERT CHARLES & ST MARY'S COUNTY					
						SITE	2	02/03/2017	02/17/2017		02/17/2017		
						SITE	1	12/22/2016	01/11/2017				
						CON	2	08/29/2016	09/15/2016	09/15/2016			
						CON	1	01/19/2016	02/25/2016				
16-PR-0006	1	Sonja Hardman	Joseph Bartell	Andrew Radcliffe	D7	HO1535277	MD 32	IHB - North of MD 108 to Structure 13114 Over Middle Patuxent River					
						FIN	1	03/01/2016	03/02/2016			03/02/2016	
						SITE	1	02/09/2016	02/10/2016		02/10/2016		
						CON	1	01/19/2016	01/20/2016	01/20/2016			
16-PR-0007	1	Brandon Scott	Joseph Bartell	Mike Helenius	OED	MO0645124	MD 190	Intersection at MD 190 and MD 188					
						FIN	1	04/14/2016	04/20/2016			04/20/2016	
						SITE	1	03/16/2016	03/28/2016		03/28/2016		
						CON	1	02/03/2016	02/09/2016	02/09/2016			
16-PR-0008	1	Sonja Hardman	Johathan Brown	Jonathan Brown	OHD	XY1685174	VAR VARIES	Statewide Stormwater Facility Maintenance, Group 1BMP 130172, 1300225, 130230, 160377					
						CON	1	02/09/2016	02/09/2016	02/09/2016			
16-PR-0008	2	Brandon Scott	Meredith Wilson	Jonathan Brown	OHD	XY1685174	MD 2/4	SITE 2, Statewide Stormwater Facility Maintenance					
						SITE	1	11/21/2016	09/01/2017		09/01/2017		
						FIN	1	11/21/2016	12/05/2016			12/05/2016	
						CON	1	11/04/2016	11/04/2016	11/04/2016			
16-PR-0009	1	Jeff Knaub	Johathan Brown	Jonathan Brown	OHD	PG0705174	VAR VARIES	IHB - AT VARIOUS LOCATIONS IN PRINCE'S GEORGE COUNTY					
						FIN	1	02/14/2017	02/24/2017			02/24/2017	
						SITE	6	01/23/2017	01/24/2017		01/24/2017		
						SITE	5	01/06/2017	01/09/2017				
						SITE	4	12/07/2016	12/22/2016				
						SITE	3	10/31/2016	11/18/2016				
						SITE	2	09/15/2016	09/28/2016				
						SITE	1	06/20/2016	07/22/2016				
						CON	1	02/09/2016	03/07/2016	03/07/2016			
16-PR-0010	1	Tesfamichael Bogale	Armand de Rosset	AJ de Rosset	OHD	MO2805174	MD 117	IHB - BETWEEN MD 117 AND IN-STREAM STORMWATER MANAGEMENT STRUCTURE					
						FIN	2	06/05/2017	06/07/2017			06/07/2017	
						FIN	1	05/23/2017	05/30/2017				
						SITE	5	04/12/2017	04/21/2017		04/21/2017		
						SITE	4	03/23/2017	04/05/2017				
						SITE	3	01/25/2017	02/10/2017				
						SITE	2	12/14/2016	12/30/2016				
						SITE	1	08/11/2016	09/07/2016				
						CON	1	02/10/2016	03/24/2016	03/24/2016			

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
16-PR-0011	1	Brandon Scott	Johathan Brown	Jonathan Brown	OHD	TBD		MD 760	Outfall Stabilization and Repair				
						CON	1	02/11/2016	02/25/2016	02/25/2016			
16-PR-0012	1	Sonja Hardman	Joseph Bartell	Sutapa Samanta	D4	BA5325277		I 695	MD 140 TO STEVENSON ROAD - OUTER AND INNER LOOP				
						FIN	1	06/02/2016	06/06/2016			06/06/2016	
						SITE	1	04/20/2016	04/22/2016		04/22/2016		
						CON	1	02/18/2016	02/23/2016	02/23/2016			
16-PR-0013	1	Jeff Knaub	Joseph Bartell		OOS	FR1145180		US 40	BRIDGE 1014600 AT US 40 RAMP F				
						M1	2	03/24/2017	04/04/2017				04/04/2017
						M1	1	03/15/2017	03/17/2017				
						FIN	1	09/07/2016	09/08/2016			09/08/2016	
						SITE	2	08/24/2016	08/25/2016		08/25/2016		
						SITE	1	07/26/2016	08/09/2016				
						CON	2	05/18/2016	06/03/2016	06/03/2016			
						CON	1	02/18/2016	03/14/2016				
16-PR-0014	1	Tesfamichael Bogale	Joseph Bartell		OOS	BA0135180		I 695	IHB - BRIDGE 0312500 OVER I-695				
						FIN	1	05/09/2017	05/10/2017			05/10/2017	
						SITE	5	04/21/2017	04/24/2017		04/24/2017		
						SITE	4	03/27/2017	04/05/2017				
						SITE	3	03/13/2017	03/13/2017				
						SITE	2	02/23/2017	02/28/2017				
						SITE	1	01/19/2017	02/06/2017				
						CON	4	11/23/2016	12/08/2016	12/08/2016			
						CON	3	10/20/2016	11/16/2016				
						CON	2	07/18/2016	07/28/2016				
						CON	1	02/19/2016	03/18/2016				
16-PR-0015	1	Brandon Scott	Polly Solliday	David Mitchell	D6	GA1845177		US 40 A	IHB - US 219 to Green Lantern Road				
						FIN	1	05/02/2016	05/11/2016			05/11/2016	
						SITE	2	04/18/2016	04/21/2016		04/21/2016		
						SITE	1	03/28/2016	04/12/2016				
						CON	1	02/26/2016	03/02/2016	03/02/2016			
16-PR-0016	1	Doug Roys	Michael Weber	Jason Alwine	OED	CH1885282		VAR VARIES	AT VARIOUS LOCATIONS - GROUP 1A				
						SITE	2	01/31/2017	02/08/2017		02/08/2017		
						SITE	1	11/09/2016	11/22/2016				
						CON	1	02/29/2016	03/02/2016	03/02/2016			
16-PR-0017	1	Jeff Knaub	Joseph Bartell	Barry Ritchie	D6	WA4445177		US 40	NOTTINGHAM DRIVE TO CANNON AVENUE				
						FIN	1	05/26/2016	06/22/2016			06/22/2016	
						SITE	1	05/05/2016	05/23/2016		05/23/2016		
						CON	2	03/24/2016	04/18/2016	04/18/2016			
						CON	1	03/01/2016	03/17/2016				
16-PR-0018	1	Tesfamichael Bogale	Joseph Bartell	Jay Thaker	OOTS	BA2435185		I 83	I-695 I-795 AT MD 940 (OWINGS MILLS BOULEVARD) , MD 940 at Painters Mill Road				
						FIN	1	05/31/2016	06/02/2016			06/02/2016	
						SITE	2	04/25/2016	05/04/2016		05/04/2016		
						SITE	1	03/09/2016	03/18/2016				
						CON	1	03/02/2016	03/02/2016	03/02/2016			

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
16-PR-0019	1	Brandon Scott	Alicia Brandys	Jared Paper-Evers	OHD	AA5105271		MD 198	RUSSET GREEN EAST TO MD 295 NB RAMP - PHASE 1				
						SITE	3	04/06/2017	04/21/2017				
						SITE	2	11/22/2016	12/15/2016				
						SITE	1	09/01/2016	10/04/2016				
						CON	3	05/05/2016	05/27/2016	05/27/2016			
						CON	2	04/01/2016	04/12/2016				
						CON	1	03/03/2016	03/17/2016				
16-PR-0020	1	Sonja Hardman	Joseph Bartell	Erica Rigby	D3	N/A		NA N/A	Gradall Equipment Training at Fairland Road and Old Columbia Pike				
						FIN	1	04/14/2016	04/18/2016			04/18/2016	
						SITE	1	03/31/2016	03/31/2016		03/31/2016		
						CON	1	03/03/2016	03/08/2016	03/08/2016			
16-PR-0021	1	Jeff Knaub	Joseph Bartell	Yasin Gregg	OED	QA2815249		NA N/A	CENTREVILLE SHOP - REPLACEMENT OF FUEL SYSTEM				
						FIN	1	10/26/2016	11/02/2016			11/02/2016	
						SITE	5	10/17/2016	10/18/2016		10/18/2016		
						SITE	4	10/06/2016	10/11/2016				
						SITE	3	09/28/2016	09/29/2016				
						SITE	2	08/04/2016	08/29/2016				
						SITE	1	06/07/2016	06/29/2016				
						CON	2	04/21/2016	05/16/2016	05/16/2016			
						CON	1	03/09/2016	04/04/2016				
16-PR-0022	1	Tesfamichael Bogale	Joseph Bartell		OOTS	PG1155285		MD 214	Central Avenue at I-94/I-495 AND MD 202				
						FIN	2	11/10/2016	11/14/2016			11/14/2016	
						FIN	1	11/01/2016	11/07/2016				
						SITE	2	09/29/2016	10/12/2016		10/12/2016		
						SITE	1	07/12/2016	08/05/2016				
						CON	1	03/09/2016	03/17/2016	03/17/2016			
16-PR-0023	1	Brandon Scott	Joseph Bartell	Dorey Uong	D3	MO9485177		MD 28	QUINCE ORCHARD ROAD TO ARGOSY DRIVE				
						FIN	2	10/26/2016	11/17/2016			11/17/2016	
						FIN	1	09/21/2016	09/28/2016				
						SITE	1	08/17/2016	08/23/2016		08/23/2016		
						CON	2	06/08/2016	06/24/2016	06/24/2016			
						CON	1	03/09/2016	03/25/2016				
16-PR-0024	1	Sonja Hardman	Junaid Khan	Chris Weber	OHD	HA4335174		MD 623	IHB - FRANKLIN CHURCH ROAD TO GLEN COVE ROAD				
						M2	1	06/28/2017	06/30/2017				06/30/2017
						M1	2	04/14/2017	05/02/2017				05/02/2017
						M1	1	03/31/2017	04/03/2017				
						FIN	2	01/31/2017	02/06/2017			02/06/2017	
						FIN	1	12/12/2016	12/16/2016				
						SITE	4	10/21/2016	10/31/2016		10/31/2016		
						SITE	3	10/04/2016	10/05/2016				
						SITE	2	08/31/2016	09/07/2016				
						SITE	1	06/24/2016	06/28/2016				
						CON	2	04/12/2016	04/13/2016	04/13/2016			
						CON	1	03/10/2016	03/15/2016				
16-PR-0025	1	Jeff Knaub	Tyler Bazan	Jeff Robert	OOS	CL2395180		MD 86	IHB - BRIDGE 0601900 OVER SOUTH BRANCH OF GUNPOWDER FALLS				
						SITE	1	05/30/2017	06/16/2017				

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						CON	2	02/01/2017	02/22/2017	02/22/2017			
						CON	1	03/11/2016	04/08/2016				
16-PR-0026	1	Brandon Scott	Joseph Bartell	Jay Thaker	OOTS	BA0155185 I 95 AT I-695							
						FIN	1	07/18/2016	07/22/2016			07/22/2016	
						SITE	2	06/22/2016	07/08/2016		07/08/2016		
						SITE	1	05/02/2016	06/01/2016				
						CON	1	03/14/2016	03/31/2016	03/31/2016			
16-PR-0027	1	Tesfamichael Bogale	Gina Goettler	Jeff Robert	OOS	PG0465180R MD 381 BRIDGE 1630500 OVER TIMOTHY BRANCH							
						FIN	2	11/18/2016	11/18/2016			11/18/2016	
						FIN	1	10/21/2016	11/14/2016				
						SITE	2	07/18/2016	07/18/2016		07/18/2016		
						SITE	1	05/31/2016	06/03/2016				
						CON	1	03/16/2016	03/17/2016	03/17/2016			
16-PR-0028	1	Doug Roys	Michael Weber	Larry Trout	OED	WA2655382 VAR VARIES AT VARIOUS LOCATIONS IN WASHINGTON COUNTY - GROUP 1A							
						FIN	1	05/11/2017	06/09/2017				
						SITE	2	03/01/2017	03/02/2017		03/02/2017		
						SITE	1	11/18/2016	12/13/2016				
						CON	2	07/01/2016	07/25/2016	07/25/2016			
						CON	1	03/17/2016	04/11/2016				
16-PR-0029	1	Brandon Scott	Shreemal Perera	Kelly Nash	OOS	FR5595180 MD 355 IHB - BRIDGE 1008400 OVER CSX							
						FIN	1	03/23/2017	03/24/2017			03/24/2017	
						SITE	3	02/28/2017	03/08/2017		03/08/2017		
						SITE	2	02/09/2017	02/17/2017				
						SITE	1	01/09/2017	01/24/2017				
						CON	4	12/01/2016	12/14/2016	12/14/2016			
						CON	3	11/07/2016	11/22/2016				
						CON	2	08/23/2016	09/13/2016				
						CON	1	03/29/2016	04/21/2016				
16-PR-0030	1	Sonja Hardman	Gina Goettler	Dana Morse	OOS	KE2945180 US 301 BRIDGE 1400501 OVER MD 290							
						FIN	2	01/11/2017	01/11/2017			01/11/2017	
						FIN	1	12/09/2016	12/12/2016				
						SITE	3	09/06/2016	09/09/2016		09/09/2016		
						SITE	2	08/25/2016	08/29/2016				
						SITE	1	07/12/2016	07/15/2016				
						CON	3	05/12/2016	05/18/2016	05/18/2016			
						CON	2	04/21/2016	04/25/2016				
						CON	1	03/29/2016	03/31/2016				
16-PR-0031	1	Tesfamichael Bogale	Patrick Nadeau	Dorey Uong	D3	MO9125130 MD 198 IHB - AT RIDING STABLE ROAD							
						FIN	3	04/28/2017	05/03/2017			05/03/2017	
						FIN	2	02/06/2017	02/10/2017				
						FIN	1	12/12/2016	12/28/2016				
						SITE	4	10/31/2016	11/21/2016		11/21/2016		
						SITE	3	10/06/2016	10/19/2016				
						SITE	2	09/14/2016	09/28/2016				
						SITE	1	08/02/2016	08/18/2016				
						CON	3	06/13/2016	07/07/2016	07/07/2016			
						CON	2	05/20/2016	05/26/2016				

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						CON	1	04/01/2016	05/06/2016				
16-PR-0032	1	Jeff Knaub	Joseph Bartell		OOS	AA7765180		MD 450	BRIDGE 02243X0 02335X0 02288XO 02244X0				
						CON	2	07/06/2016	08/23/2016	08/23/2016			
						CON	1	04/06/2016	05/12/2016				
16-PR-0033	1	Sonja Hardman	Joseph Bartell	Henry Teets	D2	N/A		US 301	Gradall Equipment Training at US 301 / Bay County Rest Area, D2				
						FIN	1	05/05/2016	05/05/2016			05/05/2016	
						SITE	1	04/26/2016	05/02/2016		05/02/2016		
						CON	1	04/07/2016	04/13/2016	04/13/2016			
16-PR-0034	1	Brandon Scott	Michael Weber	Mark Thayer	OED	CE2725282		VAR VARIES	AT VARIOUS LOCATIONS IN CECIL COUNTY - GROUP 1				
						M1	1	05/19/2017	06/13/2017				06/13/2017
						FIN	1	02/21/2017	02/28/2017			02/28/2017	
						SITE	3	01/13/2017	01/24/2017		01/24/2017		
						SITE	2	12/05/2016	12/16/2016				
						SITE	1	10/19/2016	11/07/2016				
						CON	2	07/19/2016	08/03/2016	08/03/2016			
						CON	1	04/08/2016	05/06/2016				
16-PR-0035	1	Tesfamichael Bogale	Jeremy Ash		OHD	TBD		I 83	Water Quality Mitigation Sites on I-83 and Freeland Road				
						CON	2	09/29/2016	10/24/2016				
						CON	1	04/08/2016	05/11/2016				
16-PR-0036	1	Jeff Knaub	Regina Kennedy	Regina Kennedy	OHD	MO1605174		I 270	IHB - MONTROSE ROAD RAMP TO SB I-270 CD LANES				
						FIN	1	03/23/2017	03/24/2017			03/24/2017	
						SITE	2	03/08/2017	03/16/2017		03/16/2017		
						SITE	1	02/09/2017	02/23/2017				
						CON	3	11/21/2016	12/08/2016	12/08/2016			
						CON	2	08/24/2016	09/15/2016				
						CON	1	04/18/2016	05/10/2016				
16-PR-0037	1	Brandon Scott	Garvin Guide	Armando Henriquez	OHD	WO1685177		MD 528	62ND STREET TO 26TH STREET				
						M2	1	05/01/2017	05/04/2017				05/04/2017
						M1	1	04/12/2017	04/26/2017				
						FIN	1	11/17/2016	11/22/2016			11/22/2016	
						SITE	2	10/21/2016	10/31/2016		10/31/2016		
						SITE	1	09/08/2016	09/20/2016				
						CON	2	07/27/2016	08/12/2016	08/12/2016			
						CON	1	04/18/2016	05/10/2016				
16-PR-0038	1	Tesfamichael Bogale	Jeremy Ash		OHD	TBD		I 68	WQ Mitigation Sites from Old Morgantown Road to Pigs Ear Road				
						CON	2	09/29/2016	10/24/2016				
						CON	1	04/18/2016	05/13/2016				
16-PR-0039	1	Jeff Knaub	Johathan Brown	Jonathan Brown	OHD	WA2805174		MD 64	LITTLE ANTIETAM ROAD TO MD 804B				
						SITE	2	05/30/2017					
						SITE	1	03/27/2017	04/07/2017				
						CON	4	12/12/2016	12/30/2016	12/30/2016			
						CON	3	10/11/2016	11/07/2016				
						CON	2	07/27/2016	09/08/2016				
						CON	1	04/25/2016	06/10/2016				

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
16-PR-0040	1	Brandon Scott	Joseph Bartell	John Jenkins	D7	CL2145187	MD 97	SOUTH OF AIRPORT DRIVE TO PLEASANT VALLEY ROAD					
						FIN	1	04/11/2017	04/24/2017			04/24/2017	
						SITE	3	03/27/2017	03/31/2017		03/31/2017		
						SITE	2	03/09/2017	03/20/2017				
						SITE	1	02/08/2017	02/17/2017				
						CON	3	12/07/2016	12/20/2016	12/20/2016			
						CON	2	09/19/2016	10/13/2016				
						CON	1	04/25/2016	06/02/2016				
16-PR-0041	1	Tesfamichael Bogale	Abdul Wakil	John Narer	OOS	GA1975180	MD 39	IHB - BRIDGE 1100200 OVER YOUGHIOGHENY RIVER					
						CON	4	02/09/2017	02/24/2017	02/24/2017			
						CON	3	12/20/2016	01/10/2017				
						CON	2	10/19/2016	11/21/2016				
						CON	1	04/26/2016	05/18/2016				
16-PR-0042	1	Jeff Knaub	Patrick Nadeau		OOS	CH2265180	MD 254	IHB - BRIDGE 0803800 OVER NEALE SOUND					
						SITE	2	01/27/2017	02/16/2017		02/16/2017		
						SITE	1	11/09/2016	11/22/2016				
						CON	3	09/19/2016	10/03/2016	10/03/2016			
						CON	2	07/20/2016	08/18/2016				
						CON	1	04/26/2016	05/26/2016				
16-PR-0043	1	Brandon Scott		Jeff Robert	OOS	CL4035180	MD 496	IHB - BRIDGE 0603800 OVER BIG PIPE CREEK					
						FIN	1	02/16/2017	02/24/2017			02/24/2017	
						SITE	4	02/16/2017	02/24/2017		02/24/2017		
						SITE	3	01/19/2017	02/03/2017				
						SITE	2	11/16/2016	12/01/2016				
						SITE	1	10/12/2016	10/28/2016				
						CON	2	07/15/2016	07/26/2016	07/26/2016			
						CON	1	04/26/2016	05/25/2016				
16-PR-0044	1	Tesfamichael Bogale	Garvin Guide	Thomas Revelle	D2	CE2925130	MD 213	IHB - AT FRENCHTOWN ROAD					
						FIN	1	01/27/2017	02/13/2017			02/13/2017	
						SITE	1	01/06/2017	01/06/2017		01/06/2017		
						CON	4	12/15/2016	12/27/2016	12/27/2016			
						CON	3	10/18/2016	11/21/2016				
						CON	2	06/10/2016	06/22/2016				
						CON	1	05/05/2016	05/18/2016				
16-PR-0045	1	Jeff Knaub	Meredith Wilson		OHD	FR1115179	MD 17	B STREET TO CENTER STREET					
						M1	1	05/22/2017	06/06/2017				06/06/2017
						FIN	1	05/01/2017	05/09/2017			05/09/2017	
						SITE	4	02/15/2017	02/28/2017		02/28/2017		
						SITE	3	11/29/2016	12/16/2016				
						SITE	2	10/21/2016	11/18/2016				
						SITE	1	09/16/2016	10/06/2016				
						CON	2	07/18/2016	09/02/2016	09/02/2016			
						CON	1	05/06/2016	06/17/2016				
16-PR-0046	1	Doug Roys	Armand de Rosset	Ashby Strassburger	OED	PG9535182	VAR VARIES	CHARLES BRANCH TRIBUTARIES					
						SITE	3	12/22/2016	01/05/2017		01/05/2017		
						SITE	2	11/21/2016	12/06/2016				

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						SITE	1	09/29/2016	10/19/2016				
						CON	2	08/01/2016	08/18/2016	08/18/2016			
						CON	1	05/09/2016	06/03/2016				
16-PR-0048	1	Tesfamichael Bogale	Meredith Wilson		OHD	FR1115279		MD 464	MD 17 TO 9TH AVENUE				
						CON	3	03/01/2017	03/07/2017	03/07/2017			
						CON	2	11/04/2016	11/30/2016				
						CON	1	05/10/2016	05/26/2016				
16-PR-0049	1	Jeff Knaub	Joseph Bartell	Tobi Kester	OED	AW0465182		VAR VARIES	TREE PLANTING AT VARIOUS LOCATIONS IN DISTRICT 3				
						FIN	1	08/05/2016	08/15/2016			08/15/2016	
						SITE	2	07/22/2016	07/26/2016		07/26/2016		
						SITE	1	06/24/2016	06/30/2016				
						CON	1	05/12/2016	05/13/2016	05/13/2016			
16-PR-0050	1	Brandon Scott	Gina Goettler	Virginia Keenan	OHD	SM7745171		MD 5	IHB - THE CAUSEWAY TO SOUTH OF CAMP BROWN ROAD				
						SITE	1	04/13/2017	05/05/2017				
						CON	2	07/18/2016	08/18/2016	08/18/2016			
						CON	1	05/12/2016	06/13/2016				
16-PR-0051	1	Tesfamichael Bogale	Joseph Bartell		OOM	CA1435129		MD 231	PRINCE FREDERICK FACILITY - LIFE CODE/FIRE SAFETY IMPROVEMENTS PHASE 2				
						FIN	1	03/13/2017	03/16/2017			03/16/2017	
						SITE	3	12/05/2016	12/21/2016		12/21/2016		
						SITE	2	11/04/2016	11/16/2016				
						SITE	1	09/06/2016	09/22/2016				
						CON	1	05/16/2016	05/16/2016	05/16/2016			
16-PR-0052	1	Jeff Knaub	Joseph Bartell		OED	AW0765182		VAR VARIES	D3 Tree Establishment				
						FIN	1	02/01/2017	02/10/2017			02/10/2017	
						SITE	2	12/08/2016	12/12/2016		12/12/2016		
						SITE	1	11/16/2016	11/23/2016				
						CON	1	05/16/2016	05/16/2016	05/16/2016			
16-PR-0053	1	Brandon Scott	Sonia Hossain	Yasin Gregg	OED	WA4455149		NA N/A	Hagerstown Shop Wash Bay				
						FIN	1	10/26/2016	10/31/2016			10/31/2016	
						SITE	2	09/27/2016	10/03/2016		10/03/2016		
						SITE	1	08/26/2016	09/08/2016				
						CON	2	07/20/2016	08/10/2016	08/10/2016			
						CON	1	05/16/2016	06/13/2016				
16-PR-0054	1	Tesfamichael Bogale	Tyler Bazan	Dorey Uong	D3	PG6265176		MD 223	AT PISCATAWAY DRIVE				
						CON	4	03/03/2017	03/27/2017	03/27/2017			
						CON	3	12/09/2016	12/27/2016				
						CON	2	10/11/2016	11/01/2016				
						CON	1	05/18/2016	06/01/2016				
16-PR-0055	1	Jeff Knaub	Joseph Bartell		OED	AW0775482		NA N/A	Tree Establishment at Various Locations in Howard and Carroll Counties				
						SITE	2	02/02/2017					
						SITE	1	11/17/2016	11/23/2016				
						CON	1	05/18/2016	05/19/2016	05/19/2016			
16-PR-0056	1	Brandon Scott	Joseph Bartell	Dorey Uong	D3	PG0445177		US 301	SOUTH OSBORNE ROAD TO MD 381 (OLD CRAIN HIGHWAY)				
						FIN	1	03/13/2017	03/23/2017			03/23/2017	
						SITE	2	10/19/2016	11/16/2016		11/16/2016		

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						SITE	1	09/08/2016	09/22/2016				
						CON	1	05/19/2016	06/15/2016	06/15/2016			
16-PR-0057	1	Jeff Knaub	Joseph Bartell		OED	AW0775182		NA N/A	Tree Establishment at Various Locations in Baltimore County				
						SITE	1	02/01/2017					
						CON	1	05/20/2016	05/20/2016	05/20/2016			
16-PR-0058	1	Tesfamichael Bogale	Joseph Bartell	Teresa Bondi	D3	MO1865177		I 495	I-270 Y to Seminary Rd - OL				
						FIN	2	04/05/2017	04/07/2017			04/07/2017	
						FIN	1	03/21/2017	04/04/2017				
						SITE	3	01/12/2017	01/18/2017		01/18/2017		
						SITE	2	11/30/2016	12/19/2016				
						SITE	1	10/05/2016	11/01/2016				
						CON	1	05/25/2016	06/08/2016	06/08/2016			
16-PR-0059	1	Brandon Scott	Joseph Bartell	John Jenkins	D7	FR6735177		MD 26	IHB - Safety and Resurfacing from US 15 TO EAST OF MD 194				
						FIN	1	01/25/2017	02/08/2017			02/08/2017	
						SITE	2	10/27/2016	10/31/2016		10/31/2016		
						SITE	1	09/07/2016	09/26/2016				
						CON	1	05/26/2016	06/16/2016	06/16/2016			
16-PR-0060	1	Doug Roys	Daniel Sharar-Salgado	Eric Freidly	OED	CO1415170		MD 404	Wetland Mitigation at Smith Farm				
						FIN	1	08/01/2016	08/02/2016			08/02/2016	
						SITE	2	07/18/2016	07/18/2016		07/18/2016		
						SITE	1	06/14/2016	06/16/2016				
						CON	1	05/31/2016	06/02/2016	06/02/2016			
16-PR-0061	1	Jeff Knaub	Joseph Bartell	John Narer	OOS	CH2205180		MD 224	STRUCTURE 08021X0 OVER BRANCH OF POTOMAC RIVER				
						CON	1	05/31/2016	06/29/2016	06/29/2016			
16-PR-0062	1	Tesfamichael Bogale	Joseph Bartell	Andrew Radcliffe	D7	HO1535177		MD 32	IHB - STRUCTURE 13114 OVER MIDDLE PATUXENT RIVER TO NORTH OF MD 108				
						FIN	1	02/01/2017	02/13/2017			02/13/2017	
						SITE	4	12/07/2016	12/23/2016		12/23/2016		
						SITE	3	11/01/2016	11/14/2016				
						SITE	2	09/21/2016	10/06/2016				
						SITE	1	07/21/2016	08/09/2016				
						CON	1	05/31/2016	06/15/2016	06/15/2016			
16-PR-0063	1	Brandon Scott	Tyler Bazan	Jane Lee	OOM	MO5245129		MD 185	CONNECTICUT AVENUE - SALT BARN REPLACEMENT				
						FIN	1	06/27/2017	07/13/2017			07/13/2017	
						SITE	3	05/23/2017	05/26/2017		05/26/2017		
						SITE	2	04/13/2017	04/26/2017				
						SITE	1	02/08/2017	02/24/2017				
						CON	3	08/15/2016	09/02/2016	09/02/2016			
						CON	2	07/15/2016	08/11/2016				
						CON	1	06/02/2016	06/24/2016				
16-PR-0064	1	Doug Roys	Michael Weber	Rahul Kesarkar	OED	CH1885382		VAR Varies	MD 5, US 301 Retrofit Existing SWM BMP's to meet TMDL				
						CON	1	06/03/2016	07/06/2016				
16-PR-0065	1	Tesfamichael Bogale	Johathan Brown		HHD	AW730A21		US 50/301	Emergency repair for a stormdrain and slope stabilization				
						SITE	1	07/29/2016	08/03/2016				
						CON	1	06/06/2016	06/23/2016	06/23/2016			

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
									-				
						FIN	1	09/13/2016	09/16/2016				
						SITE	2	08/30/2016	09/06/2016				
						SITE	1	07/26/2016	08/08/2016				
						CON	1	06/06/2016	06/24/2016				
						M1	1	05/12/2017	05/24/2017				
						FIN	1	03/27/2017	04/06/2017				
						SITE	3	02/01/2017	02/17/2017				
						SITE	2	11/23/2016	12/16/2016				
						SITE	1	08/29/2016	09/19/2016				
						CON	1	06/07/2016	07/08/2016				
-													
						CON	1	06/07/2016	06/24/2016				
16-PR-0068	2	Tesfamichael Bogale	Joseph Bartell	Jordan Howard	D3	XY2425377	MD 27	Oak Drive to Sunset Drive					
						CON	2	02/07/2017	02/22/2017				
						CON	1	06/14/2016	07/07/2016				
16-PR-0068	3	Tesfamichael Bogale	Joseph Bartell	Jordan Howard	D3	XY2425377	MD 547	Flanders Ave to Weymouth Street					
						SITE	1	11/16/2016	11/25/2016				
						CON	1	08/23/2016	09/16/2016				
						CON	2	01/25/2017	02/06/2017				
						CON	1	11/16/2016	11/25/2016				
						CON	1	01/27/2017	02/07/2017	02/07/2017			
						CON	1	01/27/2017	02/03/2017	02/03/2017			
16-PR-0068	7	Tesfamichael Bogale	Joseph Bartell	Jordan Howard	D3	XY2425377	MD 410	50' East of S. Boston Ave to 50' West of Park Ave					
						FIN	1	04/19/2017	04/25/2017				
						SITE	1	03/02/2017	03/10/2017				
						CON	1	01/30/2017	02/16/2017				
						SITE	1	03/31/2017	04/12/2017				
						CON	1	02/01/2017	02/14/2017				
						CON	1	02/08/2017	02/17/2017	02/17/2017			
16-PR-0068	10	Tesfamichael Bogale	Joseph Bartell	Jordan Howard	D3	XY2425377	MD 190	MD190 Gary road to Harrington Drive					
						CON	1	02/08/2017	02/17/2017	02/17/2017			
16-PR-0069	1	Brandon Scott	Jessica Lain	Toria Lassiter	OHD	GA6715184	US 219	MD 135 TO 325 FEET NORTH OF EAST ORCHID STREET					
						CON	3	09/07/2016	09/22/2016	09/22/2016			
						CON	2	08/05/2016	08/22/2016				
						CON	1	06/07/2016	06/24/2016				

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
16-PR-0070	1	Jeff Knaub	Polly Solliday		OHD	BA7295170	MD 140	NORTH OF PAINTERS MILL ROAD TO NORTH OF OWINGS MILLS OVERPASS (PHASE 2)					
						SITE	1	12/27/2016	01/11/2017				
						CON	2	09/12/2016	09/22/2016	09/22/2016			
						CON	1	06/09/2016	07/15/2016				
16-PR-0071	1	Tesfamichael Bogale	Joseph Bartell	Scott Dutrow	D7	AT8235117	MD 97	Gradall Equipment Training, D7					
						SITE	1	07/18/2016	07/25/2016		07/25/2016		
						FIN	1	07/18/2016	07/25/2016			07/25/2016	
						CON	1	06/13/2016	06/15/2016	06/15/2016			
16-PR-0072	1	Brandon Scott	Joseph Bartell	Sarah Gentner	D3	MO4055176	MD 108	MD 650 (NEW HAMPSHIRE AVE) TO ENTRANCE TO SHARP STREET UNITED METHODIST CHURCH					
						CON	1	06/14/2016	07/07/2016				
16-PR-0073	1	Tesfamichael Bogale	Joseph Bartell	Karen Fiasco	D5	AX0475114	NA N/A	Gradall Equipment Training, D5					
						FIN	1	07/19/2016	07/27/2016			07/27/2016	
						SITE	1	07/07/2016	07/14/2016		07/14/2016		
						CON	1	06/15/2016	06/15/2016	06/15/2016			
16-PR-0074	1	Doug Roys	Tyler Bazan	Jason Alwine	OED	HA1925282	NA N/A	AT VARIOUS LOCATIONS IN HARFORD COUNTY - GROUP 1A					
						FIN	1	04/10/2017	04/10/2017			04/10/2017	
						SITE	3	03/30/2017	04/05/2017		04/05/2017		
						SITE	2	03/21/2017	03/27/2017				
						SITE	1	02/07/2017	02/23/2017				
						CON	3	09/20/2016	09/28/2016	09/28/2016			
						CON	2	08/22/2016	09/09/2016				
						CON	1	06/16/2016	07/11/2016				
16-PR-0075	1	Jeff Knaub	Garvin Guide		OHD	TBD	MD 312	MD 312 Culvert Replacement/Enhancement					
						CON	2	06/13/2017	06/23/2017				
						CON	1	07/12/2016	08/12/2016				
16-PR-0076	1	Doug Roys	Michael Weber	Nimish Desai		BA2015582	NA N/A	AT VARIOUS LOCATIONS IN BALTIMORE COUNTY - GROUP 1B					
						FIN	1	04/10/2017	04/10/2017			04/10/2017	
						SITE	2	03/06/2017	03/08/2017		03/08/2017		
						SITE	1	01/25/2017	02/10/2017				
						CON	3	11/10/2016	12/01/2016	12/01/2016			
						CON	2	09/15/2016	10/13/2016				
						CON	1	06/16/2016	07/13/2016				
16-PR-0077	1	Brandon Scott	Joseph Bartell	Andrew Radcliffe	D7	FR1625177	MD 26	WEST SOUTH STREET TO MD 31					
						FIN	1	03/02/2017	03/15/2017			03/15/2017	
						SITE	1	02/09/2017	02/15/2017		02/15/2017		
						CON	3	12/22/2016	01/05/2017	01/05/2017			
						CON	2	10/12/2016	10/28/2016				
						CON	1	06/21/2016	07/16/2016				
16-PR-0078	1	Jeff Knaub	Joseph Bartell		D4	BA9825277	MD 45	TOWSON ROUNDABOUT TO CAVAN DRIVE					
						SITE	2	04/13/2017	04/24/2017				
						SITE	1	03/03/2017	03/13/2017				
						CON	3	11/21/2016	12/14/2016	12/14/2016			
						CON	2	09/26/2016	10/13/2016				
						CON	1	06/24/2016	07/20/2016				

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
16-PR-0079	1	Tesfamichael Bogale	Glen Helms		OHD	AA2315176	MD 4	FISHER STATION ROAD TO MD 258					
						CON	2	11/29/2016	12/16/2016	12/16/2016			
						CON	1	06/27/2016	07/14/2016				
16-PR-0080	1	Brandon Scott	Glen Helms	Lindsay Bobian	OHD	MO4195287	I 495	I-495 at MD 650 - Ramp from Inner Loop to Southbound MD 650					
						FIN	1	12/19/2016	01/03/2017			01/03/2017	
						SITE	3	11/14/2016	11/22/2016		11/22/2016		
						SITE	2	10/25/2016	11/04/2016				
						SITE	1	09/30/2016	10/14/2016				
						CON	2	09/07/2016	09/12/2016	09/12/2016			
						CON	1	06/28/2016	08/08/2016				
16-PR-0081	1	Jeff Knaub	Joseph Bartell	Karen Fiasco	D5	AA1975177	MD 295	MD 175 TO MD 100					
						CON	2	01/18/2017	01/27/2017	01/27/2017			
						CON	1	06/29/2016	07/29/2016				
16-PR-0082	1	Doug Roys	Tyler Bazan		OED	FR6635382	VAR N/A	AT VARIOUS LOCATIONS IN FREDERICK COUNTY - GROUP 1A					
						FIN	1	03/23/2017	03/24/2017			03/24/2017	
						SITE	2	03/13/2017	03/15/2017		03/15/2017		
						SITE	1	02/16/2017	03/02/2017				
						CON	2	11/29/2016	12/16/2016	12/16/2016			
						CON	1	07/01/2016	08/05/2016				
16-PR-0083	1	Brandon Scott	Johathan Brown	Jonathan Brown	OHD	TBD	MD 349	Emergency Repair Riawalkin Dam					
						FIN	1	01/10/2017	01/25/2017			01/25/2017	
						CON	1	07/05/2016	07/05/2016	07/05/2016			
16-PR-0084	1	Jeff Knaub	Ryan Doheny		OHD	FR6785171	MD 180	WEST OF SWALLOWTAIL DRIVE TO I-70 RAMP STRUCTURE 10140					
						SITE	1	02/15/2017	03/09/2017				
						CON	3	11/16/2016	12/07/2016	12/07/2016			
						CON	2	09/29/2016	11/01/2016				
						CON	1	07/05/2016	07/29/2016				
16-PR-0085	1	Tesfamichael Bogale	Joseph Bartell	Kim Livezey	D4	BA0445177	US 1	IHB - NORTH OF I-695 TO DUNFIELD ROAD					
						FIN	2	05/12/2017	05/16/2017			05/16/2017	
						FIN	1	04/18/2017	04/25/2017				
						SITE	2	03/13/2017	03/27/2017		03/27/2017		
						SITE	1	01/31/2017	02/22/2017				
						CON	3	12/20/2016	01/06/2017	01/06/2017			
						CON	2	09/29/2016	10/13/2016				
						CON	1	07/05/2016	07/22/2016				
16-PR-0086	1	Brandon Scott	Joseph Bartell	Sarah Gentner	D3	MO9755187	MD 650	AT OAKVIEW DRIVE					
						CON	2	11/16/2016	12/01/2016				
						CON	1	07/06/2016	08/10/2016				
16-PR-0087	1	Doug Roys	Tyler Bazan	Jason Alwine	OED	WA2655482	VAR VARIES	AT VARIOUS LOCATION IN WASHINGTON COUNTY - GROUP 1B					
						FIN	1	03/30/2017	04/05/2017			04/05/2017	
						SITE	2	03/02/2017	03/02/2017		03/02/2017		
						SITE	1	01/31/2017	02/16/2017				
						CON	2	10/18/2016	11/10/2016	11/10/2016			
						CON	1	07/07/2016	07/29/2016				

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
16-PR-0089	1	Brandon Scott	Kiona Leah	Chris Dalton	OED	WA2775182	VAR N/A		Tree Planting at Various Locations				
						FIN	1	09/01/2016	09/14/2016			09/14/2016	
						SITE	1	08/09/2016	08/18/2016		08/18/2016		
						CON	1	07/19/2016	07/20/2016	07/20/2016			
16-PR-0090	1	Brandon Scott	Joseph Bartell	Sheila Mahoney	OED	AW0475182	VAR N/A		At Various Locations in District 5				
						FIN	1	10/05/2016	10/27/2016			10/27/2016	
						SITE	2	09/01/2016	09/09/2016		09/09/2016		
						SITE	1	08/09/2016	08/18/2016				
						CON	1	07/19/2016	07/20/2016	07/20/2016			
16-PR-0091	1	Jeff Knaub	Joseph Bartell	Barry Ritchie	D6	XY1755677	US 40		Project withdrawn 9/12/16 Clear Spring (contract = 16-PR-0103)				
						CON	3	09/12/2016					
						CON	2	08/24/2016	08/24/2016				
						CON	1	07/20/2016	08/12/2016				
16-PR-0092	1	Dan O'Leary	Meredith Wilson	Hicham Baassiri	D1	WO2375188	US 50		MD 611 TO BRIDGE OVER SINEPUXENT BAY				
						SITE	4	06/19/2017	06/30/2017		06/30/2017		
						SITE	3	04/14/2017	04/24/2017				
						SITE	2	02/09/2017	02/22/2017				
						SITE	1	12/07/2016	12/16/2016				
						CON	2	08/17/2016	08/23/2016	08/23/2016			
						CON	1	07/22/2016	07/28/2016				
16-PR-0093	1	Tesfamichael Bogale	Joseph Bartell	Yinka Olagoke	OOS	PG1275280	I 495		BRIDGE 1615305 1615306 ON I-495/95 OVER MD 214				
						CON	2	01/17/2017	01/30/2017	01/30/2017			
						CON	1	07/25/2016	08/15/2016				
16-PR-0094	1	Jeff Knaub	Joseph Bartell	Kim Livezey	D4	BA2605277	MD 150		BACK RIVER BRIDGE TO RIVERSIDE DRIVE				
						SITE	1	06/22/2017	07/12/2017				
						CON	2	12/08/2016	12/22/2016	12/22/2016			
						CON	1	07/26/2016	09/01/2016				
16-PR-0095	1	Tesfamichael Bogale	Joseph Bartell	April Stitt	D7	FR1945177	US 340		IHB - WASHINGTON COUNTY LINE TO MD 17				
						FIN	1	02/16/2017	03/07/2017			03/07/2017	
						SITE	1	01/25/2017	01/31/2017		01/31/2017		
						CON	3	12/15/2016	12/27/2016	12/27/2016			
						CON	2	11/09/2016	11/30/2016				
						CON	1	07/27/2016	08/09/2016				
16-PR-0096	1	Brandon Scott	Joseph Bartell	Sutapa Samanta	D4	BA7505277	I 695		Greenspring Ave to MD 25 (Falls Road)				
						CON	1	07/27/2016	08/18/2016	08/18/2016			
16-PR-0097	1	Jeff Knaub	Alicia Brandys	Virginia Keenan	OHD	BW6415599	NA N/A		MDOT SECRETARY'S OFFICE SITE REMEDIATION				
						M1	1	05/10/2017	05/15/2017				05/15/2017
						FIN	1	03/07/2017	03/10/2017			03/10/2017	
						SITE	2	02/16/2017	02/21/2017		02/21/2017		
						SITE	1	02/03/2017	02/07/2017				
						CON	2	09/30/2016	10/13/2016	10/13/2016			
						CON	1	07/29/2016	08/23/2016				
16-PR-0098	1	Tesfamichael Bogale	Joseph Bartell	Karen Fiasco	D5	SM1925187	MD 235		ACCESS ROAD TO WOODLAND ACRES				
						SITE	2	06/07/2017	06/15/2017				
						SITE	1	05/18/2017	05/24/2017				

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

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						CON	3	03/23/2017	04/12/2017				
						CON	2	10/17/2016	11/03/2016				
						CON	1	08/05/2016	08/25/2016				
						CON	4	06/02/2017	06/23/2017				
						CON	3	02/06/2017	02/24/2017				
						CON	2	10/20/2016	11/10/2016				
						CON	1	08/09/2016	09/01/2016				
						FIN	1	01/27/2017	02/10/2017				
						SITE	2	01/17/2017	01/19/2017				
						SITE	1	01/06/2017	01/09/2017				
						CON	2	10/17/2016	11/15/2016				
						CON	1	08/09/2016	08/31/2016				
						FIN	2	03/08/2017	03/10/2017				
						FIN	1	03/03/2017	03/07/2017				
						SITE	2	01/23/2017	01/24/2017				
						SITE	1	11/18/2016	12/07/2016				
						CON	2	10/17/2016	11/01/2016				
						CON	1	08/12/2016	09/15/2016				
						SITE	2	05/08/2017	05/24/2017				
						SITE	1	02/22/2017	02/22/2017				
						CON	1	08/15/2016	09/15/2016				
									Hancock ADA Compliance Upgrades				
						CON	1	08/16/2016	08/16/2016				
16-PR-0103	2	Jeff Knaub	Joseph Bartell	Barry Ritchie	D6	XY1755677		MD 36	Withdrawn 9/12/16 Seldom Seen Road to Park Street				
						CON	1	08/25/2016	09/07/2016				
16-PR-0103	3	Jeff Knaub	Joseph Bartell	Barry Ritchie	D6	XY1755677		MD 135	Withdrawn 9/12/16 Victory Post Road to River Road Drive				
						CON	1	08/25/2016	09/07/2016				
16-PR-0103	4	Jeff Knaub	Joseph Bartell	Barry Ritchie	D6	XY1755677		MD 135	Withdrawn 9/12/16 Lonaconing Street to Paradise Street				
						CON	1	09/08/2016	09/08/2016				
16-PR-0104	1	Tesfamichael Bogale	Joseph Bartell	Cathy Spady	D1	WO1785176		US 50	AT MD 589				
						SITE	1	02/03/2017	02/22/2017				
						CON	2	10/27/2016	11/22/2016	11/22/2016			
						CON	1	08/22/2016	09/09/2016				
16-PR-0105	1	Brandon Scott	Joseph Bartell	Dorey Uong	D3	XX1645476		MD 185	Same as 15-PR-0064, Site 2 Median Beautification - Project appears to be VOID				
						CON	2	10/19/2016	10/19/2016				
						CON	1	08/25/2016	09/22/2016				
16-PR-0106	1	Tesfamichael Bogale	Alicia Brandys	Vivian Berra-Figuereo	OHD	BA4515172		I 795	AT DOLFIELD BOULEVARD - SOUTH OF OWINGS MILLS BOULEVARD TO FRANKLIN BOULEVARD				
						CON	3	06/13/2017	06/28/2017	06/28/2017			
						CON	2	03/02/2017	03/23/2017				
						CON	1	08/30/2016	10/13/2016				

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
16-PR-0107	1	Brandon Scott	Meredith Wilson		OOS	AA2215170	US 50	IHB - MD 70 TO MD 2 (NORTH)					
						M1	1	05/01/2017	05/05/2017				05/05/2017
						FIN	1	04/10/2017	04/20/2017			04/20/2017	
						SITE	3	04/03/2017	04/06/2017		04/06/2017		
						SITE	2	03/16/2017	03/30/2017				
						SITE	1	02/06/2017	02/21/2017				
						CON	2	11/16/2016	11/30/2016	11/30/2016			
						CON	1	08/31/2016	09/19/2016				
16-PR-0108	1	Jeff Knaub	Shreemal Perera	Jared Paper-Evers	OHD	TA2865184	MD 33	YACHT CLUB ROAD TO PEA NECK ROAD					
						CON	3	02/14/2017	03/02/2017	03/02/2017			
						CON	2	11/18/2016	12/13/2016				
						CON	1	09/02/2016	09/15/2016				
16-PR-0109	1	Tesfamichael Bogale	Joseph Bartell	Sutapa Samanta	D4	BA2635277	I 95	Baltimore County/City Line to US 1					
						FIN	2	01/19/2017	01/23/2017			01/23/2017	
						FIN	1	01/06/2017	01/11/2017				
						SITE	2	11/23/2016	12/08/2016		12/08/2016		
						SITE	1	10/20/2016	11/14/2016				
						CON	1	09/08/2016	09/16/2016	09/16/2016			
16-PR-0110	1	Jeff Knaub	Joseph Bartell	Sheila Mahoney	OED	AW0435182	NA N/A	TREE PLANTING AT VARIOUS LOCATIONS IN DISTRICT 4					
						CON	1	09/12/2016	09/20/2016	09/20/2016			
16-PR-0111	1	Brandon Scott	Armand de Rosset	Dipa Patel	OOS	BA6095180	US 40	IHB-BRIDGE 03034 & BRIDGE 03035 OVER LITTLE GUNPOWDER FALLS AND GUNPOWDER FALLS					
						SITE	5	05/26/2017	06/06/2017		06/06/2017		
						SITE	4	05/10/2017	05/19/2017				
						SITE	3	04/21/2017	04/28/2017				
						SITE	2	03/24/2017	04/04/2017				
						SITE	1	02/13/2017	03/03/2017				
						CON	3	12/15/2016	12/30/2016	12/30/2016			
						CON	2	11/04/2016	11/22/2016				
						CON	1	09/12/2016	09/30/2016				
16-PR-0112	1	Tesfamichael Bogale	Daniel Sharar-Salgado		D3	MO2105326	I 270	NORTH OF MD 28 (MONTGOMERY AVENUE)					
						CON	3	11/30/2016	12/08/2016	12/08/2016			
						CON	2	10/18/2016	11/14/2016				
						CON	1	09/15/2016	09/27/2016				
16-PR-0113	1	Brandon Scott			D6	N/A	NA N/A	D6 Gradall Training					
						FIN	1	09/22/2016	09/22/2016			09/22/2016	
						SITE	1	09/21/2016	09/22/2016		09/22/2016		
						CON	1	09/16/2016	09/19/2016	09/19/2016			
16-PR-0114	1	Tesfamichael Bogale	Joseph Bartell		D5	XY2425577	US 301	Site 1 Centennial Street to MD 225 (Hawthorne Road)					
						CON	2	10/31/2016	11/22/2016	11/22/2016			
						CON	1	09/19/2016	10/06/2016				
16-PR-0114	2	Tesfamichael Bogale	Joseph Bartell	Karen Fiasco	D5	XY2425577	MD 170	Site 2 10th Avenue to MD 2					
						SITE	1	06/12/2017	06/23/2017				
						CON	1	10/03/2016	10/27/2016	10/27/2016			
16-PR-0114	3	Tesfamichael Bogale	Joseph Bartell		D5	XY2425577	MD 5	Site 3 MD 246 to Chingville Road					
						SITE	1	11/29/2016	12/08/2016		12/08/2016		

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						CON	1	10/17/2016	11/04/2016	11/04/2016			
16-PR-0114	4	Tesfamichael Bogale	Joseph Bartell	Chau Chiem	D5	XY2425577 MD 235 Site 4, MD235 , Old Rolling Road to Town Creek Drive							
						FIN	1	06/07/2017	06/07/2017				
						SITE	2	05/30/2017	05/31/2017		05/31/2017		
						SITE	1	05/15/2017	05/24/2017				
						CON	1	04/26/2017	05/03/2017	05/03/2017			
16-PR-0114	5	Tesfamichael Bogale	Joseph Bartell	Karen Fiasco	D5	XY2425577 MD 435 Site 5 MD 435 from Rosedale St to Herbert Sachs Blvd							
						CON	1	06/12/2017	06/22/2017				
16-PR-0115	1	Jeff Knaub	Joseph Bartell	John Narer	OOS	WA2635180 US 522 BRIDGE 2109000 OVER I-70 EASTBOUND							
						CON	2	11/29/2016	12/20/2016	12/20/2016			
						CON	1	09/26/2016	10/25/2016				
16-PR-0116	1	Sonja Hardman	Johathan Brown	Jonathan Brown	OHD	XX1685174 NA N/A BMP Maintenance for 030050, 030225, 030226, 030227, 030228, 030229							
						M1	1	05/15/2017	05/18/2017				05/18/2017
						FIN	1	03/02/2017	03/02/2017			03/02/2017	
						SITE	2	03/01/2017	03/02/2017		03/02/2017		
						SITE	1	12/28/2016	12/29/2016				
						CON	1	09/26/2016	10/05/2016	10/05/2016			
16-PR-0117	1	Brandon Scott	Jessica Lain		OHD	AA6915184 MD 648 MD 2 TO MD 10							
						CON	2	12/14/2016	12/29/2016	12/29/2016			
						CON	1	09/27/2016	10/18/2016				
16-PR-0118	1	Doug Roys	Junaid Khan		OED	HA4235182 NA N/A HOLLANDS BRANCH AT TRAPPE CHURCH ROAD							
						SITE	1	02/10/2017	02/15/2017				
						CON	1	09/30/2016	10/27/2016	10/27/2016			
16-PR-0119	1	Jeff Knaub	Ryan Doheny		D6	GA1695130 US 219 AT MOSSER ROAD							
						CON	2	06/07/2017	06/20/2017				
						CON	1	09/30/2016	10/31/2016				
16-PR-0120	1	Doug Roys	Joseph Bartell	Dan Beck	OED	WA2655682 NA N/A LITTLE TONOLOWAY CREEK AT KIRKWOOD PARK - STREAM RESTORATION							
						SITE	2	06/30/2017	07/19/2017				
						SITE	1	03/29/2017	03/30/2017				
						CON	2	01/20/2017	02/01/2017	02/01/2017			
						CON	1	10/06/2016	10/31/2016				
16-PR-0121	1	Brandon Scott	Joseph Bartell		D3	MO3595223 I 270 Southbound Acceleration Lane Improvements							
						CON	3	01/03/2017	01/05/2017	01/05/2017			
						CON	2	11/18/2016	12/01/2016				
						CON	1	10/11/2016	10/24/2016				
16-PR-0122	1	Tesfamichael Bogale	Alicia Brandys	John Jenkins	D7	HO1765176 US 1 AT KIT KAT ROAD							
						SITE	2	06/13/2017	06/23/2017				
						SITE	1	05/22/2017	05/25/2017				
						CON	2	01/20/2017	02/07/2017	02/07/2017			
						CON	1	10/12/2016	11/01/2016				
16-PR-0123	1	Jeff Knaub	Joseph Bartell	Thomas Revelle	D2	TA2895176 US 50 Dutchman's Lane to Lomax St							
						CON	2	02/09/2017	02/28/2017				
						CON	1	10/13/2016	11/09/2016				

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
16-PR-0124	1	Brandon Scott	Joseph Bartell	Sutapa Samanta	D4	BA0215177		MD 140	IHB - ROSEWOOD LANE TO EAST PLEASANT HILL ROAD				
						FIN	1	05/23/2017	05/30/2017				
						SITE	3	04/19/2017	04/28/2017		04/28/2017		
						SITE	2	02/10/2017	03/02/2017				
						SITE	1	12/19/2016	12/29/2016				
						CON	2	11/04/2016	11/17/2016	11/17/2016			
						CON	1	10/13/2016	10/28/2016				
16-PR-0125	1	Tesfamichael Bogale	Johathan Brown	John Jenkins	D7	TBD		NA N/A	Areawide Drainage Improvements in Carroll and Frederick County				
						CON	3	05/26/2017	06/06/2017				
						CON	2	04/07/2017	04/19/2017				
						CON	1	10/13/2016	11/04/2016				
16-PR-0126	1	Sonja Hardman	Joseph Bartell	Yasin Gregg	OED	FR6685149		I 70	I-70 WELCOME CENTER - WASTEWATER TREATMENT PLANT OUTFALL RELOCATION				
						FIN	1	06/02/2017	06/06/2017			06/06/2017	
						SITE	3	04/24/2017	05/02/2017		05/02/2017		
						SITE	2	03/31/2017					
						SITE	1	12/15/2016	12/16/2016				
						CON	1	10/17/2016	11/01/2016	11/01/2016			
16-PR-0127	1	Sonja Hardman	Joseph Bartell	John Narer	OOS	BA5345180		US 1	IHB - BRIDGE 0300800 OVER CSX				
						SITE	2	06/21/2017	07/11/2017				
						SITE	1	05/08/2017	05/26/2017				
						CON	3	02/14/2017	02/16/2017	02/16/2017			
						CON	2	12/20/2016	12/27/2016				
						CON	1	10/17/2016	11/10/2016				
16-PR-0128	1	Jeff Knaub	Joseph Bartell	Sheila Mahoney	OED	AW0445282		NA N/A	TREE PLANTING AT VARIOUS LOCATIONS IN CARROLL COUNTY				
						CON	2	01/11/2017	01/12/2017	01/12/2017			
						CON	1	10/19/2016	11/16/2016				
16-PR-0129	1	Brandon Scott	Patrick Nadeau	Thomas Revelle	D2	TBD		US 40	At Maloney Road - Intersection Safety and Geometric Improvements				
						CON	2	02/14/2017	03/01/2017	03/01/2017			
						CON	1	10/21/2016	11/16/2016				
16-PR-0130	1	Tesfamichael Bogale	Joseph Bartell	Kim Livezey	D4	XY5125277		MD 23	Overlay, installation of metal barrier, and associated grading				
						FIN	2	03/06/2017	03/10/2017				
						FIN	1	03/03/2017					
						SITE	2	01/17/2017	02/13/2017		02/13/2017		
						SITE	1	12/15/2016	12/30/2016				
						CON	1	11/02/2016	11/22/2016	11/22/2016			
16-PR-0131	1	Sonja Hardman	Gina Goettler	Kim Livezey	D4	HA5005187		MD 543	AT MD 136 (CALVARY ROAD)				
						SITE	1	06/08/2017	07/07/2017				
						CON	3	01/18/2017	01/18/2017	01/18/2017			
						CON	2	12/15/2016	12/29/2016				
						CON	1	11/03/2016	11/18/2016				
16-PR-0132	1	Doug Roys	Michael Weber		OED	AX7665B82		NA N/A	AT VARIOUS LOCATIONS IN ANNE ARUNDEL COUNTY - GROUP 1A				
						SITE	4	03/17/2017	03/27/2017		03/27/2017		
						SITE	3	01/25/2017	02/16/2017				
						SITE	2	11/14/2016	12/07/2016				
						SITE	1	08/26/2016	09/15/2016				

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						CON	2	04/28/2016	06/08/2016	06/08/2016			
						CON	1	06/01/2015	07/08/2015				
16-PR-0133	1	Jeff Knaub	Joseph Bartell	Sarah Gentner	D3	PG8115187		MD 410	At US 50 Diverging Diamond Interchange				
						CON	3	02/13/2017	02/28/2017				
						CON	2	11/18/2016	12/08/2016				
						CON	1	11/14/2016					
16-PR-0134	1	Brandon Scott	Joseph Bartell	Jason Pollock	OOS	FR1325180		MD 355	IHB - BRIDGE 1008600 OVER BENNETT CREEK				
						CON	3	06/08/2017	06/15/2017	06/15/2017			
						CON	2	04/17/2017	05/12/2017				
						CON	1	11/17/2016	12/08/2016				
16-PR-0135	1	Sonja Hardman	Joseph Bartell	Dorey Uong	D3	PG0405177		MD 4	MD 458 TO DC LINE				
						SITE	1	01/30/2017	01/30/2017		01/30/2017		
						CON	1	11/18/2016	11/21/2016	11/21/2016			
16-PR-0136	1	Tesfamichael Bogale	Joseph Bartell		OOS	WI2225180		US 13 BU	BRIDGE 2200400 OVER EAST BRANCH WICOMICO RIVER				
						SITE	1	05/30/2017	06/12/2017				
						CON	2	01/11/2017	01/24/2017	01/24/2017			
						CON	1	11/21/2016	12/07/2016				
16-PR-0137	1	Jeff Knaub	Joseph Bartell	John Narer	OOS	QA1835180		MD 544	STRUCTURE 17068X0 OVER TRIBUTARY TO FOREMAN BRANCH				
						FIN	2	04/24/2017	05/04/2017			05/04/2017	
						FIN	1	04/07/2017	04/17/2017				
						SITE	2	02/14/2017	03/02/2017		03/02/2017		
						SITE	1	01/23/2017	02/01/2017				
						CON	1	11/21/2016	12/15/2016	12/15/2016			
16-PR-0138	1	Doug Roys	Michael Weber		OED	BA2015482		NA NA	WHITE MARSH TRIBUTARY AT MD 43 (SILVER HILL FARM)				
						SITE	2	03/13/2017	03/13/2017		03/13/2017		
						SITE	1	02/09/2017	02/10/2017				
						CON	1	11/25/2016	12/08/2016	12/08/2016			
16-PR-0139	1	Tesfamichael Bogale	Joseph Bartell	Barry Ritchie	D6	WA4475177		MD 68	BOTTOM ROAD TO INNER CORP LIMITS OF WILLIAMSPORT				
						FIN	1	05/17/2017	05/23/2017			05/23/2017	
						SITE	3	04/12/2017	04/21/2017		04/21/2017		
						SITE	2	03/08/2017	03/24/2017				
						SITE	1	02/09/2017	02/24/2017				
						CON	1	11/28/2016	12/21/2016	12/21/2016			
16-PR-0140	1	Sonja Hardman	Joseph Bartell		D3	PG8085187		MD 4	Dower House Road Intersection Improvements				
						CON	2	03/30/2017	04/05/2017	04/05/2017			
						CON	1	11/29/2016	12/13/2016				
16-PR-0141	1	Sonja Hardman	Meredith Wilson	Jonathan Brown	OHD	TBD		I 270	Emergency Drainage Repair				
						FIN	1	05/09/2017	05/23/2017			05/23/2017	
						CON	1	11/30/2016	12/01/2016	12/01/2016			
16-PR-0142	1	Jeff Knaub	Joseph Bartell	Sutapa Samanta	D4	BA5385177		MD 45	IHB - NORTH OF PADONIA TO WIGHT AVENUE - 24 INCH WATERLINE REPLACEMENT				
						FIN	1	03/28/2017	04/10/2017			04/10/2017	
						SITE	1	02/08/2017	02/16/2017		02/16/2017		
						CON	1	12/01/2016	12/16/2016	12/16/2016			

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
16-PR-0143	1	Brandon Scott	Joseph Bartell	Kim Livezey	D4	BA9035176	MD 43	AT HONEYGO BOULEVARD					
						CON	2	06/15/2017	06/28/2017				
						CON	1	12/01/2016	12/19/2016				
16-PR-0144	1	Tesfamichael Bogale	Junaid Khan		OHD	AA1695174	VAR N/A	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL COUNTY					
						SITE	5	06/13/2017	06/29/2017				
						SITE	4	05/16/2017	05/25/2017				
						SITE	3	04/13/2017	05/03/2017				
						SITE	2	03/09/2017	03/24/2017				
						SITE	1	01/27/2017	02/17/2017				
						CON	1	12/02/2016	12/14/2016	12/14/2016			
16-PR-0144	2	Tesfamichael Bogale	Junaid Khan		OHD	AA1695174	VAR varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL COUNTY					
						CON	1	12/15/2016	01/02/2017	01/02/2017			
16-PR-0145	1	Jeff Knaub	Michael Weber		OHD	DO5775174	MD 16	MD 335 TO BRANNOCKS NECK ROAD					
						CON	2	01/25/2017	02/03/2017	02/03/2017			
						CON	1	12/05/2016	12/22/2016				
16-PR-0146	1	Brandon Scott	Joseph Bartell	John Jenkins	D7	HO1375177	I 70 WB	MARRIOTTSVILLE ROAD TO BALTIMORE COUNTY LINE					
						CON	2	01/09/2017	01/11/2017	01/11/2017			
						CON	1	12/05/2016	12/15/2016				
16-PR-0147	1	Tesfamichael Bogale	Joseph Bartell	Chau Chiem	D5	AA0985174	MD 32	At Samford Road, Drainage Remediation					
						CON	1	12/08/2016	12/27/2016	12/27/2016			
16-PR-0148	1	Sonja Hardman	Tyler Bazan		OHD	AA1725279	MD 214	MD 2 (SOLOMONS ISLAND ROAD) TO MD 253 (MAYO ROAD)					
						CON	2	04/25/2017	05/10/2017	05/10/2017			
						CON	1	12/13/2016	12/23/2016				
16-PR-0149	0	Brandon Scott	Joseph Bartell	April Stitt	D7	CL2255187	MD 26	Formerly 11-SF-0302, CA 9/1/16. Emerald Lane to Calvert Way - Eastbound and Westbound					
						FIN	2	01/10/2017	01/27/2017			01/27/2017	
						FIN	1	12/20/2016	12/23/2016				
16-PR-0150	1	Sonja Hardman		Yinka Olagoke	OOS	HA5215180	US 1	Retaining Wall 12167RO, South of Conowingo Hydro Station					
						SITE	1	06/16/2017	06/27/2017				
						CON	1	12/16/2016	12/19/2016	12/19/2016			
16-PR-0151	1	Jeff Knaub	Joseph Bartell	Teresa Bondi	D3	PG0425177	MD 201	DC LINE TO LAWRENCE STREET					
						FIN	1	06/28/2017	06/30/2017			06/30/2017	
						SITE	3	06/15/2017	06/16/2017		06/16/2017		
						SITE	2	06/02/2017	06/08/2017				
						SITE	1	03/07/2017	03/20/2017				
						CON	2	02/06/2017	02/17/2017	02/17/2017			
						CON	1	12/19/2016	01/05/2017				
16-PR-0152	1	Tesfamichael Bogale	Joseph Bartell	Teresa Bondi	D3	PG0475177	US 1	NORTH OF ICC TO OAK STREET					
						FIN	1	04/26/2017	05/02/2017			05/02/2017	
						SITE	1	03/29/2017	04/10/2017		04/10/2017		
						CON	2	01/30/2017	02/22/2017	02/22/2017			
						CON	1	12/19/2016	01/02/2017				
16-PR-0153	1	Jeff Knaub	Joseph Bartell	Chau Chiem	D5	AA4115177	US 50	SEVERN RIVER BRIDGE TO END SHA MAINTENANCE					
						FIN	2	05/24/2017	05/24/2017			05/24/2017	

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						FIN	1	05/18/2017	05/23/2017				
						SITE	3	05/03/2017	05/10/2017				
						SITE	2	04/07/2017	04/18/2017				
						SITE	1	02/10/2017	02/28/2017				
						CON	1	12/22/2016	01/05/2017				
						FIN	2	02/08/2017	02/16/2017				
						FIN	1	01/18/2017	01/23/2017				
						CON	1	12/27/2016	01/06/2017				
						SITE	1	04/17/2017	04/28/2017				
						CON	1	12/27/2016	12/29/2016				
						SITE	1	06/06/2017	06/23/2017				
						CON	2	04/26/2017	05/10/2017				
						CON	1	12/28/2016	01/12/2017				
						CON	2	03/27/2017	04/14/2017				
						CON	1	01/05/2017	01/19/2017				
						SITE	2	04/10/2017	04/10/2017				
						SITE	1	04/04/2017	04/05/2017				
						CON	3	03/17/2017	03/20/2017				
						CON	2	02/03/2017	02/08/2017				
						CON	1	01/06/2017	01/12/2017				
						M1	1	05/30/2017	06/05/2017				
						FIN	3	04/05/2017	04/19/2017				
						FIN	2	03/22/2017	03/29/2017				
						FIN	1	01/24/2017	02/07/2017				
						CON	1	01/27/2017	02/10/2017				
17-PR-0006	1	Tesfamichael Bogale	Joe Bartell	Jeff Robert	OOS	SO2125180 MD 364 BRIDGE 1901000 OVER DIVIDING CREEK							
						CON	1	01/09/2017	01/18/2017	01/18/2017			
17-PR-0007	1	Brandon Scott	Joseph Bartell	Dorey Uong	D3	PG0435177 US 301 BERRY STREET TO US 301 SOUTH BOUND RAMP							
						CON	1	01/17/2017	02/01/2017				
17-PR-0008	1	Jeff Knaub	Patrick Nadeau	John Jenkins	D7	FR6725130 MD 355 1000 SOUTH OF DOCTOR PERRY ROAD/BIG WOODS ROAD TO 1000 NORTH							
						CON	3	05/16/2017	06/01/2017	06/01/2017			
						CON	2	04/13/2017	03/01/2017				
						CON	1	01/18/2017	02/01/2017				
17-PR-0009	0	Brandon Scott	Joe Bartell	Dorey Uong	D3	MO1685187 MD 97 IHB - AT MD 28 (Formerly 15-SF-0100, CA)							
						FIN	3	04/04/2017	04/07/2017			04/07/2017	
						FIN	2	03/16/2017	03/27/2017				
						FIN	1	02/22/2017	03/08/2017				

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						CON	1	01/31/2017	02/06/2017	02/06/2017			
17-PR-0010	1	Sonja Hardman	Ryan Doheny		OOS	HO1525180		US 40 WB	BRIDGE 13055 OVER I-70				
						CON	1	01/18/2017	01/18/2017	01/18/2017			
17-PR-0011	1	Jeff Knaub	Joseph Bartell	Kim Livezey	D4	HA4625130		MD 23	AT GRAFTON SHOP ROAD				
						FIN	2	06/27/2017	07/11/2017			07/11/2017	
						FIN	1	06/07/2017	06/14/2017				
						SITE	1	05/19/2017	05/22/2017		05/22/2017		
						CON	3	03/23/2017	04/07/2017	04/07/2017			
						CON	2	02/16/2017	03/09/2017				
						CON	1	01/19/2017	01/27/2017				
17-PR-0012	1	Tesfamichael Bogale	Joseph Bartell	John Narer	OOS	WA4435180		I 70	BRIDGE 21112 ON I-70/US 11 AND BRIDGE 21113 ON I-70/NORFOLK SOUTHERN RAILROAD				
						CON	1	01/19/2017	02/07/2017	02/07/2017			
17-PR-0013	0	Brandon Scott	Joseph Bartell	April Stitt	D7	CL2125130		MD 27	2300 FT SOUTH OF WESTMINSTER STREET TO 1300 FT NORTH OF WESTMINSTER STREET				
						FIN	2	02/22/2017	03/10/2017				
						FIN	1	01/23/2017	02/08/2017				
17-PR-0014	1	Sonja Hardman		Chau Chiem	D5	BW316		MD 231	Roadway Widening				
						SITE	2	05/12/2017	05/26/2017				
						SITE	1	03/03/2017	03/08/2017				
						CON	1	01/25/2017	01/25/2017	01/25/2017			
17-PR-0015	0	Brandon Scott	Joseph Bartell	Sutapa Samanta	D4	BA1055277		US 1	Formerly 15-SF-0037, CA Howard / Baltimore County line to 550 feet South of CSX Railroad Tracks				
						M1	2	06/16/2017	06/22/2017				06/22/2017
						M1	1	05/24/2017	05/31/2017				
						FIN	2	02/14/2017	02/21/2017			02/21/2017	
						FIN	1	01/25/2017	02/06/2017				
17-PR-0016	1	Sonja Hardman		Jonathan Brown	OHD	AW730A21		MD 225	Formerly MDE No. 12-SF-0298, No CA. Streambank Stabilization				
						FIN	1	06/06/2017	06/14/2017				
						CON	1	01/25/2017	02/06/2017	02/06/2017			
17-PR-0017	1	Doug Roys			OED	PG8315182		NA N/A	AT VARIOUS LOCATIONS IN PRINCE GEORGE'S COUNTY - GROUP 1				
						SITE	1	06/15/2017	07/13/2017				
						CON	1	01/27/2017	01/31/2017	01/31/2017			
17-PR-0018	0	Brandon Scott	Joseph Bartell		D7	CL4515130		MD 482	Formerly MDE No. 13-SF-0045. Gorsuch Road and Cape Horn Road				
						FIN	3	04/10/2017	04/12/2017			04/12/2017	
						FIN	2	03/03/2017	03/10/2017				
						FIN	1	02/21/2017	02/28/2017				
						CON	1	01/27/2017	02/09/2017	02/09/2017			
17-PR-0019	1	Jeff Knaub		John Jenkins	D7	FR6795177		I 70	EAST OF MD 75 TO STRUCTURE 10183 OVER MONOCACY RIVER				
						CON	2	04/20/2017	05/02/2017	05/02/2017			
						CON	1	01/27/2017	02/03/2017				
17-PR-0020	1	Jeff Knaub	Joseph Bartell	John Narer	OOS	FR1295180		MD 17	BRIDGE 1001900 OVER MIDDLE CREEK				
						CON	2	02/21/2017	03/09/2017	03/09/2017			
						CON	1	01/31/2017	02/10/2017				
17-PR-0021	1	Doug Roys			OED	BA2015782		MD 145	LITTLE GUNPOWDER FALLS TRIBUTARY AT MD 145 & MD 165 - STREAM RESTORATION				
						SITE	1	06/14/2017	07/05/2017				

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						CON	1	02/02/2017	02/08/2017				
17-PR-0022	1	Jeff Knaub	Joe Bartell	John Narer	OOS	WA8835180 MD 56 BRIDGE 2109600 OVER MD I-70							
						CON	2	03/22/2017	04/05/2017				
						CON	1	02/02/2017	02/24/2017				
						CON	2	03/08/2017	03/21/2017				
						CON	1	02/06/2017	02/15/2017				
						CON	1	02/06/2017	02/08/2017	02/08/2017			
17-PR-0025	1	Tesfamichael Bogale	Joseph Bartell	Kim Livezey	D4	HA5025187 MD 147 Intersection Improvement							
						CON	2	05/12/2017	05/22/2017				
						CON	1	02/06/2017	02/24/2017				
17-PR-0026	1	Jeff Knaub		John Narer	OOS	AL4655180 I 68 BRIDGE 0109300 OVER MD 639							
						CON	3	05/16/2017	06/05/2017	06/05/2017			
						CON	2	03/30/2017	04/13/2017				
						CON	1	02/06/2017	02/24/2017				
17-PR-0027	1	Jeff Knaub	Joseph Bartell	John Narer	OOS	BA0145180 I 695 BRIDGE 0312400 OVER US 40							
						CON	3	05/26/2017	06/09/2017	06/09/2017			
						CON	2	05/05/2017	05/15/2017				
						CON	1	02/07/2017	03/15/2017				
17-PR-0028	1	Sonja Hardman	Joseph Bartell	Yinka Olagoke	OOS	BA0385180 I 83 IHB - BRIDGE 03062 OVER PADONIA ROAD							
						CON	2	04/13/2017	04/21/2017	04/21/2017			
						CON	1	02/07/2017	02/09/2017				
17-PR-0029	1	Tesfamichael Bogale	Joseph Bartell	Kim Livezey	D4	HA5015187 MD 24 AT MD 755							
						SITE	1	05/18/2017	05/30/2017				
						CON	2	03/28/2017	04/10/2017	04/10/2017			
						CON	1	02/08/2017	02/24/2017				
17-PR-0030	1	Jeff Knaub		Dipa Patel	OOS	AL2975180 MD 36 IHB - BRIDGE 0100800 OVER JENNINGS RUN							
						CON	3	04/13/2017	04/19/2017	04/19/2017			
						CON	2	03/17/2017	03/31/2017				
						CON	1	02/08/2017	02/24/2017				
17-PR-0031	1	Jeff Knaub			OOS	XX1665180 US 50 EMERGENCY REPLACEMENT OF STRUCTURE 20032XO OVER A BRANCH OF MILES CREEK							
						FIN	1	04/06/2017	04/18/2017				
						CON	1	02/10/2017	02/14/2017	02/14/2017			
17-PR-0032	0	Brandon Scott	Junaid Khan	Vivian Berra-Figuereo	OHD	PG6245171 MD 924 IHB - COLLEGE AVENUE/REGENTS DRIVE TO MD 193 (UNIVERSITY BOULEVARD)							
						CON	1	02/14/2017	03/03/2017	03/03/2017			
17-PR-0033	1	Tesfamichael Bogale	Patrick Nadeau		OHD	CE2475179 MD 222 CEDAR CORNER ROAD TO ST MARKS CHURCH ROAD							
						CON	2	03/13/2017	03/24/2017	03/24/2017			
						CON	1	02/14/2017	02/24/2017				
17-PR-0034	1	Jeff Knaub	Ryan Doheny		OOS	AX7440280 MD 309 SMALL STRUCTURE REPLACEMENTS							
						CON	1	02/15/2017	03/03/2017	03/03/2017			

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
17-PR-0035	1	Doug Roys	Junaid Khan	Karen Coffman	OED	PG8325182	VAR	VARIES	AT VARIOUS LOCATIONS - GROUP 2				
						SITE	1	04/26/2017	06/09/2017				
						CON	1	02/16/2017	02/17/2017	02/17/2017			
17-PR-0036	1	Brandon Scott		Jared Paper-Evers	OHD	MO5365187	MD 355		IHB - AT WEST OLD BALTIMORE ROAD				
						CON	2	05/08/2017	05/26/2017				
						CON	1	02/17/2017	03/20/2017	03/20/2017			
17-PR-0037	1	Brandon Scott		Sutapa Samanta	D4	BA1465176	MD 147		AT JOPPA ROAD				
						FIN	2	06/30/2017	07/12/2017			07/12/2017	
						FIN	1	04/12/2017	04/26/2017				
						CON	1	02/27/2017	03/13/2017	03/13/2017			
17-PR-0037	2	Brandon Scott	Ayende Thomas	Sutapa Samanta	D4	BA1465176	MD 147		AT JOPPA ROAD				
						FIN	1	03/02/2017	03/16/2017				
17-PR-0038	1	Doug Roys		Karen Coffman	OED	AX7665C82	VAR	VARIES	AT VARIOUS LOCATIONS IN DISTRICT 7 - GROUP 2				
						SITE	4	05/09/2017	05/24/2017		05/24/2017		
						SITE	3	04/13/2017	05/02/2017				
						SITE	2	03/30/2017	04/07/2017				
						SITE	1	02/27/2017	03/15/2017				
						CON	2	03/29/2016	04/01/2016	04/01/2016			
						CON	1	09/16/2015	09/22/2015				
17-PR-0039	1	Doug Roys	Joseph Bartell	Karen Coffman	OED	MO2965182	NA	NA	AT TRIBUTARY TO CABIN JOHN CREEK (TOWER OAKS)				
						SITE	1	05/01/2017	05/15/2017		05/15/2017		
						CON	1	03/03/2017	03/07/2017	03/07/2017			
17-PR-0040	1	Tesfamichael Bogale			D7	CL2355130	MD 32		AT BENNETT ROAD AND JOHNSVILLE ROAD				
						CON	2	05/24/2017	05/30/2017				
						CON	1	03/06/2017	03/24/2017				
17-PR-0041	1	Jeff Knaub	Joseph Bartell	Sutapa Samanta	D4	AT9265276	I 795		FRANKLIN BLVD EB TO I795 NB LEFT TURN LANE				
						CON	1	03/06/2017	03/17/2017				
17-PR-0042	0	Brandon Scott			OHD	AA8225174	US 50		IHB - MD 665 TO SEVERN RIVER				
						FIN	3	06/26/2017	07/07/2017				
						FIN	2	05/11/2017	05/23/2017				
						FIN	1	03/13/2017	04/04/2017				
17-PR-0043	1	Tesfamichael Bogale	Polly Solliday	Toria Lassiter	OHD	MO1255176	MD 24		AT RUSSELL AVENUE				
						CON	1	03/13/2017	03/30/2017				
17-PR-0044	1	Jeff Knaub		Sutapa Samanta	D4	BA2625177	MD 140		EAST PLEASANT HILL ROAD TO STOCKSDALE AVENUE				
						CON	3	06/20/2017	06/28/2017				
						CON	2	05/02/2017	05/12/2017				
						CON	1	03/15/2017	03/23/2017				
17-PR-0045	1	Tesfamichael Bogale		Toria Lassiter	OHD	FR5665181	MD 140		MD140 PARK & RIDE				
						CON	3	05/16/2017	05/24/2017	05/24/2017			
						CON	2	04/21/2017	05/01/2017				
						CON	1	03/21/2017	04/05/2017				
17-PR-0046	1	Jeff Knaub		Jeff Robert	OOS	AA1245280	MD 255		STRUCTURE 02025X0 OVER BRANCH OF LERCH CREEK				
						CON	2	05/10/2017	06/02/2017				

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						CON	1	03/22/2017	04/05/2017				
17-PR-0047	1	Jeff Knaub		Jeff Robert	OOS	BA0505180		I 695	BRIDGE 0324800 OVER MD 695				
						CON	2	04/27/2017	05/08/2017	05/08/2017			
						CON	1	03/27/2017	04/11/2017				
17-PR-0048	0	Brandon Scott	Joseph Bartell	John Narer	OOS	CH2395180		MD 224	BRIDGE 0801900 OVER THORNE GUT AND BRIDGE 0802000 OVER BRANCH THORNE GUT				
						FIN	2	04/25/2017	05/02/2017			05/02/2017	
						FIN	1	03/28/2017	04/14/2017				
17-PR-0049	1	Doug Roys	Samuel Kane	Karen Coffman	OED	AT4285382		VAR VARIES	TMDL IMPERVIOUS AREA REMOVAL, DISTRICT 3				
						CON	2	05/05/2017	05/16/2017	05/16/2017			
						CON	1	03/30/2017	04/05/2017				
17-PR-0050	1	Doug Roys	Samuel Kane	Karen Coffman	OED	AT4285482		VAR NA	TMDL IMPERVOUS AREA REMOVAL,L DISTRICT 5				
						CON	2	05/05/2017	05/16/2017	05/16/2017			
						CON	1	03/30/2017	04/05/2017				
17-PR-0051	1	Tesfamichael Bogale	Joseph Bartell	Jason Pollock	OOS	WO1655180		US 13	BRIDGE 2301601 AND 2301602 ON US 13 OVER POCOMOKE RIVER				
						SITE	1	05/11/2017	05/22/2017		05/22/2017		
						CON	1	04/03/2017	04/12/2017	04/12/2017			
17-PR-0052	1	Jeff Knaub		John Narer	OOS	KE2335180		MD 298	STRUCTURE 14074X0 OVER BRANCH OF FAIRLEE LAKE				
						CON	1	04/04/2017	04/18/2017	04/18/2017			
17-PR-0053	1	Brandon Scott	Joseph Bartell		OOS	AA1245180		MD 468	STRUCTURE 02016X0 OVER LERCH CREEK				
						CON	2	06/16/2017	07/07/2017	07/07/2017			
						CON	1	04/04/2017	04/17/2017				
17-PR-0054	1	Jeff Knaub			OOS	PG5725280		VAR CO123	BRIDGE 1616600 OVER I-95/495				
						CON	3	05/09/2017	05/11/2017	05/11/2017			
						CON	2	04/27/2017	05/04/2017				
						CON	1	04/07/2017	04/20/2017				
17-PR-0055	1	Tesfamichael Bogale	Ryan Doheny		OHD	TBD		MD 346	Emergency Culvert Replacement				
						M1	1	06/30/2017	07/10/2017				07/10/2017
						SITE	1	06/21/2017	06/21/2017		06/21/2017		
						FIN	1	06/21/2017	06/21/2017			06/21/2017	
						CON	1	04/21/2017	04/21/2017	04/21/2017			
17-PR-0056	1	Jeff Knaub			OHD	XX5355233		MD 331	AT VARIOUS LOCATIONS IN DISTRICT 2				
						CON	2	06/30/2017	07/14/2017	07/14/2017			
						CON	1	04/10/2017	04/21/2017				
17-PR-0056	2	Jeff Knaub	Joseph Bartell			XX5355233		MD 331	AT VARIOUS LOCATIONS IN DISTRICT 2				
						SITE	1	06/29/2017	07/14/2017		07/14/2017		
						CON	1	05/18/2017	06/07/2017	06/07/2017			
17-PR-0057	1	Tesfamichael Bogale	Joseph Bartell		D3	PG3685187		MD 193	AT RHODE ISLAND AVENUE				
						CON	1	04/12/2017	04/24/2017				
17-PR-0058	1	Jeff Knaub			D3	MO9785130		MD 119	MD119 at High Gables Drive				
						CON	3	05/30/2017	06/12/2017	06/12/2017			
						CON	2	05/12/2017	05/19/2017				
						CON	1	04/12/2017	04/21/2017				

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						CON	2	06/27/2017	07/10/2017				
						CON	1	04/13/2017	05/10/2017				
						CON	1	04/14/2017	04/25/2017	04/25/2017			
17-PR-0061	1	Tesfamichael Bogale	Jessica Lain		D6	GA4145177		MD 450	MD 135 TO CRABTREE CREEK				
						CON	1	04/17/2017	04/25/2017				
17-PR-0062	1	Jeff Knaub	Joseph Bartell	Jason Pollock	OOS	CE2835180		MD 273	BRIDGE 0704400 OVER BIG ELK CREEK				
						CON	2	06/14/2017	06/23/2017				
						CON	1	04/18/2017	04/27/2017				
17-PR-0063	1	Brandon Scott			OED	NA		NA	NA LaPlata Training Sit				
						SITE	1	05/30/2017	06/07/2017				
						CON	1	04/18/2017	04/24/2017	04/24/2017			
17-PR-0064	1	Tesfamichael Bogale	Patrick Nadeau		D1	WI1675176		US 50	AT SIXTY FOOT ROAD				
						CON	1	04/19/2017	05/12/2017				
17-PR-0065	1	Jeff Knaub		John Vranish	OHD	XX5345133		MD 253	ADA SIDEWALKS IN DISTRICT 5				
						SITE	1	06/22/2017	07/13/2017				
						CON	2	05/25/2017	06/13/2017	06/13/2017			
						CON	1	04/20/2017	05/02/2017				
17-PR-0065	3	Jeff Knaub		John Vranish	OHD	XX5345133		MD 435	ADA SIDEWALKS IN DISTRICT 5				
						CON	1	05/12/2017	05/19/2017				
17-PR-0065	4	Jeff Knaub		John Vranish	OHD	XX5345133		MD 450	ADA SIDEWALKS IN DISTRICT 5				
						CON	2	06/30/2017	07/14/2017	07/14/2017			
						CON	1	05/12/2017	05/24/2017				
17-PR-0065	5	Jeff Knaub	Joseph Bartell	John Vranish	OHD	XX5345133		MD 435	ADA SIDEWALKS IN DISTRICT 5				
						CON	2	06/30/2017	07/14/2017	07/14/2017			
						CON	1	05/12/2017	05/30/2017				
17-PR-0066	1	Tesfamichael Bogale	Joseph Bartell		OOS	CL1725180		MD 91	BR 06020 OVER NORTH BRANCH PATAPSCO RIVER AND BR 06047 OVER MD MIDLAND RAILROAD				
						CON	1	04/20/2017	05/12/2017				
17-PR-0067	1	Jeff Knaub		April Stitt	D7	FR0935177		I 70	WASHINGTON COUNTY LINE TO GRINDSTONE RUN STRUCTURE 10135				
						CON	2	06/06/2017	06/23/2017				
						CON	1	04/20/2017	05/04/2017				
17-PR-0068	1	Brandon Scott	Joseph Bartell	John Narer	OOS	PG0675180		MD 382	BRIDGE 1606100 OVER CHARLES BRANCH				
						CON	3	06/21/2017	07/03/2017	07/03/2017			
						CON	2	06/06/2017	06/15/2017				
						CON	1	04/21/2017	05/10/2017				
17-PR-0069	1	Tesfamichael Bogale			OHD	CL1535188		MD 27	BALTIMORE BOULEVARD TO HOLLOW ROCK AVENUE				
						CON	3	06/14/2017	06/23/2017				
						CON	2	05/23/2017	05/31/2017				
						CON	1	04/26/2017	05/12/2017				

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

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						SITE	1	05/25/2017	06/09/2017				
						CON	1	05/02/2017	05/12/2017				
						CON	2	06/05/2017	06/09/2017				
						CON	1	05/04/2017	05/16/2017				
						FIN	2	06/20/2017	07/07/2017				
						FIN	1	05/08/2017	05/23/2017				
						CON	1	05/09/2017	05/19/2017				
17-PR-0074	1	Tesfamichael Bogale		Luis Gonzalez	OHD	SM2025271		MD 5	AT ABELL/MOAKLEY (ADVANCED GRADING CONTRACT)				
						SITE	2	04/28/2017	05/09/2017				
						SITE	1	04/06/2017					
						CON	5	11/23/2016	12/08/2016				
						CON	4	10/06/2016	11/01/2016				
						CON	3	03/31/2016	04/12/2016				
						CON	2	11/10/2015	12/03/2015				
						CON	1	08/05/2015	08/19/2015				
						CON	1	05/12/2017	06/23/2017				
17-PR-0076	1	Jeff Knaub	Garvin Guide		OHD	CO5585184		VAR var	TALBOT COUNTY LINE TO HILLSBORO EASTERN TOWN LIMIT				
						CON	1	05/12/2017	05/24/2017				
17-PR-0077	1	Tesfamichael Bogale		Barry Ritchie	D6	GA1545177		VAR VARIES	FRIENDSVILLE GRANTSVILLE AND ACCIDENT				
						CON	2	06/14/2017	06/23/2017	06/23/2017			
						CON	1	05/17/2017	05/30/2017				
17-PR-0078	1	Brandon Scott	Johathan Brown	Jonathan Brown	OHD	TBD		NA NA	EMERGENCY DRAINAGE REPAIR NEAR MD 336				
						CON	1	06/05/2017	06/07/2017	06/07/2017			
17-PR-0079	1	Jeff Knaub		AJ de Rosset	OHD	AX1675174		MD 382	SLOPE AND DRAINAGE REPAIR AT TANYARD ROAD				
						CON	1	05/19/2017	06/08/2017	06/08/2017			
17-PR-0080	1	Tesfamichael Bogale			D3	PG7935176		MD 769C	QUINCY STREET TO KENILWORTH TOWERS				
						CON	1	05/24/2017	06/02/2017				
17-PR-0081	1	Brandon Scott				IA-District Effor		MD 144	Re-Establish Ditches				
						FIN	1	06/28/2017	06/28/2017			06/28/2017	
						SITE	1	06/20/2017	06/28/2017		06/28/2017		
						CON	1	05/26/2017	06/13/2017	06/13/2017			
17-PR-0082	1	Tesfamichael Bogale	Joseph Bartell		OOS	FR7245180		MD 17	STRUCTURE 10236X0 OVER BRANCH OF MIDDLE CREEK				
						CON	2	06/07/2017	06/07/2017	06/07/2017			
						CON	1	05/30/2017	06/02/2017				
17-PR-0083	1	Jeff Knaub		Dipa Patel	OOS	FR1335180		MD 28	IHB - BRIDGE 1002900 OVER MONOCACY RIVER				
						CON	1	06/02/2017	06/16/2017				

MDOT SHA Design Bid Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						CON	2	06/30/2017	07/13/2017				
						CON	1	06/02/2017	06/12/2017				
						CON	1	06/05/2017	06/15/2017				
						CON	1	06/05/2017	06/21/2017				
17-PR-0087	0	Brandon Scott	Armand de Rosset	Vivian Berra-Figuereo	OHD	PG1065184		MD 212	PINE STREET TO US 1 INTERSECTION				
						FIN	1	06/07/2017	07/11/2017				
17-PR-0088	1	Tesfamichael Bogale	Tyler Bazan		OHD	SM2105171		MD 5	MD 246 TO MD 471				
						CON	1	06/07/2017	06/29/2017				
17-PR-0089	1	Doug Roys		Karen Coffman	OED	BA2705128		I 83	TMDL Outfall Restoration for Baltimore County, Group 1				
						CON	1	06/16/2017	07/14/2017				
17-PR-0090	1	Dan O'Leary	Daniel Sharar-Salgado	Jason Solicny	OHD	HO7565370		MD 32	LINDEN CHURCH ROAD TO I-70				
						CON	1	06/22/2017	07/07/2017				
17-PR-0091	1	Brandon Scott	Joseph Bartell		OIT	N/A		NA NA	Table Rock Communication Tower				
						CON	1	06/22/2017	06/30/2017				
17-PR-0092	1	Jeff Knaub		Dorey Uong	D3	MO1705176		US 29	LOCKWOOD DRIVE TO BURNT MILLS AVENUE				
						CON	1	06/22/2017	07/13/2017				
17-PR-0093	1	Sonja Hardman		Dorey Uong	D3	MO1715176		MD 28	MD 97 TO BAILEYS LANE				
						CON	1	06/23/2017	07/07/2017				
17-PR-0094	1	Tesfamichael Bogale			OHD	AX081		MD 140	Enbankment and Slope Repair				
						CON	1	06/29/2017	07/05/2017	07/05/2017			
17-PR-0095	1	Sonja Hardman	James Farkas		D7	FR5835174		MD 77	Culvert Replacement				
						CON	1	06/30/2017	07/10/2017				

MDOT SHA Design Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
15-PR-0097	1	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170 MD 404 Design-BuildIHB - US 50 to East of Holly RoadPackage 1: Overall Project							
						CON	6	02/29/2016	03/11/2016	03/11/2016			
						CON	7	02/29/2016	03/11/2016				
						CON	5	02/04/2016	02/05/2016				
						CON	4	12/30/2015	12/31/2015				
						CON	3	12/17/2015	12/21/2015				
						CON	2	11/16/2015	12/03/2015				
						CON	1	10/02/2015	10/07/2015				
15-PR-0097	2	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170 MD 404 Package 2: Utilites, Clearing, Grubbing							
						FIN	5	05/13/2016	05/16/2016			05/16/2016	
						FIN	4	05/10/2016	05/11/2016				
						FIN	3	05/02/2016	05/05/2016				
						FIN	2	04/05/2016	04/18/2016				
						FIN	1	02/18/2016	02/24/2016				
						SITE	2	01/21/2016	01/26/2016		01/26/2016		
						SITE	1	01/12/2016	01/13/2016				
						CON	2	12/14/2015	12/15/2015	12/15/2015			
						CON	1	12/02/2015	12/04/2015				
15-PR-0097	3	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170 MD 404 Package 3: Stream Diversion and Temporary Grading at Norwich Creek							
						SITE	1	12/24/2016	12/29/2015				
						CON	2	12/14/2016	12/23/2015	12/23/2015			
						MOD	3	12/08/2016	12/09/2016				12/09/2016
						CON	1	12/03/2016	12/04/2015				
						MOD	2	11/30/2016					
						MOD-R	2	10/24/2016	10/26/2016				10/26/2016
						MOD-R	1	10/06/2016	10/13/2016				10/13/2016
						FIN	3	05/18/2016	05/26/2016			05/26/2016	
						FIN	2	05/09/2016	05/11/2016				
						FIN	1	04/06/2016	04/18/2016				
						SITE	3	02/17/2016	02/17/2016		02/17/2016		
						SITE	2	01/15/2016	01/21/2016				
						MOD	1	07/20/216	07/27/2016				07/27/2016
15-PR-0097	4	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170 MD 404 Package 4: Seg. A - Sta 127 to 231 Grading							
						MOD-R	2	12/02/2016	12/06/2016				12/06/2016
						MOD-R	1	10/20/2016	11/03/2016				
						MOD	4	08/29/2016	08/31/2016				08/31/2016
						MOD	3	08/15/2016	08/23/2016				
						MOD	2	07/19/2016	08/01/2016				
						MOD	1	06/07/2016	06/21/2016				
15-PR-0097	5	Dan O'Leary		Jeff Folden	OHD	AW8965170 MD 404 Package 5: Segment A, Str S7 TS&L / Stream Diversion							
						MOD-R	2	01/04/2017	01/05/2017				01/05/2017
						MOD-R	1	09/21/2016	09/22/2016				09/22/2016
						MOD	5	09/02/2016	09/02/2016				09/02/2016
						MOD	4	08/29/2016	08/31/2016				08/31/2016
						MOD	3	08/10/2016	08/23/2016				
						MOD	2	07/18/2016	08/01/2016				
						MOD	1	06/06/2016	06/20/2016				

MDOT SHA Design Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
15-PR-0097	6	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170 MD 404 Package 6: Seg. A - Sta 127 to 231 Grading							
						MOD-R	3	09/27/2016	09/27/2016				09/27/2016
						MOD-R	2	09/15/2016	09/16/2016				09/16/2016
						MOD-R	1	09/07/2016	09/07/2016				09/07/2016
						MOD	4	08/22/2016	08/24/2016				
						MOD	3	08/03/2016	08/10/2016				08/10/2016
						MOD	2	07/15/2016	07/26/2016				
						MOD	1	06/02/2016	06/17/2016				
15-PR-0097	7	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170 MD 404 Package 7: Seg. B - Sta 231 to 317 Grading							
						MOD	5	11/22/2016	11/28/2016				11/28/2016
						MOD	4	09/20/2016	09/22/2016				09/22/2016
						MOD	3	08/19/2016	09/07/2016				
						MOD	2	07/27/2016	08/09/2016				
						MOD	1	06/20/2016	07/01/2016				
15-PR-0097	8	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170 MD 404 Package 8: Seg. C - Structure S3 (05061X0) TS&L/Stream Diversion							
						MOD	6	12/08/2016	12/09/2016				12/09/2016
						MOD	5	11/30/2016	12/02/2016				
						MOD	4	09/29/2016	10/04/2016				10/04/2016
						MOD	3	09/19/2016	09/22/2016				
						MOD	2	08/08/2016	08/30/2016				
						MOD	1	07/05/2016	07/15/2016				
15-PR-0097	9	Dan O'Leary		Jeff Folden	OHD	AW8965170 MD 404 Package 9: Seg. B - Sta 542 to 658 Grading							
						MOD-R	6	02/02/2017	02/02/2017				02/02/2017
						MOD-R	5	01/17/2017	01/20/2017				01/20/2017
						MOD-R	4	12/19/2016	12/21/2016				12/21/2016
						MOD-R	3	10/17/2016	10/18/2016				10/18/2016
						MOD-R	2	10/06/2016	10/06/2016				10/06/2016
						MOD-R	1	09/13/2016	09/15/2016				
						MOD	4	09/08/2016	09/08/2016				09/08/2016
						MOD	3	08/29/2016	09/02/2016				
						MOD	2	08/03/2016	08/18/2016				
						MOD	1	06/27/2016	07/11/2016				
15-PR-0097	10	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170 MD 404 Package 10: Seg. B - Str S9 TS&L/ Stream Diversion							
						MOD	3	09/15/2016	09/22/2016				09/22/2016
						MOD	2	08/25/2016	09/08/2016				
						MOD	1	07/29/2016	08/12/2016				
15-PR-0097	11	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170 MD 404 Package 11: Seg. C - Sta 542 to Sta 658 Grading							
						MOD-R	1	03/24/2017	04/06/2017				04/06/2017
						MOD	4	01/17/2017	01/27/2017				01/27/2017
						MOD	3	12/09/2016	12/21/2016				
						MOD	2	11/02/2016	11/10/2016				
						MOD	1	08/12/2016	08/31/2016				
15-PR-0097	12	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170 MD 404 Package 12: Seg. B - Sta 231 to Sta 305 Grading							
						MOD-R	2	03/23/2017	03/30/2017				03/30/2017
						MOD-R	1	03/08/2017	03/10/2017				
						MOD	3	10/11/2016	10/12/2016				10/12/2016

MDOT SHA Design Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						MOD	2	09/15/2016	09/22/2016				
						MOD	1	08/12/2016	08/26/2016				
15-PR-0097	13	Dan O'Leary		Jeff Folden	OHD	AW8965170 MD 404 Package 13: Seg. A - Sta 129 to Sta 231 Final SWM							
						MOD	6	05/02/2017	06/16/2017				06/16/2017
						MOD	5	04/05/2017	04/20/2017				
						MOD	4	03/03/2017	03/15/2017				
						MOD	3	11/07/2016	11/21/2016				
						MOD	2	10/17/2016	10/28/2016				
						MOD	1	08/12/2016	08/31/2016				
15-PR-0097	14	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170 MD 404 Package 14: Seg. C - Sta 466 to Sta 554 Grading							
						MOD-R	2	03/03/2017	03/10/2017				03/10/2017
						MOD-R	1	11/22/2016	11/23/2016				11/23/2016
						MOD	3	10/21/2016	10/25/2016				10/25/2016
						MOD	2	10/11/2016	10/13/2016				
						MOD	1	09/16/216	09/26/2016				
15-PR-0097	15	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170 MD 404 Package 15: Seg. C - Final EB & WB Roadway Sta. 526 to Sta. 655							
						MOD-R	1	02/24/2017	04/06/2017				04/06/2017
						MOD	3	01/12/2017	01/23/2017				01/23/2017
						MOD	2	12/09/2016	12/21/2016				
						MOD	1	11/02/2016	11/16/2016				
15-PR-0097	16	Dan O'Leary		Jeff Folden	OHD	AW8965170 MD 404 Package 16: Seg. A - Final WB Roadway Sta. 129 to Sta. 231							
						MOD-R	3	05/02/2017	05/18/2017				05/18/2017
						MOD-R	2	04/05/2017	04/20/2017				
						MOD-R	1	03/03/2017	03/15/2017				
						MOD	2	11/09/2016	11/16/2016				11/16/2016
						MOD	1	10/17/2016	10/28/2016				
15-PR-0097	17	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170 MD 404 Package 17: Seg. C - Str. S2 (05018X0)							
						MOD	2	09/20/2016	09/22/2016				09/22/2016
						MOD	1	08/25/2016	09/09/2016				09/09/2016
15-PR-0097	18	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170 MD 404 Design/Build IHB-US 50 to East of Holly road							
						MOD	2	11/29/2016	12/02/2016				12/02/2016
						MOD	1	10/20/2016	11/03/2016				
15-PR-0097	19	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170 MD 404 Package 19: Seg. C - Str. S20 TS&L/Stream Diversion							
						MOD	4	12/08/2016	12/19/2016				12/19/2016
						MOD	3	11/23/2016	12/02/2016				
						MOD	2	11/03/2016	11/09/2016				
						MOD	1	09/29/2016	10/04/2016				
15-PR-0097	20	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170 MD 404 Package 20: Seg. A Str S10 Stream Diversion							
						MOD	2	02/13/2017	02/15/2017				02/15/2017
						MOD	1	01/20/2017	01/30/2017				
15-PR-0097	21	Dan O'Leary		Jeff Folden	OHD	AW8965170 MD 404 Package 21: Seg A-Sta 76 to Sta 129 Grading							
						MOD-R	2	04/03/2017	04/05/2017				04/05/2017
						MOD-R	1	03/23/2017	03/27/2017				
						MOD	3	01/24/2017	01/31/2017				01/31/2017
						MOD	2	12/23/2016	01/05/2017				

MDOT SHA Design Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						MOD	1	12/01/2016	12/07/2016				
15-PR-0097	22	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170 MD 404 Package 22: Sylvester Driveway HHD							
						MOD	1	09/12/2016	09/13/2016				09/13/2016
15-PR-0097	23	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170 MD 404 Package 23: Seg A-Str S12 TSL/Stream Diversion							
						MOD	2	12/16/2016	12/28/2016				12/28/2016
						MOD	1	10/31/2016	11/09/2016				
15-PR-0097	24	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170 MD 404 Package 24: Seg B-Sta 305 to sta 340 Grading							
						MOD-R	4	04/20/2017	04/26/2017				
						MOD-R	3	03/31/2017	04/14/2017				
						MOD-R	2	03/24/2017	04/06/2017				
						MOD-R	1	03/10/2017	03/22/2017				
						MOD	3	01/24/2017	02/08/2017				02/08/2017
						MOD	2	12/22/2016	01/05/2017				
						MOD	1	11/22/2016	12/02/2016				
15-PR-0097	25	Dan O'Leary		Jeff Folden	OHD	AW8965170 MD 404 Package 25: Mass Grading EB Roadway Sta. 129 to Sta 231							
						MOD-R	1	06/16/2017	06/22/2017				06/22/2017
						MOD	2	02/01/2017	02/10/2017				02/10/2017
						MOD	1	01/13/2017	01/20/2017				
15-PR-0097	26	Dan O'Leary		Jeff Folden	OHD	AW8965170 MD 404 Package 26: Seg C - Sta 466+ Sta 526+ Roadway plans							
						MOD-R	1	05/30/2017	06/16/2017				
						MOD	3	03/10/2017	03/24/2017				
						MOD	2	02/15/2017	02/21/2017				
						MOD	1	01/19/2017	02/01/2017				
15-PR-0097	27	Dan O'Leary		Jeff Folden	OHD	AW8965170 US 50 PACKAGE 27: SEGMENT C-STA. 466+ TO STA. 526+ FINAL SWM REPORT							
						MOD-R	1	05/30/2017	06/16/2017				
						MOD	4	04/12/2017	04/26/2017				04/26/2017
						MOD	3	03/10/2017	03/24/2017				
						MOD	2	02/15/2017	02/21/2017				
						MOD	1	01/19/2017	02/01/2017				
15-PR-0097	28	Dan O'Leary		Jeff Folden	OHD	AW8965170 US 50 PACKAGE 28: SEBMENT B STA.231+ TO STA315+; FINAL ROADWAY							
						MOD	2	04/14/2017	05/08/2017				05/08/2017
						MOD	1	03/16/2017	03/29/2017				
15-PR-0097	29	Dan O'Leary		Jeff Folden	OHD	AW8965170 US 50 PACKAGE 29: SEGMENT B STA 231+ TO STA 315+ FINAL SWM							
						MOD	2	04/14/2017	08/17/2017				08/17/2017
						MOD	1	03/16/2017	03/28/2017				
15-PR-0130	1	Dan O'Leary		Kelly Nash	OOS	WI2145180 US 13 Package A, Design-BuildUS 13 Business to South of US 50							
						FIN	1	07/15/2016	07/15/2016			07/15/2016	
						SITE	3	07/12/2016	07/15/2016		07/15/2016		
						SITE	2	06/14/2016	06/22/2016				
						SITE	1	05/20/2016	05/24/2016				
						CON	1	12/08/2015	12/09/2015	12/09/2015			
15-PR-0130	2	Dan O'Leary		Kelly Nash	OOS	WI2145180 US 13 Package A, Design-BuildUS 13 Business to South of US 50							
						M1	5	10/17/2016	10/19/2016				10/19/2016
						M1	4	09/29/2016	10/05/2016				
						M1	3	09/19/2016	09/20/2016				

MDOT SHA Design Build Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						M1	2	07/26/2016	07/29/2016				
						M1	1	06/07/2016	06/15/2016				
						M2	5	10/17/2016	10/19/2016				
						M2	4	09/29/2016	10/05/2016				
						M2	3	09/19/2016	09/20/2016				
						M3	1	08/08/2016	08/15/2016				
						M2	2	07/26/2016	07/29/2016				
						SF	2	07/12/2016	07/15/2016				
						SF	3	06/14/2016	09/18/2017				
						M2	1	06/07/2016	06/15/2016				
						SF	1	05/20/2016	05/24/2016				
						CON	1	12/08/2015	12/09/2015	12/09/2015			
15-PR-0135	0	Dan O'Leary	Garvin Guide	David Phillips	OHD	WO6355170		US 113	Design-Build - IHB - NORTH OF MD 365 TO NORTH OF FIVE MILE BRANCH ROAD - PHASE 4				
						CON	5	01/18/2017	02/02/2017				
						CON	4	11/17/2016	12/01/2016				
						CON	3	08/30/2016	09/20/2016				
						CON	2	06/10/2016	07/12/2016				
						CON	1	12/24/2015	12/29/2015				
						CON	1	05/05/2017	06/01/2017				
						SITE	1	05/31/2017	06/13/2017				
15-PR-0135	9	Dan O'Leary				WO6355170		US 113	Structure S-1 Bridge 2302900				
						SITE	1	06/13/2017	06/29/2017				
16-PR-0047	0	Dan O'Leary		Yugiong Bai	OHD	HO1415170		MD 32	Design-Build - MD 108 TO LINDEN CHURCH ROAD INTERCHANGE				
						CON	5	04/11/2017	04/13/2017	04/13/2017			
						CON	4	03/08/2017	03/20/2017				
						CON	3	10/21/2016	11/01/2016				
						CON	2	08/15/2016	09/19/2016				
						CON	1	05/09/2016	05/20/2016				
16-PR-0047	1	Dan O'Leary				HO1415170		MD 32	Design-Build - MD 108 TO LINDEN CHURCH ROAD INTERCHANGE - Zone 1 (See Package 0 for Concept				
						SITE	4	06/28/2017	07/07/2017				
						SITE	3	06/07/2017	06/19/2017				
						SITE	2	05/16/2017	05/18/2017				
						SITE	1	04/03/2017	04/13/2017				
16-PR-0047	2	Dan O'Leary				HO1415170		MD 32	Design-Build - MD 108 TO LINDEN CHURCH ROAD INTERCHANGE - Zone 2 (See Package 0 for Concept reviews)				
						SITE	2	06/13/2017	06/27/2017				
						SITE	1	05/01/2017	05/03/2017				

MDE SF Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						AB	1	02/24/2017	03/10/2017				
						MOD	1	06/02/2017	06/05/2017				
						AB	1	04/24/2017	05/08/2017				
09-SF-0187	0	Brandon Scott				BA7295270	MD 140	MD 140 from N. of Painters Mill to S. of Garrison View					
						M1	1	06/26/2017	07/14/2017				
09-SF-0199	0	Brandon Scott				MO5935270	MD 355	MD 355 at Cedar Lane, Brac Improvement					
						AB	1	05/05/2017	05/17/2017				
09-SF-0200	0	Brandon Scott				BA4655187	MD 147	Glen Arm Rd / Mt Vista Rd Roundabout					
						M1	1	01/09/2017	01/19/2017				01/19/2017
10-SF-0099	0	Brandon Scott				PG3975172	MD 210	New Bald Eagle Road Improvements					
						AB	1	05/22/2017	06/07/2017				
10-SF-0225	0	Brandon Scott				HO3785187	US 40	At Rogers Ave					
						AB	1	02/27/2017	03/22/2017				
10-SF-0402	0	Brandon Scott				FR5715170	US 15	Monacacy Blvd Interchange					
						M2	1	06/20/2017	06/23/2017				06/23/2017
						M1	2	05/09/2017	06/01/2017				06/01/2017
						M1	1	03/28/2017	04/17/2017				
11-SF-0138	0	Brandon Scott				HA2425180	MD 7	Bridge 1200900 over James Run					
						AB	1	04/17/2017	05/02/2017				
11-SF-0337	0	Brandon Scott				AA2785187	MD 2	Magothy Bridge Road/					
						M1	1	02/15/2017	03/06/2017				
11-SF-0342	0	Brandon Scott				AA2695130	MD 2	Owensville Sudley Rd Intersection Improvements					
						AB	1	01/19/2017	02/06/2017				
11-SF-0368	0	Brandon Scott				BA4625280	I 695	Over Milford Mill Road					
						M2	1	06/09/2017	06/13/2017				06/13/2017
						M1	2	04/24/2017	04/26/2017				04/26/2017
						M1	1	04/11/2017	04/20/2017				
12-SF-0036	0	Brandon Scott				AA2705130	MD 2	At Harwood Drive Left Turn Lane Improvements					
						AB	1	05/24/2017	06/06/2017				
12-SF-0070	0	Brandon Scott				WI3095176	US 50	Walkston Switch Road Intersection Improvements					
						AB	1	12/23/2016	12/27/2016				
12-SF-0084	0	Brandon Scott				CA3825176	MD 2	At Mt. Harmony Road					
						AB	1	02/17/2017	03/08/2017				
12-SF-0091	0	Brandon Scott				HO4745130	MD 97	Burntwoods Road					
						M1	1	05/01/2017	05/15/2017				05/15/2017

MDE SF Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						AB	1	03/07/2017	03/21/2017				
						AB	1	01/12/2017	02/01/2017				
						AB	1	05/05/2017	05/17/2017				
12-SF-0326	0	Brandon Scott				BA4215180	MD 137	Bridge over I-83					
						AB	1	01/13/2017	02/02/2017				
12-SF-0335	0	Brandon Scott				PG7805270	MD 337	South of I-95/I-495 to North of Suitland Parkway					
						FIN	1	05/11/2017	03/17/2017			03/17/2017	
12-SF-0404	0	Brandon Scott				BA6075180	MD 140	Bridge 0308300 over North Branch of Patapsco River					
						AB	1	04/03/2017	04/18/2017				
-						PG5435174	US 1	Ammendale Road Drainage Imrpovement					
						AB	2	01/04/2017	01/20/2017				
						AB	1	12/23/2016	12/27/2016				
-													
						M1	1	01/24/2017	01/27/2017				01/27/2017
13-SF-0190	0	Brandon Scott				BA8165284	US 40	At Mohrs Lane					
						M1	1	05/08/2017	05/19/2017				05/19/2017
13-SF-0264	0	Brandon Scott				FR3505184	US 40A	Ivy Hill Dr to Middletown Pkwy					
						M2	1	02/10/2017	02/13/2017				02/13/2017
						M1	1	01/12/2017	02/02/2017				02/02/2017
13-SF-0313	0	Brandon Scott				AL3605180	MD 47	ToolkitBridge 0104300 over North Branch					
						AB	1	02/22/2017	03/22/2017				
13-SF-0331	0	Brandon Scott				CL4355187	MD 140	WMC Drive to Meadow Branch/Royer Road					
						M2	1	05/01/2017	05/12/2017				05/12/2017
						M1	2	04/21/2017	04/25/2017				04/25/2017
						M1	1	03/09/2017	03/20/2017				
14-SF-0043	0	Brandon Scott				MO1505188	MD 187	Lincoln Drive to Charles Street, Bethesda Trolley Trail					
						M1	2	03/24/2017	03/30/2017				03/30/2017
						M1	3	03/13/2017	03/30/2017				
						M1	1	02/07/2017	02/28/2017				
14-SF-0060	0	Brandon Scott				BA4585172	I 695	MD 41 to MD 147					
						M2	1	05/08/2017	05/09/2017				05/09/2017
						M1	2	03/30/2017	04/18/2017				04/18/2017
						M1	1	03/16/2017	03/22/2017				
14-SF-0092	0	Brandon Scott				AA0935174	MD 450	Near War Memorial					
						M1	1	02/02/2017	02/14/2017				02/14/2017
14-SF-0126	0	Brandon Scott				MO2405180	MD 195	Bridge 1503300					
						FIN	1	05/11/2017	05/18/2017			05/18/2017	

MDE SF Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						M1	1	06/29/2017	07/14/2017				
						AB	1	04/06/2017	04/18/2017				
						M1	1	01/13/2017	01/13/2017				
15-SF-0106	0	Brandon Scott				AX7665182		Varies Varies	TMDL				
						M1	1	05/18/2017	05/22/2017				
15-SF-0115	0	Brandon Scott				BA8105180		MD 25	Bridge 0301900				
						FIN	1	05/11/2017	03/20/2017			03/20/2017	

Representative Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
15-PR-0023	1	Sonja Hardman	Kiona Leah	Chris Weber	OHD	AA4365471	MD 175	WEST OF REECE ROAD TO EAST OF DISNEY ROAD					
						FIN	2	11/10/2016	11/14/2016			11/14/2016	
						FIN	1	10/19/2016	10/25/2016				
						SITE	7	09/16/2016	09/21/2016		09/21/2016		
						SITE	6	08/05/2016	08/19/2016				
						SITE	5	07/12/2016	07/15/2016				
						SITE	4	06/09/2016	07/05/2016				
						SITE	3	04/01/2016	04/04/2016				
						SITE	2	03/04/2016	03/11/2016				
						SITE	1	12/30/2015	01/04/2016				
						CON	4	08/10/2015	08/14/2015	08/14/2015			
						CON	3	06/18/2015	06/23/2015				
						CON	2	05/29/2015	06/04/2015				
						CON	1	03/23/2015	04/08/2015				
15-PR-0047	1	Tesfamichael Bogale	Gina Goettler	Meridith LeDue	OHD	CL8415184	MD 31	LAMBERT AVENUE TO EAST OF CHURCH STREET					
						SITE	1	05/23/2017	06/02/2017				
						CON	5	01/28/2016	02/12/2016	02/12/2016			
						CON	4	12/17/2015	01/08/2016				
						CON	3	10/28/2015	11/12/2015				
						CON	2	08/21/2015	09/17/2015				
						CON	1	07/27/2015	08/03/2015				
15-PR-0073	1	Sonja Hardman	Christie Minami	Aimee Zhang	OHD	MO7465171	MD 97	IHB - SOUTH OF BROOKEVILLE TO MD 97 NORTH OF BROOKEVILLE					
						SITE	7	06/15/2017	07/07/2017		07/07/2017		
						SITE	6	05/01/2017	05/18/2017				
						SITE	5	03/28/2017	04/06/2017				
						SITE	4	01/25/2017	02/08/2017				
						SITE	3	12/19/2016	01/11/2017				
						SITE	2	08/05/2016	08/26/2016				
						SITE	1	04/08/2016	04/15/2016				
						CON	3	01/07/2016	01/07/2016	01/07/2016			
						CON	2	09/29/2015	10/02/2015				
						CON	1	08/19/2015	08/26/2015				
15-PR-0095	1	Tesfamichael Bogale	Joseph Bartell	Angela Strevig	D3	MO1835177	MD 650	MILESTONE DRIVE TO SHAW AVENUE					
						SITE	3	10/17/2016	11/01/2016				
						SITE	2	04/04/2016	05/10/2016				
						SITE	1	03/11/2016	03/17/2016				
						CON	2	11/06/2015	12/07/2015	12/07/2015			
						CON	1	10/05/2015	10/14/2015				
15-PR-0097	1	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170	MD 404	Design-BuildIHB - US 50 to East of Holly RoadPackage 1: Overall Project					
						CON	6	02/29/2016	03/11/2016	03/11/2016			
						CON	7	02/29/2016	03/11/2016				
						CON	5	02/04/2016	02/05/2016				
						CON	4	12/30/2015	12/31/2015				
						CON	3	12/17/2015	12/21/2015				
						CON	2	11/16/2015	12/03/2015				
						CON	1	10/02/2015	10/07/2015				

Representative Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
15-PR-0097	2	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170 MD 404 Package 2: Utilites, Clearing, Grubbing							
						FIN	5	05/13/2016	05/16/2016			05/16/2016	
						FIN	4	05/10/2016	05/11/2016				
						FIN	3	05/02/2016	05/05/2016				
						FIN	2	04/05/2016	04/18/2016				
						FIN	1	02/18/2016	02/24/2016				
						SITE	2	01/21/2016	01/26/2016		01/26/2016		
						SITE	1	01/12/2016	01/13/2016				
						CON	2	12/14/2015	12/15/2015	12/15/2015			
						CON	1	12/02/2015	12/04/2015				
15-PR-0097	3	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170 MD 404 Package 3: Stream Diversion and Temporary Grading at Norwich Creek							
						SITE	1	12/24/2016	12/29/2015				
						CON	2	12/14/2016	12/23/2015	12/23/2015			
						MOD	3	12/08/2016	12/09/2016				12/09/2016
						CON	1	12/03/2016	12/04/2015				
						MOD	2	11/30/2016					
						MOD-R	2	10/24/2016	10/26/2016				10/26/2016
						MOD-R	1	10/06/2016	10/13/2016				10/13/2016
						FIN	3	05/18/2016	05/26/2016			05/26/2016	
						FIN	2	05/09/2016	05/11/2016				
						FIN	1	04/06/2016	04/18/2016				
						SITE	3	02/17/2016	02/17/2016		02/17/2016		
						SITE	2	01/15/2016	01/21/2016				
						MOD	1	07/20/216	07/27/2016				07/27/2016
15-PR-0097	4	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170 MD 404 Package 4: Seg. A - Sta 127 to 231 Grading							
						MOD-R	2	12/02/2016	12/06/2016				12/06/2016
						MOD-R	1	10/20/2016	11/03/2016				
						MOD	4	08/29/2016	08/31/2016				08/31/2016
						MOD	3	08/15/2016	08/23/2016				
						MOD	2	07/19/2016	08/01/2016				
						MOD	1	06/07/2016	06/21/2016				
15-PR-0097	5	Dan O'Leary		Jeff Folden	OHD	AW8965170 MD 404 Package 5: Segment A, Str S7 TS&L / Stream Diversion							
						MOD-R	2	01/04/2017	01/05/2017				01/05/2017
						MOD-R	1	09/21/2016	09/22/2016				09/22/2016
						MOD	5	09/02/2016	09/02/2016				09/02/2016
						MOD	4	08/29/2016	08/31/2016				08/31/2016
						MOD	3	08/10/2016	08/23/2016				
						MOD	2	07/18/2016	08/01/2016				
						MOD	1	06/06/2016	06/20/2016				
15-PR-0097	6	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170 MD 404 Package 6: Seg. A - Sta 127 to 231 Grading							
						MOD-R	3	09/27/2016	09/27/2016				09/27/2016
						MOD-R	2	09/15/2016	09/16/2016				09/16/2016
						MOD-R	1	09/07/2016	09/07/2016				09/07/2016
						MOD	4	08/22/2016	08/24/2016				
						MOD	3	08/03/2016	08/10/2016				08/10/2016
						MOD	2	07/15/2016	07/26/2016				
						MOD	1	06/02/2016	06/17/2016				

Representative Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
15-PR-0097	7	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170	MD 404	Package 7: Seg. B - Sta 231 to 317 Grading					
						MOD	5	11/22/2016	11/28/2016				11/28/2016
						MOD	4	09/20/2016	09/22/2016				09/22/2016
						MOD	3	08/19/2016	09/07/2016				
						MOD	2	07/27/2016	08/09/2016				
						MOD	1	06/20/2016	07/01/2016				
15-PR-0097	8	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170	MD 404	Package 8: Seg. C - Structure S3 (05061X0) TS&L/Stream Diversion					
						MOD	6	12/08/2016	12/09/2016				12/09/2016
						MOD	5	11/30/2016	12/02/2016				
						MOD	4	09/29/2016	10/04/2016				10/04/2016
						MOD	3	09/19/2016	09/22/2016				
						MOD	2	08/08/2016	08/30/2016				
						MOD	1	07/05/2016	07/15/2016				
15-PR-0097	9	Dan O'Leary		Jeff Folden	OHD	AW8965170	MD 404	Package 9: Seg. B - Sta 542 to 658 Grading					
						MOD-R	6	02/02/2017	02/02/2017				02/02/2017
						MOD-R	5	01/17/2017	01/20/2017				01/20/2017
						MOD-R	4	12/19/2016	12/21/2016				12/21/2016
						MOD-R	3	10/17/2016	10/18/2016				10/18/2016
						MOD-R	2	10/06/2016	10/06/2016				10/06/2016
						MOD-R	1	09/13/2016	09/15/2016				
						MOD	4	09/08/2016	09/08/2016				09/08/2016
						MOD	3	08/29/2016	09/02/2016				
						MOD	2	08/03/2016	08/18/2016				
						MOD	1	06/27/2016	07/11/2016				
15-PR-0097	10	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170	MD 404	Package 10: Seg. B - Str S9 TS&L/ Stream Diversion					
						MOD	3	09/15/2016	09/22/2016				09/22/2016
						MOD	2	08/25/2016	09/08/2016				
						MOD	1	07/29/2016	08/12/2016				
15-PR-0097	11	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170	MD 404	Package 11: Seg. C - Sta 542 to Sta 658 Grading					
						MOD-R	1	03/24/2017	04/06/2017				04/06/2017
						MOD	4	01/17/2017	01/27/2017				01/27/2017
						MOD	3	12/09/2016	12/21/2016				
						MOD	2	11/02/2016	11/10/2016				
						MOD	1	08/12/2016	08/31/2016				
15-PR-0097	12	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170	MD 404	Package 12: Seg. B - Sta 231 to Sta 305 Grading					
						MOD-R	2	03/23/2017	03/30/2017				03/30/2017
						MOD-R	1	03/08/2017	03/10/2017				
						MOD	3	10/11/2016	10/12/2016				10/12/2016
						MOD	2	09/15/2016	09/22/2016				
						MOD	1	08/12/2016	08/26/2016				
15-PR-0097	13	Dan O'Leary		Jeff Folden	OHD	AW8965170	MD 404	Package 13: Seg. A - Sta 129 to Sta 231 Final SWM					
						MOD	6	05/02/2017	06/16/2017				06/16/2017
						MOD	5	04/05/2017	04/20/2017				
						MOD	4	03/03/2017	03/15/2017				
						MOD	3	11/07/2016	11/21/2016				
						MOD	2	10/17/2016	10/28/2016				

Representative Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
						MOD	1	08/12/2016	08/31/2016				
15-PR-0097	14	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170 MD 404 Package 14: Seg. C - Sta 466 to Sta 554 Grading							
						MOD-R	2	03/03/2017	03/10/2017				03/10/2017
						MOD-R	1	11/22/2016	11/23/2016				11/23/2016
						MOD	3	10/21/2016	10/25/2016				10/25/2016
						MOD	2	10/11/2016	10/13/2016				
						MOD	1	09/16/216	09/26/2016				
15-PR-0097	15	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170 MD 404 Package 15: Seg. C - Final EB & WB Roadway Sta. 526 to Sta. 655							
						MOD-R	1	02/24/2017	04/06/2017				04/06/2017
						MOD	3	01/12/2017	01/23/2017				01/23/2017
						MOD	2	12/09/2016	12/21/2016				
						MOD	1	11/02/2016	11/16/2016				
15-PR-0097	16	Dan O'Leary		Jeff Folden	OHD	AW8965170 MD 404 Package 16: Seg. A - Final WB Roadway Sta. 129 to Sta. 231							
						MOD-R	3	05/02/2017	05/18/2017				05/18/2017
						MOD-R	2	04/05/2017	04/20/2017				
						MOD-R	1	03/03/2017	03/15/2017				
						MOD	2	11/09/2016	11/16/2016				11/16/2016
						MOD	1	10/17/2016	10/28/2016				
15-PR-0097	17	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170 MD 404 Package 17: Seg. C - Str. S2 (05018X0)							
						MOD	2	09/20/2016	09/22/2016				09/22/2016
						MOD	1	08/25/2016	09/09/2016				09/09/2016
15-PR-0097	18	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170 MD 404 Design/Build IHB-US 50 to East of Holly road							
						MOD	2	11/29/2016	12/02/2016				12/02/2016
						MOD	1	10/20/2016	11/03/2016				
15-PR-0097	19	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170 MD 404 Package 19: Seg. C - Str. S20 TS&L/Stream Diversion							
						MOD	4	12/08/2016	12/19/2016				12/19/2016
						MOD	3	11/23/2016	12/02/2016				
						MOD	2	11/03/2016	11/09/2016				
						MOD	1	09/29/2016	10/04/2016				
15-PR-0097	20	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170 MD 404 Package 20: Seg. A Str S10 Stream Diversion							
						MOD	2	02/13/2017	02/15/2017				02/15/2017
						MOD	1	01/20/2017	01/30/2017				
15-PR-0097	21	Dan O'Leary		Jeff Folden	OHD	AW8965170 MD 404 Package 21: Seg A-Sta 76 to Sta 129 Grading							
						MOD-R	2	04/03/2017	04/05/2017				04/05/2017
						MOD-R	1	03/23/2017	03/27/2017				
						MOD	3	01/24/2017	01/31/2017				01/31/2017
						MOD	2	12/23/2016	01/05/2017				
						MOD	1	12/01/2016	12/07/2016				
15-PR-0097	22	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170 MD 404 Package 22: Sylvester Driveway HHD							
						MOD	1	09/12/2016	09/13/2016				09/13/2016
15-PR-0097	23	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170 MD 404 Package 23: Seg A-Str S12 TSL/Stream Diversion							
						MOD	2	12/16/2016	12/28/2016				12/28/2016
						MOD	1	10/31/2016	11/09/2016				

Representative Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
15-PR-0097	24	Dan O'Leary	Daniel Sharar-Salgado	Jeff Folden	OHD	AW8965170	MD 404	Package 24: Seg B-Sta 305 to sta 340 Grading					
						MOD-R	4	04/20/2017	04/26/2017				
						MOD-R	3	03/31/2017	04/14/2017				
						MOD-R	2	03/24/2017	04/06/2017				
						MOD-R	1	03/10/2017	03/22/2017				
						MOD	3	01/24/2017	02/08/2017				02/08/2017
						MOD	2	12/22/2016	01/05/2017				
						MOD	1	11/22/2016	12/02/2016				
15-PR-0097	25	Dan O'Leary		Jeff Folden	OHD	AW8965170	MD 404	Package 25: Mass Grading EB Roadway Sta. 129 to Sta 231					
						MOD-R	1	06/16/2017	06/22/2017				06/22/2017
						MOD	2	02/01/2017	02/10/2017				02/10/2017
						MOD	1	01/13/2017	01/20/2017				
15-PR-0097	26	Dan O'Leary		Jeff Folden	OHD	AW8965170	MD 404	Package 26: Seg C - Sta 466+ Sta 526+ Roadway plans					
						MOD-R	1	05/30/2017	06/16/2017				
						MOD	3	03/10/2017	03/24/2017				
						MOD	2	02/15/2017	02/21/2017				
						MOD	1	01/19/2017	02/01/2017				
15-PR-0097	27	Dan O'Leary		Jeff Folden	OHD	AW8965170	US 50	PACKAGE 27: SEGMENT C-STA. 466+ TO STA. 526+ FINAL SWM REPORT					
						MOD-R	1	05/30/2017	06/16/2017				
						MOD	4	04/12/2017	04/26/2017				04/26/2017
						MOD	3	03/10/2017	03/24/2017				
						MOD	2	02/15/2017	02/21/2017				
						MOD	1	01/19/2017	02/01/2017				
15-PR-0097	28	Dan O'Leary		Jeff Folden	OHD	AW8965170	US 50	PACKAGE 28: SEBMENT B STA.231+ TO STA315+; FINAL ROADWAY					
						MOD	2	04/14/2017	05/08/2017				05/08/2017
						MOD	1	03/16/2017	03/29/2017				
15-PR-0097	29	Dan O'Leary		Jeff Folden	OHD	AW8965170	US 50	PACKAGE 29: SEGMENT B STA 231+ TO STA 315+ FINAL SWM					
						MOD	2	04/14/2017	08/17/2017				08/17/2017
						MOD	1	03/16/2017	03/28/2017				
15-PR-0098	1	Brandon Scott	Kiona Leah	Steve Collins	OED	AX7665682	NA N/A	AT VARIOUS LOCATIONS IN DISTRICT 3 - GROUP 1					
						SITE	1	12/19/2016	12/29/2016		12/29/2016		
						CON	2	05/25/2016	06/21/2016	06/21/2016			
						CON	1	10/06/2015	11/03/2015				
15-PR-0128	1	Jeff Knaub	Joseph Bartell	John Jenkins	D7	HO1775177	I 70	Marriottsville Road to Baltimore County Line					
						FIN	2	04/08/2016	04/22/2016			04/22/2016	
						FIN	1	02/17/2016	03/09/2016				
						SITE	1	12/30/2015	02/05/2016		02/05/2016		
						CON	1	12/01/2015	12/14/2015	12/14/2015			
16-PR-0019	1	Brandon Scott	Alicia Brandys	Jared Paper-Evers	OHD	AA5105271	MD 198	RUSSET GREEN EAST TO MD 295 NB RAMP - PHASE 1					
						SITE	3	04/06/2017	04/21/2017				
						SITE	2	11/22/2016	12/15/2016				
						SITE	1	09/01/2016	10/04/2016				
						CON	3	05/05/2016	05/27/2016	05/27/2016			
						CON	2	04/01/2016	04/12/2016				
						CON	1	03/03/2016	03/17/2016				

Representative Projects - Reporting Period July 1, 2016 through June 30, 2017

PRD#	Phase	PRD TL	HHD Liaison	SHA PM	Lead Office	Stage	Sub	Received	Comment/ Approval	Concept Approved	Site Dev Approved	Final Approved	Mod Approved
16-PR-0069	1	Brandon Scott	Jessica Lain	Toria Lassiter	OHD	GA6715184		US 219	MD 135 TO 325 FEET NORTH OF EAST ORCHID STREET				
						CON	3	09/07/2016	09/22/2016	09/22/2016			
						CON	2	08/05/2016	08/22/2016				
						CON	1	06/07/2016	06/24/2016				
16-PR-0081	1	Jeff Knaub	Joseph Bartell	Karen Fiasco	D5	AA1975177		MD 295	MD 175 TO MD 100				
						CON	2	01/18/2017	01/27/2017	01/27/2017			
						CON	1	06/29/2016	07/29/2016				
16-PR-0125	1	Tesfamichael Bogale	Johathan Brown	John Jenkins	D7	TBD		NA N/A	Areawide Drainage Improvements in Carroll and Frederick County				
						CON	3	05/26/2017	06/06/2017				
						CON	2	04/07/2017	04/19/2017				
						CON	1	10/13/2016	11/04/2016				
17-PR-0023	1	Brandon Scott		Chris Weber	OHD	AA4365371		MD 175	IHB - NATIONAL BUSINESS PARKWAY TO MCCARRON COURT				
						CON	2	03/08/2017	03/21/2017	03/21/2017			
						CON	1	02/06/2017	02/15/2017				
17-PR-0061	1	Tesfamichael Bogale	Jessica Lain		D6	GA4145177		MD 450	MD 135 TO CRABTREE CREEK				
						CON	1	04/17/2017	04/25/2017				
17-PR-0072	0	Brandon Scott		Luis Gonzalez	OHD	MO1505388		MD 124	DOSH DRIVE TO MD 117				
						FIN	2	06/20/2017	07/07/2017				
						FIN	1	05/08/2017	05/23/2017				

2.2 WAIVERS AND VARIANCES

FY 2017 - Waiver Summary

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Waiver	Waiver Type	Justification	Accepted	Granted
15-PR-0023	1	AA4365471	71	MD175	WEST OF REECE ROAD TO EAST OF DISNEY ROAD	LOI 7	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0025	1	CE3395176	76	MD272	IHB - SOUTH OF US 40 TO ROGERS ROAD	2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0028	1	FR3905184	84	MD180	MD 383 (BROAD RUN ROAD) TO OLD HOLTER ROAD	8	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence received	Y	Y
15-PR-0028	1	FR3905184	84	MD180	MD 383 (BROAD RUN ROAD) TO OLD HOLTER ROAD	4	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence received	Y	Y
15-PR-0028	1	FR3905184	84	MD180	MD 383 (BROAD RUN ROAD) TO OLD HOLTER ROAD	7	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence received	Y	Y
15-PR-0032	1	CO2795177	77	MD404 BU	IHB - 1ST STREET TO 9TH STREET or MD 404 BU from 1st St to 9th St	2	3.3.B.1.a	No Adverse Impact, Discharge to tidal (Quant)	Stable outfall, Direct discharge to tidal waters	Y	Y
15-PR-0033	1	PG8945177	77	MD201	MD 201 from Edmonston Rd to Good Luck Rd	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0033	1	PG8945177	77	MD201	MD 201 from Edmonston Rd to Good Luck Rd	2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0033	1	PG8945177	77	MD201	MD 201 from Edmonston Rd to Good Luck Rd	3	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0033	1	PG8945177	77	MD201	MD 201 from Edmonston Rd to Good Luck Rd	4	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0033	1	PG8945177	77	MD201	MD 201 from Edmonston Rd to Good Luck Rd	5	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0033	1	PG8945177	77	MD201	MD 201 from Edmonston Rd to Good Luck Rd	6	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0033	1	PG8945177	77	MD201	MD 201 from Edmonston Rd to Good Luck Rd	7	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0033	1	PG8945177	77	MD201	MD 201 from Edmonston Rd to Good Luck Rd	8	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0033	1	PG8945177	77	MD201	MD 201 from Edmonston Rd to Good Luck Rd	9	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0033	1	PG8945177	77	MD201	MD 201 from Edmonston Rd to Good Luck Rd	10	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0033	1	PG8945177	77	MD201	MD 201 from Edmonston Rd to Good Luck Rd	11	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0033	1	PG8945177	77	MD201	MD 201 from Edmonston Rd to Good Luck Rd	12	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0033	1	PG8945177	77	MD201	MD 201 from Edmonston Rd to Good Luck Rd	13	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0033	1	PG8945177	77	MD201	MD 201 from Edmonston Rd to Good Luck Rd	14	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y

FY 2017 - Waiver Summary

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Waiver	Waiver Type	Justification	Accepted	Granted
15-PR-0033	1	PG8945177	77	MD201	MD 201 from Edmonston Rd to Good Luck Rd	15	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0036	1	XX1605174	74	I270	I-270 N prior to MD 28, washout	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0042	1	WA1065184	84	MD845A	SOUTH CORPORATE LIMITS OF KEEDYSVILLE TO NORTH CORPORATE TOWN LIMITS	8	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
15-PR-0057	1	AA1805179	79	MD424	DUKE OF KENT DRIVE TO MD 450 (DEFENSE HIGHWAY) - PHASE 2	LOI 1	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
15-PR-0061	1	AA1025129	29	N/A	HANOVER COMPLEX BLDG 1-OOM OOTS SOC ROOF/GUTTER REPAIR REPLACEMENT	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0074	1	BA1445174	74	I795	Maintenance Repairs to Painters Mill Levee at I-795 and Painters Mill Road	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0075	1	AA1945130	30	MD174	1000 FT SOUTH TO 700 FT NORTH OF SEVERN ROAD	LOI 4	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
15-PR-0075	1	AA1945130	30	MD174	1000 FT SOUTH TO 700 FT NORTH OF SEVERN ROAD	POI 5	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
15-PR-0075	1	AA1945130	30	MD174	1000 FT SOUTH TO 700 FT NORTH OF SEVERN ROAD	POI 6	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
15-PR-0078	1	FR5365180	80	MD140	BRIDGE 1006200 REPLACEMENT OVER FLAT RUN	2	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence received	Y	Y
15-PR-0078	1	FR5365180	80	MD140	BRIDGE 1006200 REPLACEMENT OVER FLAT RUN	3	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence received	Y	Y
15-PR-0079	1	AL2665130	30	MD935	IHB - AT RAILROAD STREET or Intersection Improvement at S. Railroad Street	1-P	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence received	Y	Y
15-PR-0079	1	AL2665130	30	MD935	IHB - AT RAILROAD STREET or Intersection Improvement at S. Railroad Street	2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0081	1	AX0265124R	4R	Varies	Landscape Sustainability Improvements at Various Locations	4BA-09	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0081	1	AX0265124R	4R	Varies	Landscape Sustainability Improvements at Various Locations	4BA-10	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0081	1	AX0265124R	4R	Varies	Landscape Sustainability Improvements at Various Locations	4BA-11	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0081	1	AX0265124R	4R	Varies	Landscape Sustainability Improvements at Various Locations	4BA-03	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0081	1	AX0265124R	4R	Varies	Landscape Sustainability Improvements at Various Locations	4BA-04	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0081	1	AX0265124R	4R	Varies	Landscape Sustainability Improvements at Various Locations	4BA-05	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0081	1	AX0265124R	4R	Varies	Landscape Sustainability Improvements at Various Locations	4BA-06	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y

FY 2017 - Waiver Summary

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Waiver	Waiver Type	Justification	Accepted	Granted
15-PR-0081	1	AX0265124R	4R	Varies	Landscape Sustainability Improvements at Various Locations	4BA-07	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0081	1	AX0265124R	4R	Varies	Landscape Sustainability Improvements at Various Locations	4BA-12	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0081	1	AX0265124R	4R	Varies	Landscape Sustainability Improvements at Various Locations	4BA-14	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0081	1	AX0265124R	4R	Varies	Landscape Sustainability Improvements at Various Locations	4BA-18	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0091	1	MO0815177	77	MD190	MD 614 TO DC LINE	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0091	1	MO0815177	77	MD190	MD 614 TO DC LINE	3	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0091	1	MO0815177	77	MD190	MD 614 TO DC LINE	4	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0091	1	MO0815177	77	MD190	MD 614 TO DC LINE	5	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0091	1	MO0815177	77	MD190	MD 614 TO DC LINE	6	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0096	1	PG0395177	77	MD5	IHB - MOORES ROAD TO SURRATTS ROAD	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0104	1	MO9465177	77	MD586	IHB - STRUCTURE 15063 TO MD 185 AND MD 193 TO MD 97	5	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0104	1	MO9465177	77	MD586	IHB - STRUCTURE 15063 TO MD 185 AND MD 193 TO MD 97	6	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0104	1	MO9465177	77	MD586	IHB - STRUCTURE 15063 TO MD 185 AND MD 193 TO MD 97	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0104	1	MO9465177	77	MD586	IHB - STRUCTURE 15063 TO MD 185 AND MD 193 TO MD 97	4	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0106	6	XY2335277	77	MD273	Harrington Drive to MD 274	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0106	5	XY2335277	77	MD213	Howard Street to Railroad Ave	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0106	5	XY2335277	77	MD213	Howard Street to Railroad Ave	2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0106	5	XY2335277	77	MD213	Howard Street to Railroad Ave	3A	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0106	5	XY2335277	77	MD213	Howard Street to Railroad Ave	3B	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0106	5	XY2335277	77	MD213	Howard Street to Railroad Ave	4	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y

FY 2017 - Waiver Summary

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Waiver	Waiver Type	Justification	Accepted	Granted
15-PR-0106	5	XY2335277	77	MD213	Howard Street to Railroad Ave	5A	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0106	5	XY2335277	77	MD213	Howard Street to Railroad Ave	5B	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0108	3	XX3145133	33	MD542	Site 3 Loch Hill Road to Yakona Road	2	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
15-PR-0108	3	XX3145133	33	MD542	Site 3 Loch Hill Road to Yakona Road	4	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
15-PR-0108	3	XX3145133	33	MD542	Site 3 Loch Hill Road to Yakona Road	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
15-PR-0108	3	XX3145133	33	MD542	Site 3 Loch Hill Road to Yakona Road	3	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
15-PR-0108	3	XX3145133	33	MD542	Site 3 Loch Hill Road to Yakona Road	5	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
15-PR-0108	3	XX3145133	33	MD542	Site 3 Loch Hill Road to Yakona Road	8	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
15-PR-0108	5	XX3145133	33	MD26	Site 5 Deer Park Road to Pikeswood Drive	5	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
15-PR-0108	5	XX3145133	33	MD26	Site 5 Deer Park Road to Pikeswood Drive	7	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
15-PR-0108	3	XX3145133	33	MD542	Site 3 Loch Hill Road to Yakona Road	6	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
15-PR-0108	5	XX3145133	33	MD26	Site 5 Deer Park Road to Pikeswood Drive	1	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
15-PR-0108	5	XX3145133	33	MD26	Site 5 Deer Park Road to Pikeswood Drive	2	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
15-PR-0108	5	XX3145133	33	MD26	Site 5 Deer Park Road to Pikeswood Drive	3	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
15-PR-0108	5	XX3145133	33	MD26	Site 5 Deer Park Road to Pikeswood Drive	4	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
15-PR-0108	5	XX3145133	33	MD26	Site 5 Deer Park Road to Pikeswood Drive	6	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
15-PR-0109	1	TA2805149	49	N/A	Buried Drum Removal 10877 Lewistown Road, Cordova	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
15-PR-0117	1	AL4795180	80	MD51	BRIDGE 01092 OVER CSX AND CANAL PARKWAY	2	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
15-PR-0121	1	PG6985180	80	I95/495	IHB - BRIDGE 1616205 AND 1616206 OVER SUITLAND ROAD	4	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence received	Y	Y
15-PR-0127	1	TBD	74	MD175	Outfall Repair Near MP 11.00	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y

FY 2017 - Waiver Summary

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Waiver	Waiver Type	Justification	Accepted	Granted
15-PR-0131	1	KE4385184	84	MD291	WEST OF SCHOOL STREET TO EAST OF CRANE STREET	4	3.3.B.1.a	No Adverse Impact, Discharge to tidal (Quant)	Stable outfall, Direct discharge to tidal waters	Y	
15-PR-0131	1	KE4385184	84	MD291	WEST OF SCHOOL STREET TO EAST OF CRANE STREET	6	3.3.B.1.a	No Adverse Impact, Discharge to tidal (Quant)	Stable outfall, Direct discharge to tidal waters	Y	
15-PR-0131	1	KE4385184	84	MD291	WEST OF SCHOOL STREET TO EAST OF CRANE STREET	2	3.3.B.1.a	No Adverse Impact, Discharge to tidal (Quant)	Stable outfall, Direct discharge to tidal waters	Y	
15-PR-0133	1	BA0805180	80	MD137	IHB - BRIDGE 03050 OVER I-83	1	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence received	Y	Y
15-PR-0133	1	BA0805180	80	MD137	IHB - BRIDGE 03050 OVER I-83	2	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence received	Y	Y
15-PR-0134	1	AA1965177	77	MD295	Hanover Road to Winterson Road, Hammonds Ferry Road to Baltimore County Line	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0001	1	FR2595149	49	N/A	FREDERICK SHOP WASHBAY	POI 1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0005	1	AT6885274	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL CALVERT CHARLES & ST MARY'S COUNTY	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0005	2	AT6885274	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL CALVERT CHARLES & ST MARY'S COUNTY	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0005	5	AT6885274	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL CALVERT CHARLES & ST MARY'S COUNTY	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0005	6	AT6885274	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL CALVERT CHARLES & ST MARY'S COUNTY	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0005	7	AT6885274	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL CALVERT CHARLES & ST MARY'S COUNTY	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0005	8	AT6885274	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL CALVERT CHARLES & ST MARY'S COUNTY	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0005	9	AT6885274	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL CALVERT CHARLES & ST MARY'S COUNTY	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0005	10	AT6885274	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL CALVERT CHARLES & ST MARY'S COUNTY	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0005	11	AT6885274	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL CALVERT CHARLES & ST MARY'S COUNTY	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0005	12	AT6885274	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL CALVERT CHARLES & ST MARY'S COUNTY	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0005	14	AT6885274	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL CALVERT CHARLES & ST MARY'S COUNTY	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0005	9	AT6885274	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL CALVERT CHARLES & ST MARY'S COUNTY	2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0005	3	AT6885274	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL CALVERT CHARLES & ST MARY'S COUNTY	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y

FY 2017 - Waiver Summary

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Waiver	Waiver Type	Justification	Accepted	Granted
16-PR-0005	4	AT6885274	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL CALVERT CHARLES & ST MARY'S COUNTY	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0009	1	PG0705174	74	Varies	IHB - AT VARIOUS LOCATIONS IN PRINCE'S GEORGE COUNTY	Site 1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0009	1	PG0705174	74	Varies	IHB - AT VARIOUS LOCATIONS IN PRINCE'S GEORGE COUNTY	Site 9	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0009	1	PG0705174	74	Varies	IHB - AT VARIOUS LOCATIONS IN PRINCE'S GEORGE COUNTY	Site 14	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0009	1	PG0705174	74	Varies	IHB - AT VARIOUS LOCATIONS IN PRINCE'S GEORGE COUNTY	POI 11	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0009	1	PG0705174	74	Varies	IHB - AT VARIOUS LOCATIONS IN PRINCE'S GEORGE COUNTY	POI 5	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0009	1	PG0705174	74	Varies	IHB - AT VARIOUS LOCATIONS IN PRINCE'S GEORGE COUNTY	POI 6	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0009	1	PG0705174	74	Varies	IHB - AT VARIOUS LOCATIONS IN PRINCE'S GEORGE COUNTY	POI 7	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0009	1	PG0705174	74	Varies	IHB - AT VARIOUS LOCATIONS IN PRINCE'S GEORGE COUNTY	POI 13	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0021	1	QA2815249	49	N/A	CENTREVILLE SHOP - REPLACEMENT OF FUEL SYSTEM	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0022	1	PG1155285	85	MD214	Central Avenue at I-94/I-495 AND MD 202	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0023	1	MO9485177	77	MD28	QUINCE ORCHARD ROAD TO ARGOSY DRIVE	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0026	1	BA0155185	85	I95	AT I-695	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0029	1	FR5595180	80	MD355	IHB - BRIDGE 1008400 OVER CSX	LOI 103	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, Owner concurrence received	Y	Y
16-PR-0032	1	AA7765180	80	MD450	BRIDGE 02243X0 02335X0 02288XO 02244X0	02244X0	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0032	1	AA7765180	80	MD450	BRIDGE 02243X0 02335X0 02288XO 02244X0	02335X0	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0032	1	AA7765180	80	MD450	BRIDGE 02243X0 02335X0 02288XO 02244X0	02243X0	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0032	1	AA7765180	80	MD450	BRIDGE 02243X0 02335X0 02288XO 02244X0	02288X0	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0036	1	MO1605174	74	I270	IHB - MONTROSE ROAD RAMP TO SB I-270 CD LANES	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0040	1	CL2145187	87	MD97	SOUTH OF AIRPORT DRIVE TO PLEASANT VALLEY ROAD	1	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence received	Y	Y

FY 2017 - Waiver Summary

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Waiver	Waiver Type	Justification	Accepted	Granted
16-PR-0040	1	CL2145187	87	MD97	SOUTH OF AIRPORT DRIVE TO PLEASANT VALLEY ROAD	2	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence received	Y	Y
16-PR-0040	1	CL2145187	87	MD97	SOUTH OF AIRPORT DRIVE TO PLEASANT VALLEY ROAD	LOI 7	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence received	Y	Y
16-PR-0040	1	CL2145187	87	MD97	SOUTH OF AIRPORT DRIVE TO PLEASANT VALLEY ROAD	8	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence received	Y	Y
16-PR-0040	1	CL2145187	87	MD97	SOUTH OF AIRPORT DRIVE TO PLEASANT VALLEY ROAD	5	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence received	Y	Y
16-PR-0040	1	CL2145187	87	MD97	SOUTH OF AIRPORT DRIVE TO PLEASANT VALLEY ROAD	6	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence received	Y	Y
16-PR-0041	1	GA1975180	80	MD39	IHB - BRIDGE 1100200 OVER YOUGHIOGHENY RIVER	2	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
16-PR-0042	1	CH2265180	80	MD254	IHB - BRIDGE 0803800 OVER NEALE SOUND	2	3.3.B.1.a	No Adverse Impact, Discharge to tidal (Quant)	Stable outfall, Direct discharge to tidal waters	Y	Y
16-PR-0042	1	CH2265180	80	MD254	IHB - BRIDGE 0803800 OVER NEALE SOUND	3	3.3.B.1.a	No Adverse Impact, Discharge to tidal (Quant)	Stable outfall, Direct discharge to tidal waters	Y	Y
16-PR-0042	1	CH2265180	80	MD254	IHB - BRIDGE 0803800 OVER NEALE SOUND	LOI 2	3.3.B.1.a	No Adverse Impact, Discharge to tidal (Quant)	Stable outfall, Direct discharge to tidal waters	Y	Y
16-PR-0042	1	CH2265180	80	MD254	IHB - BRIDGE 0803800 OVER NEALE SOUND	LOI 3	3.3.B.1.a	No Adverse Impact, Discharge to tidal (Quant)	Stable outfall, Direct discharge to tidal waters	Y	Y
16-PR-0042	1	CH2265180	80	MD254	IHB - BRIDGE 0803800 OVER NEALE SOUND	LOI 4	3.3.B.1.a	No Adverse Impact, Discharge to tidal (Quant)	Stable outfall, Direct discharge to tidal waters	Y	Y
16-PR-0050	1	SM7745171	71	MD5	IHB - THE CAUSEWAY TO SOUTH OF CAMP BROWN ROAD	6	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
16-PR-0050	1	SM7745171	71	MD5	IHB - THE CAUSEWAY TO SOUTH OF CAMP BROWN ROAD	15	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0050	1	SM7745171	71	MD5	IHB - THE CAUSEWAY TO SOUTH OF CAMP BROWN ROAD	11	3.3.B.1.a	No Adverse Impact, Discharge to tidal (Quant)	Stable outfall, Direct discharge to tidal waters	Y	
16-PR-0050	1	SM7745171	71	MD5	IHB - THE CAUSEWAY TO SOUTH OF CAMP BROWN ROAD	12	3.3.B.1.a	No Adverse Impact, Discharge to tidal (Quant)	Stable outfall, Direct discharge to tidal waters	Y	
16-PR-0050	1	SM7745171	71	MD5	IHB - THE CAUSEWAY TO SOUTH OF CAMP BROWN ROAD	13	3.3.B.1.a	No Adverse Impact, Discharge to tidal (Quant)	Stable outfall, Direct discharge to tidal waters	Y	
16-PR-0050	1	SM7745171	71	MD5	IHB - THE CAUSEWAY TO SOUTH OF CAMP BROWN ROAD	14	3.3.B.1.a	No Adverse Impact, Discharge to tidal (Quant)	Stable outfall, Direct discharge to tidal waters	Y	
16-PR-0050	1	SM7745171	71	MD5	IHB - THE CAUSEWAY TO SOUTH OF CAMP BROWN ROAD	16	3.3.B.1.a	No Adverse Impact, Discharge to tidal (Quant)	Stable outfall, Direct discharge to tidal waters	Y	
16-PR-0050	1	SM7745171	71	MD5	IHB - THE CAUSEWAY TO SOUTH OF CAMP BROWN ROAD	8	3.3.B.1.b	No Adverse Impact, Discharge to site (Quant)	Stable outfall, Stable conveyance to tidal waters	Y	
16-PR-0050	1	SM7745171	71	MD5	IHB - THE CAUSEWAY TO SOUTH OF CAMP BROWN ROAD	9	3.3.B.1.b	No Adverse Impact, Discharge to site (Quant)	Stable outfall, Stable conveyance to tidal waters	Y	

FY 2017 - Waiver Summary

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Waiver	Waiver Type	Justification	Accepted	Granted
16-PR-0050	1	SM7745171	71	MD5	IHB - THE CAUSEWAY TO SOUTH OF CAMP BROWN ROAD	17	3.3.B.1.b	No Adverse Impact, Discharge to site (Quant)	Stable outfall, Stable conveyance to tidal waters	Y	
16-PR-0056	1	PG0445177	77	US301	SOUTH OSBORNE ROAD TO MD 381 (OLD CRAIN HIGHWAY)	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0056	1	PG0445177	77	US301	SOUTH OSBORNE ROAD TO MD 381 (OLD CRAIN HIGHWAY)	2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0056	1	PG0445177	77	US301	SOUTH OSBORNE ROAD TO MD 381 (OLD CRAIN HIGHWAY)	4	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0058	1	MO1865177	77	I495	I-270 Y to Seminary Rd - OL	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0059	1	FR6735177	77	MD26	IHB - Safety and Resurfacing from US 15 TO EAST OF MD 194	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0062	1	HO1535177	77	MD32	IHB - STRUCTURE 13114 OVER MIDDLE PATUXENT RIVER TO NORTH OF MD 108	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0068	3	XY2425377	77	MD547	Flanders Ave to Weymouth Street	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	3	XY2425377	77	MD547	Flanders Ave to Weymouth Street	2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	3	XY2425377	77	MD547	Flanders Ave to Weymouth Street	3	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	8	XY2425377	77	MD332	DC Line to MD 214 (E. Capitol St)	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	8	XY2425377	77	MD332	DC Line to MD 214 (E. Capitol St)	2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	8	XY2425377	77	MD332	DC Line to MD 214 (E. Capitol St)	3	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	6	XY2425377	77	MD28	South Van Buren Street to Monroe Street	POI 1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	6	XY2425377	77	MD28	South Van Buren Street to Monroe Street	LOI 2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	6	XY2425377	77	MD28	South Van Buren Street to Monroe Street	LOI 3	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	6	XY2425377	77	MD28	South Van Buren Street to Monroe Street	POI 4	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	4	XY2425377	77	MD192	Plyers Mill Road to MD 97	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	4	XY2425377	77	MD192	Plyers Mill Road to MD 97	2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	4	XY2425377	77	MD192	Plyers Mill Road to MD 97	3	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	

FY 2017 - Waiver Summary

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Waiver	Waiver Type	Justification	Accepted	Granted
16-PR-0068	4	XY2425377	77	MD192	Plyers Mill Road to MD 97	4	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	4	XY2425377	77	MD192	Plyers Mill Road to MD 97	5	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	4	XY2425377	77	MD192	Plyers Mill Road to MD 97	6	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	4	XY2425377	77	MD192	Plyers Mill Road to MD 97	7	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	4	XY2425377	77	MD192	Plyers Mill Road to MD 97	8	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	4	XY2425377	77	MD192	Plyers Mill Road to MD 97	9	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	4	XY2425377	77	MD192	Plyers Mill Road to MD 97	10	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	9	XY2425377	77	MD191	MD 191, MCCLEAN DRIVE TO WEST AVENUE	POI 1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	9	XY2425377	77	MD191	MD 191, MCCLEAN DRIVE TO WEST AVENUE	LOI 2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	9	XY2425377	77	MD191	MD 191, MCCLEAN DRIVE TO WEST AVENUE	LOI 3	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	9	XY2425377	77	MD191	MD 191, MCCLEAN DRIVE TO WEST AVENUE	LOI 4	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	10	XY2425377	77	MD190	MD190 Gary road to Harrington Drive	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	10	XY2425377	77	MD190	MD190 Gary road to Harrington Drive	2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	10	XY2425377	77	MD190	MD190 Gary road to Harrington Drive	3	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	10	XY2425377	77	MD190	MD190 Gary road to Harrington Drive	4	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	10	XY2425377	77	MD190	MD190 Gary road to Harrington Drive	5	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	10	XY2425377	77	MD190	MD190 Gary road to Harrington Drive	6	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	10	XY2425377	77	MD190	MD190 Gary road to Harrington Drive	7	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	10	XY2425377	77	MD190	MD190 Gary road to Harrington Drive	8	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	5	XY2425377	77	MD117	MD 119 to Entrance of Seneca Creek State Park	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	

FY 2017 - Waiver Summary

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Waiver	Waiver Type	Justification	Accepted	Granted
16-PR-0068	5	XY2425377	77	MD117	MD 119 to Entrance of Seneca Creek State Park	2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	5	XY2425377	77	MD117	MD 119 to Entrance of Seneca Creek State Park	3	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0068	5	XY2425377	77	MD117	MD 119 to Entrance of Seneca Creek State Park	4	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0071	1	AT8235117	17	MD97	Gradall Equipment Training, D7	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0073	1	AX0475114	14	N/A	Gradall Equipment Training, D5	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0073	1	AX0475114	14	N/A	Gradall Equipment Training, D5	2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0077	1	FR1625177	77	MD26	WEST SOUTH STREET TO MD 31	3	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence received	Y	Y
16-PR-0077	1	FR1625177	77	MD26	WEST SOUTH STREET TO MD 31	5	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0078	1	BA9825277	77	MD45	TOWSON ROUNDABOUT TO CAVAN DRIVE	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0078	1	BA9825277	77	MD45	TOWSON ROUNDABOUT TO CAVAN DRIVE	2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0078	1	BA9825277	77	MD45	TOWSON ROUNDABOUT TO CAVAN DRIVE	3	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0081	1	AA1975177	77	MD295	MD 175 TO MD 100	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0081	1	AA1975177	77	MD295	MD 175 TO MD 100	2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0083	1	TBD	74	MD349	Emergency Repair Riawalkin Dam	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0084	1	FR6785171	71	MD180	WEST OF SWALLOWTAIL DRIVE TO I-70 RAMP STRUCTURE 10140	POI 2	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence received	Y	
16-PR-0084	1	FR6785171	71	MD180	WEST OF SWALLOWTAIL DRIVE TO I-70 RAMP STRUCTURE 10140	POI 3	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence received	Y	
16-PR-0084	1	FR6785171	71	MD180	WEST OF SWALLOWTAIL DRIVE TO I-70 RAMP STRUCTURE 10140	POI 6	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0084	1	FR6785171	71	MD180	WEST OF SWALLOWTAIL DRIVE TO I-70 RAMP STRUCTURE 10140	LOI 1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0085	1	BA0445177	77	US1	IHB - NORTH OF I-695 TO DUNFIELD ROAD	POI 7	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0085	1	BA0445177	77	US1	IHB - NORTH OF I-695 TO DUNFIELD ROAD	POI 8	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y

FY 2017 - Waiver Summary

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Waiver	Waiver Type	Justification	Accepted	Granted
16-PR-0085	1	BA0445177	77	US1	IHB - NORTH OF I-695 TO DUNFIELD ROAD	POI 9	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0085	1	BA0445177	77	US1	IHB - NORTH OF I-695 TO DUNFIELD ROAD	POI 2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0085	1	BA0445177	77	US1	IHB - NORTH OF I-695 TO DUNFIELD ROAD	POI 3	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0085	1	BA0445177	77	US1	IHB - NORTH OF I-695 TO DUNFIELD ROAD	POI 4	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0085	1	BA0445177	77	US1	IHB - NORTH OF I-695 TO DUNFIELD ROAD	POI 5	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0085	1	BA0445177	77	US1	IHB - NORTH OF I-695 TO DUNFIELD ROAD	POI 6	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0092	1	WO2375188	88	US50	MD 611 TO BRIDGE OVER SINEPUXENT BAY	POI 1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0092	1	WO2375188	88	US50	MD 611 TO BRIDGE OVER SINEPUXENT BAY	LOI 2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0092	1	WO2375188	88	US50	MD 611 TO BRIDGE OVER SINEPUXENT BAY	POI 7	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0092	1	WO2375188	88	US50	MD 611 TO BRIDGE OVER SINEPUXENT BAY	POI 4	3.3.B.1.a	No Adverse Impact, Discharge to tidal (Quant)	Stable outfall, Direct discharge to tidal waters	Y	
16-PR-0092	1	WO2375188	88	US50	MD 611 TO BRIDGE OVER SINEPUXENT BAY	POI 5	3.3.B.1.a	No Adverse Impact, Discharge to tidal (Quant)	Stable outfall, Direct discharge to tidal waters	Y	
16-PR-0094	1	BA2605277	77	MD150	BACK RIVER BRIDGE TO RIVERSIDE DRIVE	2	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
16-PR-0094	1	BA2605277	77	MD150	BACK RIVER BRIDGE TO RIVERSIDE DRIVE	4	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
16-PR-0094	1	BA2605277	77	MD150	BACK RIVER BRIDGE TO RIVERSIDE DRIVE	2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0094	1	BA2605277	77	MD150	BACK RIVER BRIDGE TO RIVERSIDE DRIVE	3	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0094	1	BA2605277	77	MD150	BACK RIVER BRIDGE TO RIVERSIDE DRIVE	4	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0094	1	BA2605277	77	MD150	BACK RIVER BRIDGE TO RIVERSIDE DRIVE	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0095	1	FR1945177	77	US340	IHB - WASHINGTON COUNTY LINE TO MD 17	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0095	1	FR1945177	77	US340	IHB - WASHINGTON COUNTY LINE TO MD 17	2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0095	1	FR1945177	77	US340	IHB - WASHINGTON COUNTY LINE TO MD 17	4	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y

FY 2017 - Waiver Summary

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Waiver	Waiver Type	Justification	Accepted	Granted
16-PR-0095	1	FR1945177	77	US340	IHB - WASHINGTON COUNTY LINE TO MD 17	5	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0095	1	FR1945177	77	US340	IHB - WASHINGTON COUNTY LINE TO MD 17	6	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0095	1	FR1945177	77	US340	IHB - WASHINGTON COUNTY LINE TO MD 17	8	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0096	1	BA7505277	77	I695	Greenspring Ave to MD 25 (Falls Road)	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0097	1	BW6415599	99	N/A	MDOT SECRETARY'S OFFICE SITE REMEDIATION	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0097	1	BW6415599	99	N/A	MDOT SECRETARY'S OFFICE SITE REMEDIATION	2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0099	1	FR1155130	30	MD26	AT OLD ANNAPOLIS ROAD/WATER STREET ROAD	POI 4	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
16-PR-0100	1	BA1285177	77	I83	Shawan Road to Mt Carmel Road	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0101	1	MO1625177	77	I270	MD 121 TO FREDERICK COUNTY LINE	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0101	1	MO1625177	77	I270	MD 121 TO FREDERICK COUNTY LINE	2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0107	1	AA2215170	70	US50	IHB - MD 70 TO MD 2 (NORTH)	2	3.3.B.1.a	No Adverse Impact, Discharge to tidal (Quant)	Stable outfall, Direct discharge to tidal waters	Y	Y
16-PR-0107	1	AA2215170	70	US50	IHB - MD 70 TO MD 2 (NORTH)	3	3.3.B.1.a	No Adverse Impact, Discharge to tidal (Quant)	Stable outfall, Direct discharge to tidal waters	Y	Y
16-PR-0108	1	TA2865184	84	MD33	YACHT CLUB ROAD TO PEA NECK ROAD	4	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0108	1	TA2865184	84	MD33	YACHT CLUB ROAD TO PEA NECK ROAD	5	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0108	1	TA2865184	84	MD33	YACHT CLUB ROAD TO PEA NECK ROAD	7	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0108	1	TA2865184	84	MD33	YACHT CLUB ROAD TO PEA NECK ROAD	9	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0108	1	TA2865184	84	MD33	YACHT CLUB ROAD TO PEA NECK ROAD	10	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0109	1	BA2635277	77	I95	Baltimore County/City Line to US 1	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0111	1	BA6095180	80	US40	IHB-BRIDGE 03034 & BRIDGE 03035 OVER LITTLE GUNPOWDER FALLS AND GUNPOWDER FALLS	4	3.3.B.1.a	No Adverse Impact, Discharge to tidal (Quant)	Stable outfall, Direct discharge to tidal waters	Y	
16-PR-0112	1	MO2105326	26	I270	NORTH OF MD 28 (MONTGOMERY AVENUE)	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	

FY 2017 - Waiver Summary

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Waiver	Waiver Type	Justification	Accepted	Granted
16-PR-0114	1	XY2425577	77	US301	Site 1 Centennial Street to MD 225 (Hawthorne Road)	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0114	3	XY2425577	77	MD5	Site 3 MD 246 to Chingville Road	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0114	4	XY2425577	77	MD235	Site 4, MD235 , Old Rolling Road to Town Creek Drive	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0114	4	XY2425577	77	MD235	Site 4, MD235 , Old Rolling Road to Town Creek Drive	2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0114	2	XY2425577	77	MD170	Site 2 10th Avenue to MD 2	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0114	2	XY2425577	77	MD170	Site 2 10th Avenue to MD 2	2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0114	2	XY2425577	77	MD170	Site 2 10th Avenue to MD 2	3	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0114	2	XY2425577	77	MD170	Site 2 10th Avenue to MD 2	4	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0118	1	HA4235182	82	N/A	HOLLANDS BRANCH AT TRAPPE CHURCH ROAD	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0124	1	BA0215177	77	MD140	IHB - ROSEWOOD LANE TO EAST PLEASANT HILL ROAD	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0126	1	FR6685149	49	I70	I-70 WELCOME CENTER - WASTEWATER TREATMENT PLANT OUTFALL RELOCATION	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0130	1	XY5125277	77	MD23	Overlay, installation of metal barrier, and associated grading	1A	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0130	1	XY5125277	77	MD23	Overlay, installation of metal barrier, and associated grading	1B	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0135	1	PG0405177	77	MD4	MD 458 TO DC LINE	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0135	1	PG0405177	77	MD4	MD 458 TO DC LINE	2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0135	1	PG0405177	77	MD4	MD 458 TO DC LINE	3	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0135	1	PG0405177	77	MD4	MD 458 TO DC LINE	4	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0137	1	QA1835180	80	MD544	STRUCTURE 17068X0 OVER TRIBUTARY TO FOREMAN BRANCH	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0141	1	TBD	74	I270	Emergency Drainage Repair	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0142	1	BA5385177	77	MD45	IHB - NORTH OF PADONIA TO WIGHT AVENUE - 24 INCH WATERLINE REPLACEMENT	3	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y

FY 2017 - Waiver Summary

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Waiver	Waiver Type	Justification	Accepted	Granted
16-PR-0142	1	BA5385177	77	MD45	IHB - NORTH OF PADONIA TO WIGHT AVENUE - 24 INCH WATERLINE REPLACEMENT	4	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0142	1	BA5385177	77	MD45	IHB - NORTH OF PADONIA TO WIGHT AVENUE - 24 INCH WATERLINE REPLACEMENT	5	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0142	1	BA5385177	77	MD45	IHB - NORTH OF PADONIA TO WIGHT AVENUE - 24 INCH WATERLINE REPLACEMENT	6	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0142	1	BA5385177	77	MD45	IHB - NORTH OF PADONIA TO WIGHT AVENUE - 24 INCH WATERLINE REPLACEMENT	7	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0142	1	BA5385177	77	MD45	IHB - NORTH OF PADONIA TO WIGHT AVENUE - 24 INCH WATERLINE REPLACEMENT	8	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0142	1	BA5385177	77	MD45	IHB - NORTH OF PADONIA TO WIGHT AVENUE - 24 INCH WATERLINE REPLACEMENT	9	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0142	1	BA5385177	77	MD45	IHB - NORTH OF PADONIA TO WIGHT AVENUE - 24 INCH WATERLINE REPLACEMENT	10	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0142	1	BA5385177	77	MD45	IHB - NORTH OF PADONIA TO WIGHT AVENUE - 24 INCH WATERLINE REPLACEMENT	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0142	1	BA5385177	77	MD45	IHB - NORTH OF PADONIA TO WIGHT AVENUE - 24 INCH WATERLINE REPLACEMENT	2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0144	2	AA1695174	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL COUNTY	202632.002	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0144	2	AA1695174	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL COUNTY	202641.001	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0144	2	AA1695174	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL COUNTY	202645.001	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0144	2	AA1695174	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL COUNTY	201691.001	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0144	2	AA1695174	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL COUNTY	200108.001	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0144	1	AA1695174	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL COUNTY	200182.001	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0144	1	AA1695174	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL COUNTY	201597.002	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0144	1	AA1695174	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL COUNTY	201993.001	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0144	1	AA1695174	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL COUNTY	202663.001	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0144	1	AA1695174	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL COUNTY	202389.001	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0144	1	AA1695174	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL COUNTY	290805.001	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y

FY 2017 - Waiver Summary

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Waiver	Waiver Type	Justification	Accepted	Granted
16-PR-0144	1	AA1695174	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL COUNTY	203153.001	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0144	1	AA1695174	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL COUNTY	203153.002	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0144	1	AA1695174	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL COUNTY	202485.001	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0144	1	AA1695174	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL COUNTY	202904.001	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0144	1	AA1695174	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL COUNTY	201691.001	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0144	1	AA1695174	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL COUNTY	201445.001	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0144	1	AA1695174	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL COUNTY	201415.001	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0144	1	AA1695174	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL COUNTY	201422.001	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0144	1	AA1695174	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL COUNTY	202632.002	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0144	1	AA1695174	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL COUNTY	202641.001	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0144	1	AA1695174	74	Varies	IHB - AT VARIOUS LOCATIONS IN ANNE ARUNDEL COUNTY	202645.001	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0145	1	DO5775174	74	MD16	MD 335 TO BRANNOCKS NECK ROAD	POI 1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0145	1	DO5775174	74	MD16	MD 335 TO BRANNOCKS NECK ROAD	POI 2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0145	1	DO5775174	74	MD16	MD 335 TO BRANNOCKS NECK ROAD	POI 3	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0145	1	DO5775174	74	MD16	MD 335 TO BRANNOCKS NECK ROAD	POI 4	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0145	1	DO5775174	74	MD16	MD 335 TO BRANNOCKS NECK ROAD	POI 5	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0146	1	HO1375177	77	I70 WB	MARRIOTTSVILLE ROAD TO BALTIMORE COUNTY LINE	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0146	1	HO1375177	77	I70 WB	MARRIOTTSVILLE ROAD TO BALTIMORE COUNTY LINE	19	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0146	1	HO1375177	77	I70 WB	MARRIOTTSVILLE ROAD TO BALTIMORE COUNTY LINE	20	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0146	1	HO1375177	77	I70 WB	MARRIOTTSVILLE ROAD TO BALTIMORE COUNTY LINE	21	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	

FY 2017 - Waiver Summary

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Waiver	Waiver Type	Justification	Accepted	Granted
16-PR-0146	1	HO1375177	77	I70 WB	MARRIOTTSVILLE ROAD TO BALTIMORE COUNTY LINE	22	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0146	1	HO1375177	77	I70 WB	MARRIOTTSVILLE ROAD TO BALTIMORE COUNTY LINE	23	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0146	1	HO1375177	77	I70 WB	MARRIOTTSVILLE ROAD TO BALTIMORE COUNTY LINE	24	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0146	1	HO1375177	77	I70 WB	MARRIOTTSVILLE ROAD TO BALTIMORE COUNTY LINE	25	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0146	1	HO1375177	77	I70 WB	MARRIOTTSVILLE ROAD TO BALTIMORE COUNTY LINE	27	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0146	1	HO1375177	77	I70 WB	MARRIOTTSVILLE ROAD TO BALTIMORE COUNTY LINE	5	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0146	1	HO1375177	77	I70 WB	MARRIOTTSVILLE ROAD TO BALTIMORE COUNTY LINE	6	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0146	1	HO1375177	77	I70 WB	MARRIOTTSVILLE ROAD TO BALTIMORE COUNTY LINE	7	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0146	1	HO1375177	77	I70 WB	MARRIOTTSVILLE ROAD TO BALTIMORE COUNTY LINE	26	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0147	1	AA0985174	74	MD32	At Samford Road, Drainage Remediation	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0148	1	AA1725279	79	MD214	MD 2 (SOLOMONS ISLAND ROAD) TO MD 253 (MAYO ROAD)	POI 5	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
16-PR-0148	1	AA1725279	79	MD214	MD 2 (SOLOMONS ISLAND ROAD) TO MD 253 (MAYO ROAD)	POI 6	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
16-PR-0148	1	AA1725279	79	MD214	MD 2 (SOLOMONS ISLAND ROAD) TO MD 253 (MAYO ROAD)	LOI 7	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
16-PR-0150	1	HA5215180	80	US1	Retaining Wall 12167RO, South of Conowingo Hydro Station	LOI 1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
16-PR-0151	1	PG0425177	77	MD201	DC LINE TO LAWRENCE STREET	POI 1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0151	1	PG0425177	77	MD201	DC LINE TO LAWRENCE STREET	POI 1A	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0151	1	PG0425177	77	MD201	DC LINE TO LAWRENCE STREET	POI 2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0151	1	PG0425177	77	MD201	DC LINE TO LAWRENCE STREET	POI 3	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0152	1	PG0475177	77	US1	NORTH OF ICC TO OAK STREET	POI 8	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0152	1	PG0475177	77	US1	NORTH OF ICC TO OAK STREET	POI 9	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y

FY 2017 - Waiver Summary

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Waiver	Waiver Type	Justification	Accepted	Granted
16-PR-0152	1	PG0475177	77	US1	NORTH OF ICC TO OAK STREET	POI 10	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0152	1	PG0475177	77	US1	NORTH OF ICC TO OAK STREET	POI 11	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0152	1	PG0475177	77	US1	NORTH OF ICC TO OAK STREET	POI 12	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0152	1	PG0475177	77	US1	NORTH OF ICC TO OAK STREET	LOI 1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0152	1	PG0475177	77	US1	NORTH OF ICC TO OAK STREET	LOI 2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0152	1	PG0475177	77	US1	NORTH OF ICC TO OAK STREET	POI 1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0152	1	PG0475177	77	US1	NORTH OF ICC TO OAK STREET	POI 2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0152	1	PG0475177	77	US1	NORTH OF ICC TO OAK STREET	POI 3	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0152	1	PG0475177	77	US1	NORTH OF ICC TO OAK STREET	POI 4	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0152	1	PG0475177	77	US1	NORTH OF ICC TO OAK STREET	POI 5	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0152	1	PG0475177	77	US1	NORTH OF ICC TO OAK STREET	POI 6	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0152	1	PG0475177	77	US1	NORTH OF ICC TO OAK STREET	POI 7	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0153	1	AA4115177	77	US50	SEVERN RIVER BRIDGE TO END SHA MAINTENANCE	LOI 1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0153	1	AA4115177	77	US50	SEVERN RIVER BRIDGE TO END SHA MAINTENANCE	LOI 2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0153	1	AA4115177	77	US50	SEVERN RIVER BRIDGE TO END SHA MAINTENANCE	LOI 6	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0153	1	AA4115177	77	US50	SEVERN RIVER BRIDGE TO END SHA MAINTENANCE	POI 1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0153	1	AA4115177	77	US50	SEVERN RIVER BRIDGE TO END SHA MAINTENANCE	POI 3	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0153	1	AA4115177	77	US50	SEVERN RIVER BRIDGE TO END SHA MAINTENANCE	POI 4	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0153	1	AA4115177	77	US50	SEVERN RIVER BRIDGE TO END SHA MAINTENANCE	POI 5	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0153	1	AA4115177	77	US50	SEVERN RIVER BRIDGE TO END SHA MAINTENANCE	POI 8	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y

FY 2017 - Waiver Summary

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Waiver	Waiver Type	Justification	Accepted	Granted
16-PR-0153	1	AA4115177	77	US50	SEVERN RIVER BRIDGE TO END SHA MAINTENANCE	POI 10	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0153	1	AA4115177	77	US50	SEVERN RIVER BRIDGE TO END SHA MAINTENANCE	POI 11	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0153	1	AA4115177	77	US50	SEVERN RIVER BRIDGE TO END SHA MAINTENANCE	POI 12	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0153	1	AA4115177	77	US50	SEVERN RIVER BRIDGE TO END SHA MAINTENANCE	POI 13	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0153	1	AA4115177	77	US50	SEVERN RIVER BRIDGE TO END SHA MAINTENANCE	POI 14	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0153	1	AA4115177	77	US50	SEVERN RIVER BRIDGE TO END SHA MAINTENANCE	POI 16	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
16-PR-0153	1	AA4115177	77	US50	SEVERN RIVER BRIDGE TO END SHA MAINTENANCE	POI 17	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
17-PR-0001	1	TA2735179	79	MD565	HOMERUNBAKER PARK TO WHITE MARSH ROAD	4B	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
17-PR-0001	1	TA2735179	79	MD565	HOMERUNBAKER PARK TO WHITE MARSH ROAD	2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0006	1	SO2125180	80	MD364	BRIDGE 1901000 OVER DIVIDING CREEK	3	3.3.B.1.a	No Adverse Impact, Discharge to tidal (Quant)	Stable outfall, Direct discharge to tidal waters	Y	
17-PR-0006	1	SO2125180	80	MD364	BRIDGE 1901000 OVER DIVIDING CREEK	4	3.3.B.1.a	No Adverse Impact, Discharge to tidal (Quant)	Stable outfall, Direct discharge to tidal waters	Y	
17-PR-0008	1	FR6725130	30	MD355	1000 SOUTH OF DOCTOR PERRY ROAD/BIG WOODS ROAD TO 1000 NORTH	2	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
17-PR-0008	1	FR6725130	30	MD355	1000 SOUTH OF DOCTOR PERRY ROAD/BIG WOODS ROAD TO 1000 NORTH	6	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
17-PR-0009	0	MO1685187	87	MD97	IHB - AT MD 28 (Formerly 15-SF-0100, CA)	4	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence received	Y	Y
17-PR-0010	1	HO1525180	80	US40 WB	BRIDGE 13055 OVER I-70	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0010	1	HO1525180	80	US40 WB	BRIDGE 13055 OVER I-70	2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0010	1	HO1525180	80	US40 WB	BRIDGE 13055 OVER I-70	3	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0015	0	BA1055277	77	US1	Formerly 15-SF-0037, CA Howard / Baltimore County line to 550 feet South of CSX Railroad Tracks	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change		Y
17-PR-0016	1	AW730A21	74	MD225	Formerly MDE No. 12-SF-0298, No CA. Streambank Stabilization	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
17-PR-0017	1	PG8315182	82	N/A	AT VARIOUS LOCATIONS IN PRINCE GEORGE'S COUNTY - GROUP 1	583 - POI 6	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	

FY 2017 - Waiver Summary

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Waiver	Waiver Type	Justification	Accepted	Granted
17-PR-0017	1	PG8315182	82	N/A	AT VARIOUS LOCATIONS IN PRINCE GEORGE'S COUNTY - GROUP 1	584/585 - POI 7	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0017	1	PG8315182	82	N/A	AT VARIOUS LOCATIONS IN PRINCE GEORGE'S COUNTY - GROUP 1	594 - POI 4	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0017	1	PG8315182	82	N/A	AT VARIOUS LOCATIONS IN PRINCE GEORGE'S COUNTY - GROUP 1	602 - POI 1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0017	1	PG8315182	82	N/A	AT VARIOUS LOCATIONS IN PRINCE GEORGE'S COUNTY - GROUP 1	648 - POI 1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0017	1	PG8315182	82	N/A	AT VARIOUS LOCATIONS IN PRINCE GEORGE'S COUNTY - GROUP 1	998/999 - POI 5	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0017	1	PG8315182	82	N/A	AT VARIOUS LOCATIONS IN PRINCE GEORGE'S COUNTY - GROUP 1	989 - POI 1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0017	1	PG8315182	82	N/A	AT VARIOUS LOCATIONS IN PRINCE GEORGE'S COUNTY - GROUP 1	039 - POI 1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0017	1	PG8315182	82	N/A	AT VARIOUS LOCATIONS IN PRINCE GEORGE'S COUNTY - GROUP 1	065/066 - POI 1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0018	0	CL4515130	30	MD482	Formerly MDE No. 13-SF-0045. Gorsuch Road and Cape Horn Road	POI 600-1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
17-PR-0019	1	FR6795177	77	I70	EAST OF MD 75 TO STRUCTURE 10183 OVER MONOCACY RIVER	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0019	1	FR6795177	77	I70	EAST OF MD 75 TO STRUCTURE 10183 OVER MONOCACY RIVER	2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0021	1	BA2015782	82	MD145	LITTLE GUNPOWDER FALLS TRIBUTARY AT MD 145 & MD 165 - STREAM RESTORATION	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0024	1	FR6715182	82	MD550	ISRAEL CREEK AT MD 550	4	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0027	1	BA0145180	80	I695	BRIDGE 0312400 OVER US 40	2A	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0027	1	BA0145180	80	I695	BRIDGE 0312400 OVER US 40	3	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0029	1	HA5015187	87	MD24	AT MD 755	1	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence received	Y	
17-PR-0029	1	HA5015187	87	MD24	AT MD 755	2	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence received	Y	
17-PR-0030	1	AL2975180	80	MD36	IHB - BRIDGE 0100800 OVER JENNINGS RUN	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0030	1	AL2975180	80	MD36	IHB - BRIDGE 0100800 OVER JENNINGS RUN	2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0030	1	AL2975180	80	MD36	IHB - BRIDGE 0100800 OVER JENNINGS RUN	4	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	

FY 2017 - Waiver Summary

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Waiver	Waiver Type	Justification	Accepted	Granted
17-PR-0030	1	AL2975180	80	MD36	IHB - BRIDGE 0100800 OVER JENNINGS RUN	6	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0030	1	AL2975180	80	MD36	IHB - BRIDGE 0100800 OVER JENNINGS RUN	7	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0031	1	XX1665180	80	US50	EMERGENCY REPLACEMENT OF STRUCTURE 20032XO OVER A BRANCH OF MILES CREEK	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
17-PR-0032	0	PG6245171	71	MD924	IHB - COLLEGE AVENUE/REGENTS DRIVE TO MD 193 (UNIVERSITY BOULEVARD)	2	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
17-PR-0032	0	PG6245171	71	MD924	IHB - COLLEGE AVENUE/REGENTS DRIVE TO MD 193 (UNIVERSITY BOULEVARD)	4	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
17-PR-0032	0	PG6245171	71	MD924	IHB - COLLEGE AVENUE/REGENTS DRIVE TO MD 193 (UNIVERSITY BOULEVARD)	14	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
17-PR-0034	1	AX7440280	80	MD309	SMALL STRUCTURE REPLACEMENTS	17085X0	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0034	1	AX7440280	80	MD309	SMALL STRUCTURE REPLACEMENTS	17075X0	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0034	1	AX7440280	80	MD309	SMALL STRUCTURE REPLACEMENTS	17077X0	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0034	1	AX7440280	80	MD309	SMALL STRUCTURE REPLACEMENTS	17080X0	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0034	1	AX7440280	80	MD309	SMALL STRUCTURE REPLACEMENTS	17081X0	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0036	1	MO5365187	87	MD355	IHB - AT WEST OLD BALTIMORE ROAD	POI 1	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
17-PR-0036	1	MO5365187	87	MD355	IHB - AT WEST OLD BALTIMORE ROAD	LOI 3	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
17-PR-0037	1	BA1465176	76	MD147	AT JOPPA ROAD	Vault	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
17-PR-0047	1	BA0505180	80	I695	BRIDGE 0324800 OVER MD 695	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0047	1	BA0505180	80	I695	BRIDGE 0324800 OVER MD 695	2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0047	1	BA0505180	80	I695	BRIDGE 0324800 OVER MD 695	3	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0051	1	WO1655180	80	US13	BRIDGE 2301601 AND 2301602 ON US 13 OVER POCOMOKE RIVER	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
17-PR-0052	1	KE2335180	80	MD298	STRUCTURE 14074X0 OVER BRANCH OF FAIRLEE LAKE	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0053	1	AA1245180	80	MD468	STRUCTURE 02016X0 OVER LERCH CREEK	POI 100	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	

FY 2017 - Waiver Summary

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Waiver	Waiver Type	Justification	Accepted	Granted
17-PR-0053	1	AA1245180	80	MD468	STRUCTURE 02016X0 OVER LERCH CREEK	LOI 200	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0054	1	PG5725280	80	CO123	BRIDGE 1616600 OVER I-95/495	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0054	1	PG5725280	80	CO123	BRIDGE 1616600 OVER I-95/495	2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0054	1	PG5725280	80	CO123	BRIDGE 1616600 OVER I-95/495	3	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0054	1	PG5725280	80	CO123	BRIDGE 1616600 OVER I-95/495	4	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0056	2	XX5355233	33	MD331	AT VARIOUS LOCATIONS IN DISTRICT 2	4	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
17-PR-0056	1	XX5355233	33	MD331	AT VARIOUS LOCATIONS IN DISTRICT 2	POI 1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0056	1	XX5355233	33	MD331	AT VARIOUS LOCATIONS IN DISTRICT 2	POI 2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0056	1	XX5355233	33	MD331	AT VARIOUS LOCATIONS IN DISTRICT 2	POI 3	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0056	1	XX5355233	33	MD331	AT VARIOUS LOCATIONS IN DISTRICT 2	POI 4	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0056	1	XX5355233	33	MD331	AT VARIOUS LOCATIONS IN DISTRICT 2	POI 5	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0056	1	XX5355233	33	MD331	AT VARIOUS LOCATIONS IN DISTRICT 2	LOI 6	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0056	1	XX5355233	33	MD331	AT VARIOUS LOCATIONS IN DISTRICT 2	LOI 7	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0056	1	XX5355233	33	MD331	AT VARIOUS LOCATIONS IN DISTRICT 2	LOI 8	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0056	1	XX5355233	33	MD331	AT VARIOUS LOCATIONS IN DISTRICT 2	LOI 9	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0056	2	XX5355233	33	MD331	AT VARIOUS LOCATIONS IN DISTRICT 2	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0056	2	XX5355233	33	MD331	AT VARIOUS LOCATIONS IN DISTRICT 2	2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0056	2	XX5355233	33	MD331	AT VARIOUS LOCATIONS IN DISTRICT 2	3	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0056	2	XX5355233	33	MD331	AT VARIOUS LOCATIONS IN DISTRICT 2	4	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0056	2	XX5355233	33	MD331	AT VARIOUS LOCATIONS IN DISTRICT 2	5	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	

FY 2017 - Waiver Summary

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Waiver	Waiver Type	Justification	Accepted	Granted
17-PR-0056	2	XX5355233	33	MD331	AT VARIOUS LOCATIONS IN DISTRICT 2	6	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0056	2	XX5355233	33	MD331	AT VARIOUS LOCATIONS IN DISTRICT 2	7	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0056	2	XX5355233	33	MD331	AT VARIOUS LOCATIONS IN DISTRICT 2	8	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0063	1	NA	14	N/A	LaPlata Training Sit	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0063	1	NA	14	N/A	LaPlata Training Sit	2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0065	4	XX5345133	33	MD450	ADA SIDEWALKS IN DISTRICT 5	2	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
17-PR-0065	4	XX5345133	33	MD450	ADA SIDEWALKS IN DISTRICT 5	4	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
17-PR-0065	4	XX5345133	33	MD450	ADA SIDEWALKS IN DISTRICT 5	3	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0065	4	XX5345133	33	MD450	ADA SIDEWALKS IN DISTRICT 5	5	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0065	4	XX5345133	33	MD450	ADA SIDEWALKS IN DISTRICT 5	6	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0065	4	XX5345133	33	MD450	ADA SIDEWALKS IN DISTRICT 5	7	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0065	4	XX5345133	33	MD450	ADA SIDEWALKS IN DISTRICT 5	9	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0065	5	XX5345133	33	MD435	ADA SIDEWALKS IN DISTRICT 5	LOI 1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0065	5	XX5345133	33	MD435	ADA SIDEWALKS IN DISTRICT 5	POI 4	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0065	1	XX5345133	33	MD253	ADA SIDEWALKS IN DISTRICT 5	POI 1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0065	1	XX5345133	33	MD253	ADA SIDEWALKS IN DISTRICT 5	POI 3	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0065	1	XX5345133	33	MD253	ADA SIDEWALKS IN DISTRICT 5	POI 4	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0065	1	XX5345133	33	MD253	ADA SIDEWALKS IN DISTRICT 5	LOI 6	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0065	1	XX5345133	33	MD253	ADA SIDEWALKS IN DISTRICT 5	POI 7	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0065	1	XX5345133	33	MD253	ADA SIDEWALKS IN DISTRICT 5	POI 9	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	

FY 2017 - Waiver Summary

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Waiver	Waiver Type	Justification	Accepted	Granted
17-PR-0065	1	XX5345133	33	MD253	ADA SIDEWALKS IN DISTRICT 5	POI 10	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0065	1	XX5345133	33	MD253	ADA SIDEWALKS IN DISTRICT 5	POI 11	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0065	1	XX5345133	33	MD253	ADA SIDEWALKS IN DISTRICT 5	POI 12	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0065	1	XX5345133	33	MD253	ADA SIDEWALKS IN DISTRICT 5	POI 13	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0065	1	XX5345133	33	MD253	ADA SIDEWALKS IN DISTRICT 5	POI 14	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0065	1	XX5345133	33	MD253	ADA SIDEWALKS IN DISTRICT 5	POI 15	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0065	1	XX5345133	33	MD253	ADA SIDEWALKS IN DISTRICT 5	POI 16	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0065	1	XX5345133	33	MD253	ADA SIDEWALKS IN DISTRICT 5	LOI 17	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0065	1	XX5345133	33	MD253	ADA SIDEWALKS IN DISTRICT 5	POI 18	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0065	1	XX5345133	33	MD253	ADA SIDEWALKS IN DISTRICT 5	POI 19	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0065	1	XX5345133	33	MD253	ADA SIDEWALKS IN DISTRICT 5	POI 20	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0065	1	XX5345133	33	MD253	ADA SIDEWALKS IN DISTRICT 5	POI 21	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0065	1	XX5345133	33	MD253	ADA SIDEWALKS IN DISTRICT 5	POI 22	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0065	4	XX5345133	33	MD450	ADA SIDEWALKS IN DISTRICT 5	10	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
17-PR-0065	5	XX5345133	33	MD435	ADA SIDEWALKS IN DISTRICT 5	LOI 2	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
17-PR-0065	5	XX5345133	33	MD435	ADA SIDEWALKS IN DISTRICT 5	POI 3	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
17-PR-0065	1	XX5345133	33	MD253	ADA SIDEWALKS IN DISTRICT 5	POI 5	3.3.B.3	No Adverse Impact, No Historical flooding… (Quant)	Stable outfall, No downstream flooding, county concurrence requested	Y	
17-PR-0070	1	TBD	74	I95	CULVERT DEBRIS REMOVAL AND SLOPE REPAIR	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0077	1	GA1545177	77	Varies	FRIENDSVILLE GRANTSVILLE AND ACCIDENT	G1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0077	1	GA1545177	77	Varies	FRIENDSVILLE GRANTSVILLE AND ACCIDENT	G2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Waiver	Waiver Type	Justification	Accepted	Granted
17-PR-0077	1	GA1545177	77	Varies	FRIENDSVILLE GRANTSVILLE AND ACCIDENT	G3	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0077	1	GA1545177	77	Varies	FRIENDSVILLE GRANTSVILLE AND ACCIDENT	G4	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0077	1	GA1545177	77	Varies	FRIENDSVILLE GRANTSVILLE AND ACCIDENT	G5	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0077	1	GA1545177	77	Varies	FRIENDSVILLE GRANTSVILLE AND ACCIDENT	G6	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0077	1	GA1545177	77	Varies	FRIENDSVILLE GRANTSVILLE AND ACCIDENT	G7	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0077	1	GA1545177	77	Varies	FRIENDSVILLE GRANTSVILLE AND ACCIDENT	G8	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0077	1	GA1545177	77	Varies	FRIENDSVILLE GRANTSVILLE AND ACCIDENT	G9	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0077	1	GA1545177	77	Varies	FRIENDSVILLE GRANTSVILLE AND ACCIDENT	G10	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0077	1	GA1545177	77	Varies	FRIENDSVILLE GRANTSVILLE AND ACCIDENT	A1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0077	1	GA1545177	77	Varies	FRIENDSVILLE GRANTSVILLE AND ACCIDENT	A2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0077	1	GA1545177	77	Varies	FRIENDSVILLE GRANTSVILLE AND ACCIDENT	F1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0077	1	GA1545177	77	Varies	FRIENDSVILLE GRANTSVILLE AND ACCIDENT	F2	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0077	1	GA1545177	77	Varies	FRIENDSVILLE GRANTSVILLE AND ACCIDENT	F3	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0077	1	GA1545177	77	Varies	FRIENDSVILLE GRANTSVILLE AND ACCIDENT	F4	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0077	1	GA1545177	77	Varies	FRIENDSVILLE GRANTSVILLE AND ACCIDENT	F5	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0077	1	GA1545177	77	Varies	FRIENDSVILLE GRANTSVILLE AND ACCIDENT	F6	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0077	1	GA1545177	77	Varies	FRIENDSVILLE GRANTSVILLE AND ACCIDENT	F7	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0077	1	GA1545177	77	Varies	FRIENDSVILLE GRANTSVILLE AND ACCIDENT	F8	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0077	1	GA1545177	77	Varies	FRIENDSVILLE GRANTSVILLE AND ACCIDENT	F9	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0077	1	GA1545177	77	Varies	FRIENDSVILLE GRANTSVILLE AND ACCIDENT	F10	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	

FY 2017 - Waiver Summary

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Waiver	Waiver Type	Justification	Accepted	Granted
17-PR-0078	1	TBD	74	N/A	EMERGENCY DRAINAGE REPAIR NEAR MD 336	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0079	1	AX1675174	74	MD382	SLOPE AND DRAINAGE REPAIR AT TANYARD ROAD	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0081	1	NA-District Effort	14	MD144	Re-Establish Ditches	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	Y
17-PR-0084	1	BA0485180	80	US1	BRIDGE 0300300 OVER GUNPOWDER FALLS	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	
17-PR-0094	1	AX081	81	MD140	Enbankment and Slope Repair	1	3.3.A	Return to Existing Conditions (Qual & Quant)	Stable outfall, Returned to existing condition, no hydrologic change	Y	

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Variance	Variance Type	ΔAi	ΔQ1	ESDv Shortfall	Stable Outfall	Variance Justification	Notes	Accepted	Granted
15-PR-0023	1	AA4365471	71	MD175	West Of Reece Road To East Of Disney Road	POI 3	4.1.A.1	NewDev Treatment	6.91	-1.8	30740	Y	Utility conflicts, Existing groundwater, Topography	Use of a Chapter 3 Facility	Y	Y
15-PR-0023	1	AA4365471	71	MD175	West Of Reece Road To East Of Disney Road	POI 4	4.1.A.1	NewDev Treatment	0.44	-1.5	8766	Y	Agreement with Ft. Meade re: location of fencing, Steep slopes	Use of a Chapter 3 Facility	Y	Y
15-PR-0023	1	AA4365471	71	MD175	West Of Reece Road To East Of Disney Road	POI 5	4.1.A.1	NewDev Treatment	-1.93	-7.15	744	Y	Agreement with Ft. Meade re: location of fencing		Y	Y
15-PR-0027	1	CL3045130	30	MD26	At Oakland Mills Road	POI 2 / LOI 2C	4.1.A.1	NewDev Treatment	0.06	-0.02	628	Y	Steep Slope, Limited ROW		Y	Y
15-PR-0027	1	CL3045130	30	MD26	At Oakland Mills Road	POI 4	4.1.A.1	NewDev Treatment	-0.04	-1.04	359	Y	Steep Slope, Limited ROW		Y	Y
15-PR-0042	1	WA1065184	84	MD845A	South Corporate Limits Of Keedysville To North Corporate Town Limits	8	4.1.A.1	NewDev Treatment	0.18	0.4	1600	Y	Outfall At River, Highly Urbanized, Limited ROW, Karst		Y	
15-PR-0042	1	WA1065184	84	MD845A	South Corporate Limits Of Keedysville To North Corporate Town Limits	LOI 1	4.1.A.1	NewDev Treatment	0.01	0.02	72	Y	Steep Slopes, Limited ROW, Bed Rock		Y	
15-PR-0056	1	SM2025171	71	MD5	IHB - At Abell/Moakley (Phase 1)	2	4.1.A.1	NewDev Treatment	0.04	-0.1	395	Y	Limited ROW, Utility Conflicts		Y	
15-PR-0057	1	AA1805179	79	MD424	Duke Of Kent Drive To MD 450 (Defense Highway) - Phase 3	LOI 1	4.1.A.1	NewDev Treatment	0.12	0.09	633	Y	Limited ROW, Existing Topography		Y	
15-PR-0057	1	AA1805179	79	MD424	Duke Of Kent Drive To MD 450 (Defense Highway) - Phase 4	POI 3	4.1.A.1	NewDev Treatment	0.35	0	3627	Y	Limited ROW, Existing Topography		Y	
15-PR-0057	1	AA1805179	79	MD424	Duke Of Kent Drive To MD 450 (Defense Highway) - Phase 2	POI 5	4.1.A.1	NewDev Treatment	0.13	0	1130	Y	Limited ROW, Existing Topography		Y	
15-PR-0064	3	XX1645176	76	MD214	MD 214 Site 3: Madison Rd Metro Entrance Intersection Improvements	1	4.1.A.1	NewDev Treatment	-0.05	0	3	Y	Limited ROW, Highly Urbanized, Underground Utilities		Y	Y
15-PR-0071	1	PG0835130	30	MD3	IHB - At Forest Drive	LOI 2	4.1.A.1	NewDev Treatment	0	0	90	Y	Steep Slope, Limited ROW, Utility Conflicts		Y	
15-PR-0071	1	PG0835130	30	MD3	IHB - At Forest Drive	LOI 3	4.1.A.1	NewDev Treatment	0.06	0.1	628	Y	Limited ROW, Utility Conflicts		Y	
15-PR-0075	1	AA1945130	30	MD174	1000 Ft South To 700 Ft North Of Severn Road	LOI 4	4.1.A.1	NewDev Treatment	0.1	0.22	935	Y	Limited ROW		Y	

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Variance	Variance Type	ΔAi	ΔQ1	ESDv Shortfall	Stable Outfall	Variance Justification	Notes	Accepted	Granted
15-PR-0075	1	AA1945130	30	MD174	1000 Ft South To 700 Ft North Of Severn Road	POI 5	4.1.A.1	NewDev Treatment	0.03	0	347	Y	Limited ROW		Y	
15-PR-0075	1	AA1945130	30	MD174	1000 Ft South To 700 Ft North Of Severn Road	POI 6	4.1.A.1	NewDev Treatment	0.08	0	733	Y	Limited ROW		Y	
15-PR-0078	1	FR5365180	80	MD140	Bridge 1006200 Replacement Over Flat Run	1	4.1.A.1	NewDev Treatment	0.12	4.03	1019	Y	Limited ROW	Increase from diversion of offsite at POI 1	Y	Y
15-PR-0078	1	FR5365180	80	MD140	Bridge 1006200 Replacement Over Flat Run	3	4.1.A.1	NewDev Treatment	0.05	0.57	1573	Y	Limited ROW, Wetlands	Outfalls directly to stream	Y	Y
15-PR-0079	1	AL2665130	30	MD935	IHB - At Railroad Street Or Intersection Improvement At S. Railroad Street	1-P	4.1.A.1	NewDev Treatment	1.88	2.54	16888	Y	Site constraints, env impacts, utilities, Limited ROW, property impacts	Outfall not found. Drains to George's creek	Y	Y
15-PR-0108	1	XX3145133	33	MD26	Site 1 Frenbrook Drive To North Rolling Road	POI 1	4.1.A.1	NewDev Treatment	0.04	0	314	Y	Limited ROW		Y	
15-PR-0108	1	XX3145133	33	MD26	Site 1 Frenbrook Drive To North Rolling Road	POI 2	4.1.A.1	NewDev Treatment	0.03	0	269	Y	Limited ROW		Y	
15-PR-0108	1	XX3145133	33	MD26	Site 1 Frenbrook Drive To North Rolling Road	POI 3	4.1.A.1	NewDev Treatment	0.03	0	287	Y	Limited ROW		Y	
15-PR-0108	1	XX3145133	33	MD26	Site 1 Frenbrook Drive To North Rolling Road	POI 4	4.1.A.1	NewDev Treatment	0.06	0	511	Y	Limited ROW		Y	
15-PR-0108	3	XX3145133	33	MD542	Site 3 Loch Hill Road To Yakona Road	2	4.1.A.1	NewDev Treatment	0.01	0.01		Y	Limited ROW	ADA sidewalk upgrade, ESDv not computed	Y	
15-PR-0108	3	XX3145133	33	MD542	Site 3 Loch Hill Road To Yakona Road	4	4.1.A.1	NewDev Treatment	0.06	0.1		Y	Limited ROW	ADA sidewalk upgrade, ESDv not computed	Y	
15-PR-0108	3	XX3145133	33	MD542	Site 3 Loch Hill Road To Yakona Road	6	4.1.A.1	NewDev Treatment	0.02	0.06		Y	Limited ROW	ADA sidewalk upgrade, ESDv not computed	Y	
15-PR-0108	4	XX3145133	33	MD26	Site 4 Rolling Road To I-695	2	4.1.A.1	NewDev Treatment	0.03	0	207		No Downstream Impacts	Outfall not located	Y	
15-PR-0108	4	XX3145133	33	MD26	Site 4 Rolling Road To I-695	3	4.1.A.1	NewDev Treatment	0.02	0	145	Y	No Downstream Impacts		Y	
15-PR-0108	4	XX3145133	33	MD26	Site 4 Rolling Road To I-695	4	4.1.A.1	NewDev Treatment	0.02	0	139	Y	No Downstream Impacts		Y	

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Variance	Variance Type	ΔAi	ΔQ1	ESDv Shortfall	Stable Outfall	Variance Justification	Notes	Accepted	Granted
15-PR-0108	5	XX3145133	33	MD26	Site 5 Deer Park Road To Pikeswood Drive	1	4.1.A.1	NewDev Treatment	0.01	0	69	Y	Limited Disturbance Area; No Advers Impacts		Y	
15-PR-0108	5	XX3145133	33	MD26	Site 5 Deer Park Road To Pikeswood Drive	2	4.1.A.1	NewDev Treatment	0.03	0.05	207	Y	Limited Disturbance Area; No Advers Impacts		Y	
15-PR-0108	5	XX3145133	33	MD26	Site 5 Deer Park Road To Pikeswood Drive	3	4.1.A.1	NewDev Treatment	0.11	0.18	897	Y	Limited Disturbance Area; No Advers Impacts		Y	
15-PR-0108	5	XX3145133	33	MD26	Site 5 Deer Park Road To Pikeswood Drive	4	4.1.A.1	NewDev Treatment	0.02	0.03	172	Y	Limited Disturbance Area; No Advers Impacts		Y	
15-PR-0108	5	XX3145133	33	MD26	Site 5 Deer Park Road To Pikeswood Drive	6	4.1.A.1	NewDev Treatment	0.01	0.01	103	Y	Limited Disturbance Area; No Advers Impacts		Y	
15-PR-0112	1	FR1715184	84	US15	US 15 BU At MD 140	1	4.1.A.1	NewDev Treatment	0.08	0	707	Y	High groundwater, topography, wetlands, floodplains, steep slopes	Variance requested for Recharge & CPv	Y	Y
15-PR-0117	1	AL4795180	80	MD51	Bridge 01092 Over CSX And Canal Parkway	1	4.1.A.1	NewDev Treatment	0.01	0.04	35	Y	Steep Slope, Limited ROW	Outfalls directly to stream	Y	
15-PR-0117	1	AL4795180	80	MD51	Bridge 01092 Over CSX And Canal Parkway	2	4.1.A.1	NewDev Treatment	0.01	0.04	35	Y	Steep Slope, Limited ROW	Outfalls directly to stream	Y	
15-PR-0133	1	BA0805180	80	MD137	IHB - Bridge 03050 Over I-83	4	4.1.A.1	NewDev Treatment	-0.22	-0.64	180	Y	Steep Slope, Reduction In Impervious Surface		Y	Y
16-PR-0029	1	FR5595180	80	MD355	IHB - Bridge 1008400 Over CSX	101	4.1.A.1	NewDev Treatment	0.42	0	0	Y	Karst	Recharge Variance	Y	Y
16-PR-0029	1	FR5595180	80	MD355	IHB - Bridge 1008400 Over CSX	103	4.1.A.1	NewDev Treatment	0.01	0	0	Y	Karst	Recharge Variance	Y	Y
16-PR-0029	1	FR5595180	80	MD355	IHB - Bridge 1008400 Over CSX	104	4.1.A.1	NewDev Treatment	-0.02	-0.35	0	Y	Karst	Recharge Variance	Y	Y
16-PR-0029	1	FR5595180	80	MD355	IHB - Bridge 1008400 Over CSX	105	4.1.A.1	NewDev Treatment	0.26	-0.37	0	Y	Karst	Recharge Variance	Y	Y
16-PR-0029	1	FR5595180	80	MD355	IHB - Bridge 1008400 Over CSX	LOI 101B	4.1.A.1	NewDev Treatment	-0.09	0	34	Y	Karst	Recharge Variance	Y	Y
16-PR-0040	1	CL2145187	87	MD97	South Of Airport Drive To Pleasant Valley Road	2	4.1.A.1	NewDev Treatment	0.01	0.05	148	Y	Adequate Capacity, County Concurrence Received, Limited ROW, Management Downstream	Downstream County pond has excess Cpv Storage	Y	Y

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Variance	Variance Type	ΔAi	ΔQ1	ESDv Shortfall	Stable Outfall	Variance Justification	Notes	Accepted	Granted
16-PR-0040	1	CL2145187	87	MD97	South Of Airport Drive To Pleasant Valley Road	3	4.1.A.1	NewDev Treatment	0.71	-0.6	2477	Y	Adequate Capacity, County Concurrence Received, Limited ROW, Management Downstream	Downstream County pond has excess Cpv Storage	Y	Y
16-PR-0040	1	CL2145187	87	MD97	South Of Airport Drive To Pleasant Valley Road	5	4.1.A.1	NewDev Treatment	0.06	0.06	588	Y	Adequate Capacity, County Concurrence Received, Limited ROW, Management Downstream	Downstream County pond has excess Cpv Storage	Y	Y
16-PR-0040	1	CL2145187	87	MD97	South Of Airport Drive To Pleasant Valley Road	6	4.1.A.1	NewDev Treatment	0.07	0.2	668	Y	Adequate Capacity, County Concurrence Received, Steep Slope, Limited ROW, Management Downstream	Downstream County pond has excess Cpv Storage	Y	Y
16-PR-0040	1	CL2145187	87	MD97	South Of Airport Drive To Pleasant Valley Road	8	4.1.A.1	NewDev Treatment	0.02	0.09	227	Y	Adequate Capacity, County Concurrence Received, Steep Slope, Management Downstream	Downstream County pond has excess Cpv Storage	Y	Y
16-PR-0040	1	CL2145187	87	MD97	South Of Airport Drive To Pleasant Valley Road	LOI 7	4.1.A.1	NewDev Treatment	0.18	0.58	1713	Y	Adequate Capacity, County Concurrence Received, Steep Slope, Limited ROW, Management Downstream	Downstream County pond has excess Cpv Storage	Y	Y
16-PR-0041	1	GA1975180	80	MD39	IHB - Bridge 1100200 Over Youghiogheny River	1	4.1.A.4	NewDev Quantity Control	-0.2		0	Y	Steep Slope, Limited ROW	Qp10 Variance - will be replaced with waiver	Y	
16-PR-0041	1	GA1975180	80	MD39	IHB - Bridge 1100200 Over Youghiogheny River	2	4.1.A.1	NewDev Treatment	0.04		690	Y	Woods, Steep Slope, Limited ROW, Location Of 100-Year Floodplain	Qp10 Variance - will be replaced with waiver	Y	
16-PR-0041	1	GA1975180	80	MD39	IHB - Bridge 1100200 Over Youghiogheny River	3	4.1.A.1	NewDev Treatment	0.01	-0.03	1079	Y	Woods, Steep Slope, Limited ROW, Location Of 100-Year Floodplain, Wetlands		Y	
16-PR-0041	1	GA1975180	80	MD39	IHB - Bridge 1100200 Over Youghiogheny River	4	4.1.A.4	NewDev Quantity Control	0.15		0	Y	Limited ROW, Location Of 100-Year Floodplain	Qp10 Variance - will be replaced with waiver	Y	
16-PR-0043	1	CL4035180	80	MD496	IHB - Bridge 0603800 Over Big Pipe Creek	1	4.1.A.1	NewDev Treatment	0.06	0	870	Y	Steep Slope, Limited ROW, Wetlands	Outfalls directly to stream	Y	Y
16-PR-0044	1	CE2925130	30	MD213	IHB - At Frenchtown Road	3	4.1.A.1	NewDev Treatment	0.2	0.78	1264	Y	Limited ROW		Y	
16-PR-0044	1	CE2925130	30	MD213	IHB - At Frenchtown Road	4	4.1.A.1	NewDev Treatment	0.01	-1.39	276	Y	Steep Slope, Limited ROW		Y	
16-PR-0044	1	CE2925130	30	MD213	IHB - At Frenchtown Road	7	4.1.A.1	NewDev Treatment	0.26	0.29	1211	Y	Limited ROW		Y	
16-PR-0048	1	FR1115279	79	MD464	MD 17 To 9th Avenue	7	4.1.A.1	NewDev Treatment	0	0	90	Y	Steep Slope, Highly Urbanized, Potential Hotspot		Y	
16-PR-0048	1	FR1115279	79	MD464	MD 17 To 9th Avenue	8	4.1.A.1	NewDev Treatment	0.06	0	538	Y	Steep Slope, Highly Urbanized, Septic Field		Y	

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Variance	Variance Type	ΔAi	ΔQ1	ESDv Shortfall	Stable Outfall	Variance Justification	Notes	Accepted	Granted
16-PR-0050	1	SM7745171	71	MD5	IHB - The Causeway To South Of Camp BROWn Road	2	4.1.A.1	NewDev Treatment	0.28	0	655	Y	Wetland Impacts, Tidal Waters		Y	
16-PR-0063	1	MO5245129	29	MD185	Connecticut Avenue - Salt Barn Replacement	Slip Ramp 2	4.1.A.1	NewDev Treatment	0.01	0	78	Y	Steep Slopes, Limited ROW		Y	Y
16-PR-0068	7	XY2425377	77	MD410	50' East Of S. Boston Ave To 50' West Of Park Ave	1	4.1.A.1	NewDev Treatment	0.01	0	134	Y	Limited ROW		Y	
16-PR-0068	9	XY2425377	77	MD191	MD 191, Mcclean Drive To West Avenue	LOI 4	4.1.A.1	NewDev Treatment	0.02	0	139	Y	Limited ROW		Y	
16-PR-0068	9	XY2425377	77	MD191	MD 191, Mcclean Drive To West Avenue	POI 6	4.1.A.1	NewDev Treatment	0.01	0	69	Y	Limited ROW		Y	
16-PR-0069	1	GA6715184	84	US219	MD 135 To 325 Feet North Of East Orchid Street	3	4.1.A.1	NewDev Treatment	0.05	0	986	Y	Highly Urbanized, Historic Area		Y	
16-PR-0077	1	FR1625177	77	MD26	West South Street To MD 31	1	4.1.A.1	NewDev Treatment	0.01	0	83	Y	Steep Slope, Limited ROW		Y	Y
16-PR-0077	1	FR1625177	77	MD26	West South Street To MD 32	3	4.1.A.1	NewDev Treatment	0.04	0.09	303	Y	Limited ROW		Y	Y
16-PR-0079	1	AA2315176	76	MD4	Fisher Station Road To MD 258	7	4.1.A.1	NewDev Treatment	0.21	0	1718	Y	Steep Slope, Location Of Existing Bmps		Y	
16-PR-0079	1	AA2315176	76	MD4	Fisher Station Road To MD 259	8	4.1.A.1	NewDev Treatment	0.01	0	164	Y	Woods, Steep Slope		Y	
16-PR-0084	1	FR6785171	71	MD180	West Of Swallowtail Drive To I-70 Ramp Structure 10140	POI 1	4.1.A.1	NewDev Treatment	0.01	-1.45	90	Y	Limited ROW, Impacts To Residential, Commercial, And Utilities	Drainage area shift results in Q reduction	Y	
16-PR-0084	1	FR6785171	71	MD180	West Of Swallowtail Drive To I-70 Ramp Structure 10140	POI 2	4.1.A.1	NewDev Treatment				Y	Karst	Recharge Variance. To be replaced by waiver	Y	
16-PR-0084	1	FR6785171	71	MD180	West Of Swallowtail Drive To I-70 Ramp Structure 10140	POI 3	4.1.A.1	NewDev Treatment				Y	Karst	Recharge Variance. To be replaced by waiver	Y	
16-PR-0084	1	FR6785171	71	MD180	West Of Swallowtail Drive To I-70 Ramp Structure 10140	POI 4	4.1.A.1	NewDev Treatment				Y	Karst	Recharge Variance. To be replaced by waiver	Y	
16-PR-0084	1	FR6785171	71	MD180	West Of Swallowtail Drive To I-70 Ramp Structure 10140	POI 5	4.1.A.1	NewDev Treatment				Y	Karst	Recharge Variance. To be replaced by waiver	Y	

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Variance	Variance Type	ΔAi	ΔQ1	ESDv Shortfall	Stable Outfall	Variance Justification	Notes	Accepted	Granted
16-PR-0084	1	FR6785171	71	MD180	West Of Swallowtail Drive To I-70 Ramp Structure 10140	POI 7	4.1.A.1	NewDev Treatment				Y	Karst	Recharge Variance. To be replaced by waiver	Y	
16-PR-0085	1	BA0445177	77	US1	IHB - North Of I-695 To Dunfield Road	POI 1	4.1.A.1	NewDev Treatment	0.09	0	804	Y	Limited ROW		Y	Y
16-PR-0092	1	WO2375188	88	US50	MD 611 To Bridge Over Sinepuxent Bay	POI 4	4.1.A.1	NewDev Treatment	0.04	0.22	240	Y	HSG D Soils; Wetlands; Tidally Influenced Waters	Recharge Variance	Y	
16-PR-0092	1	WO2375188	88	US50	MD 611 To Bridge Over Sinepuxent Bay	POI 5	4.1.A.1	NewDev Treatment	0.29	0.28	2200	Y	HSG D Soils; Wetlands; Tidally Influenced Waters	Recharge Variance	Y	
16-PR-0093	1	PG1275280	80	I495	Bridge 1615305 1615306 On I-495/95 Over MD 214	1	4.1.A.1	NewDev Treatment	1.72	0	12803	Y	Limited ROW	Temporary Variance	Y	
16-PR-0094	1	BA2605277	77	MD150	Back River Bridge To Riverside Drive	2	4.1.A.1	NewDev Treatment	0.04	0.15	276	Y	Highly Urbanized		Y	
16-PR-0094	1	BA2605277	77	MD150	Back River Bridge To Riverside Drive	4	4.1.A.1	NewDev Treatment	0.01	0.04	69	Y	Highly Urbanized		Y	
16-PR-0095	1	FR1945177	77	US340	IHB - Washington County Line To MD 17	3	4.1.A.1	NewDev Treatment	0.05	0	406	Y	Steep Slope, Limited ROW, Proximity To Railroad		Y	Y
16-PR-0095	1	FR1945177	77	US340	IHB - Washington County Line To MD 18	7	4.1.A.1	NewDev Treatment	0.01	0	90	Y	Woods, Steep Slope, Limited ROW		Y	Y
16-PR-0098	1	SM1925187	87	MD235	Access Road To Woodland Acres	POI 21	4.1.A.1	NewDev Treatment	-0.03		55	Y	Limited ROW	Decrease in ΔQ2	Y	
16-PR-0098	1	SM1925187	87	MD235	Access Road To Woodland Acres	POI 5	4.1.A.1	NewDev Treatment	0.02		104	Y	Woods, Steep Slope, Limited ROW, Small Lot Residential	Decrease in ΔQ2	Y	
16-PR-0099	1	FR1155130	30	MD26	At Old Annapolis Road/Water Street Road	POI 1	4.1.A.1	NewDev Treatment	0.01	-0.4	193	Y	Steep Slope, Limited ROW		Y	
16-PR-0099	1	FR1155130	30	MD26	At Old Annapolis Road/Water Street Road	POI 4	4.1.A.1	NewDev Treatment	0.01	0.11	345	Y	Steep Slope, Limited ROW		Y	
16-PR-0106	1	BA4515172	72	I795	At Dolfield Boulevard - South Of Owings Mills Boulevard To Franklin Boulevard	POI 19	4.1.A.1	NewDev Treatment	0.03	0.1	283	Y	Steep Slope, Limited ROW		Y	
16-PR-0115	1	WA2635180	80	US522	Bridge 2109000 Over I-70 Eastbound	LOI 1	4.1.A.1	NewDev Treatment	0.19	0	6276	Y	Woods, Steep Slope, Highly Urbanized, Utilities	Temporary Variance	Y	

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Variance	Variance Type	ΔAi	ΔQ1	ESDv Shortfall	Stable Outfall	Variance Justification	Notes	Accepted	Granted
16-PR-0115	1	WA2635180	80	US522	Bridge 2109000 Over I-70 Eastbound	POI 1	4.1.A.1	NewDev Treatment	0	0	986	Y	Woods, Steep Slope, Highly Urbanized, Utilities		Y	
16-PR-0127	1	BA5345180	80	US1	IHB - Bridge 0300800 Over CSX	2	4.1.A.1	NewDev Treatment	-0.05	-0.25	95	Y	Limited ROW		Y	
16-PR-0127	1	BA5345180	80	US1	IHB - Bridge 0300800 Over CSX	3	4.1.A.1	NewDev Treatment	-0.18	-0.43	651	Y	Limited ROW		Y	
16-PR-0131	1	HA5005187	87	MD543	At MD 136 (Calvary Road)	2	4.1.A.1	NewDev Treatment	-0.07		414	Y	Limited ROW	ΔQ2=-0.55	Y	
16-PR-0131	1	HA5005187	87	MD543	At MD 136 (Calvary Road)	3	4.1.A.1	NewDev Treatment	0.01		259	Y	Limited ROW	ΔQ2=-0.03	Y	
16-PR-0131	1	HA5005187	87	MD543	At MD 136 (Calvary Road)	4	4.1.A.1	NewDev Treatment	0.01		90	Y	Limited ROW, Existing Septic	ΔQ2=-0.36	Y	
16-PR-0134	1	FR1325180	80	MD355	IHB - Bridge 1008600 Over Bennett Creek	POI 3	4.1.A.1	NewDev Treatment	0	0	207	Y	Woods, Steep Slope, WUS, Wetlands		Y	
16-PR-0134	1	FR1325180	80	MD355	IHB - Bridge 1008600 Over Bennett Creek	POI T1	4.1.A.4	NewDev Quantity Control				Y	Temporary Pavement, Env'L Impacts	Temporary Variance-Qp10 0.86=ΔQ10)	Y	
16-PR-0134	1	FR1325180	80	MD355	IHB - Bridge 1008600 Over Bennett Creek	POI T1	4.1.A.1	NewDev Treatment				Y	Temporary Pavement, Env'L Impacts	Temporary Variance	Y	
16-PR-0134	1	FR1325180	80	MD355	IHB - Bridge 1008600 Over Bennett Creek	POI T2	4.1.A.4	NewDev Quantity Control				Y	Temporary Pavement, Env'L Impacts	Temporary Variance-Qp10 0.75=ΔQ10)	Y	
16-PR-0134	1	FR1325180	80	MD355	IHB - Bridge 1008600 Over Bennett Creek	POI T2	4.1.A.1	NewDev Treatment				Y	Temporary Pavement, Env'L Impacts	Temporary Variance	Y	
16-PR-0134	1	FR1325180	80	MD355	IHB - Bridge 1008600 Over Bennett Creek	POI T3	4.1.A.4	NewDev Quantity Control				Y	Temporary Pavement, Env'L Impacts	Temporary Variance-Qp10 0.95=ΔQ10)	Y	
16-PR-0134	1	FR1325180	80	MD355	IHB - Bridge 1008600 Over Bennett Creek	POI T3	4.1.A.1	NewDev Treatment				Y	Temporary Pavement, Env'L Impacts	Temporary Variance	Y	
16-PR-0146	1	HO1375177	77	I70 WB	Marriottsville Road To Baltimore County Line	10	4.1.A.1	NewDev Treatment	0.01			Y	Minimal Increase To Construct Aggregate Base For Traffic Barrier End Treatments	ΔQ1 and ESDv not computed due to minimal increase	Y	
16-PR-0146	1	HO1375177	77	I70 WB	Marriottsville Road To Baltimore County Line	11	4.1.A.1	NewDev Treatment	0.01			Y	Minimal Increase To Construct Aggregate Base For Traffic Barrier End Treatments	ΔQ1 and ESDv not computed due to minimal increase	Y	

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Variance	Variance Type	ΔAi	ΔQ1	ESDv Shortfall	Stable Outfall	Variance Justification	Notes	Accepted	Granted
16-PR-0146	1	HO1375177	77	I70 WB	Marriottsville Road To Baltimore County Line	12	4.1.A.1	NewDev Treatment	0.01			Y	Minimal Increase To Construct Aggregate Base For Traffic Barrier End Treatments	ΔQ1 and ESDv not computed due to minimal increase	Y	
16-PR-0146	1	HO1375177	77	I70 WB	Marriottsville Road To Baltimore County Line	13	4.1.A.1	NewDev Treatment	0.01			Y	Minimal Increase To Construct Aggregate Base For Traffic Barrier End Treatments	ΔQ1 and ESDv not computed due to minimal increase	Y	
16-PR-0146	1	HO1375177	77	I70 WB	Marriottsville Road To Baltimore County Line	14	4.1.A.1	NewDev Treatment	0.01			Y	Minimal Increase To Construct Aggregate Base For Traffic Barrier End Treatments	ΔQ1 and ESDv not computed due to minimal increase	Y	
16-PR-0146	1	HO1375177	77	I70 WB	Marriottsville Road To Baltimore County Line	15	4.1.A.1	NewDev Treatment	0.01			Y	Minimal Increase To Construct Aggregate Base For Traffic Barrier End Treatments	ΔQ1 and ESDv not computed due to minimal increase	Y	
16-PR-0146	1	HO1375177	77	I70 WB	Marriottsville Road To Baltimore County Line	16	4.1.A.1	NewDev Treatment	0.01			Y	Minimal Increase To Construct Aggregate Base For Traffic Barrier End Treatments	ΔQ1 and ESDv not computed due to minimal increase	Y	
16-PR-0146	1	HO1375177	77	I70 WB	Marriottsville Road To Baltimore County Line	17	4.1.A.1	NewDev Treatment	0.01			Y	Minimal Increase To Construct Aggregate Base For Traffic Barrier End Treatments	ΔQ1 and ESDv not computed due to minimal increase	Y	
16-PR-0146	1	HO1375177	77	I70 WB	Marriottsville Road To Baltimore County Line	18	4.1.A.1	NewDev Treatment	0.01			Y	Minimal Increase To Construct Aggregate Base For Traffic Barrier End Treatments	ΔQ1 and ESDv not computed due to minimal increase	Y	
16-PR-0146	1	HO1375177	77	I70 WB	Marriottsville Road To Baltimore County Line	2	4.1.A.1	NewDev Treatment	0.01			Y	Minimal Increase To Construct Aggregate Base For Traffic Barrier End Treatments	ΔQ1 and ESDv not computed due to minimal increase	Y	
16-PR-0146	1	HO1375177	77	I70 WB	Marriottsville Road To Baltimore County Line	3	4.1.A.1	NewDev Treatment	0.01			Y	Minimal Increase To Construct Aggregate Base For Traffic Barrier End Treatments	ΔQ1 and ESDv not computed due to minimal increase	Y	
16-PR-0146	1	HO1375177	77	I70 WB	Marriottsville Road To Baltimore County Line	4	4.1.A.1	NewDev Treatment	0.01			Y	Minimal Increase To Construct Aggregate Base For Traffic Barrier End Treatments	ΔQ1 and ESDv not computed due to minimal increase	Y	
16-PR-0146	1	HO1375177	77	I70 WB	Marriottsville Road To Baltimore County Line	8	4.1.A.1	NewDev Treatment	0.01			Y	Minimal Increase To Construct Aggregate Base For Traffic Barrier End Treatments	ΔQ1 and ESDv not computed due to minimal increase	Y	
16-PR-0146	1	HO1375177	77	I70 WB	Marriottsville Road To Baltimore County Line	9	4.1.A.1	NewDev Treatment	0.01			Y	Minimal Increase To Construct Aggregate Base For Traffic Barrier End Treatments	ΔQ1 and ESDv not computed due to minimal increase	Y	
16-PR-0148	1	AA1725279	79	MD214	MD 2 (Solomons Island Road) To MD 253 (Mayo Road)	LOI 7	4.1.A.1	NewDev Treatment	0.09	<0.7	572	Y	Woods, WUS, Wetlands	ΔQ2=0.7	Y	
16-PR-0148	1	AA1725279	79	MD214	MD 2 (Solomons Island Road) To MD 253 (Mayo Road)	POI 4	4.1.A.1	NewDev Treatment	0.23	0	1259	Y	Woods, WUS, Wetlands, Safety	ΔQ2=0	Y	
16-PR-0148	1	AA1725279	79	MD214	MD 2 (Solomons Island Road) To MD 253 (Mayo Road)	POI 5	4.1.A.1	NewDev Treatment	0.03	<0.3	207	Y	Woods, WUS	ΔQ2=0.3	Y	

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Variance	Variance Type	ΔAi	ΔQ1	ESDv Shortfall	Stable Outfall	Variance Justification	Notes	Accepted	Granted
16-PR-0148	1	AA1725279	79	MD214	MD 2 (Solomons Island Road) To MD 253 (Mayo Road)	POI 6	4.1.A.1	NewDev Treatment	0.02	<0.1	138	Y	Woods, WUS	ΔQ2=0.1	Y	
16-PR-0149	0	CL2255187	87	MD26	Emerald Lane To Calvert Way - Eastbound And Westbound	4	4.1.A.1	NewDev Treatment	-0.4	-0.4	269	Y	Limited ROW	MDE transfer		Y
16-PR-0151	1	PG0425177	77	MD201	DC Line To Lawrence Street	POI 1	4.1.A.1	NewDev Treatment	0.01	0	38	Y	Highly Urbanized		Y	Y
16-PR-0154	0	HO4615176	76	US29	At MD 175	500	4.1.A.1	NewDev Treatment	0.01	0	57	Y	Limited ROW	Runoff joins POI 100 w/in ROW; Cpv provided in POI 100 is	Y	Y
17-PR-0001	1	TA2735179	79	MD565	Homerunbaker Park To White Marsh Road	4B	4.1.A.1	NewDev Treatment	0.04	0.08	350	Y	Limited ROW, Highly Urbanized, Utility Impacts		Y	
17-PR-0003	1	BA1425277	77	MD140	IHB - Milford Mill Road To The Baltimore County/City Line	1	4.1.A.1	NewDev Treatment	0.01	0	69		Limited ROW, Highly Urbanized, Utilitiy Impacts	Outfall not found	Y	Y
17-PR-0003	1	BA1425277	77	MD140	IHB - Milford Mill Road To The Baltimore County/City Line	3	4.1.A.1	NewDev Treatment	0.01	0	69		Limited ROW, Highly Urbanized, Utilitiy Impacts	Outfall not found	Y	Y
17-PR-0004	0	FR3885171	71	MD85	IHB - S Of District 7 Office Entrance To N Of Spectrum Drive (Phase 1) At I-270	12	4.1.A.1	NewDev Treatment	0	-1.55	28	Y	Adjacent development, topography	MDE transfer		Y
17-PR-0008	1	FR6725130	30	MD355	1000 South Of Doctor Perry Road/Big Woods Road To 1000 North	9	4.1.A.1	NewDev Treatment	0.05	-0.11	456	Y	Steep Slope		Y	
17-PR-0009	0	MO1685187	87	MD97	IHB - At MD 28 (Formerly 15-Sf-0100, Ca)	4	4.1.A.1	NewDev Treatment	0.01	0		Y	Limited ROW	ESDv computations not provided	Y	Y
17-PR-0011	1	HA4625130	30	MD23	At Grafton Shop Road	2A	4.1.A.1	NewDev Treatment	0.01	0	33	Y	Woods, Small Lot Residential		Y	Y
17-PR-0011	1	HA4625130	30	MD23	At Grafton Shop Road	2B	4.1.A.1	NewDev Treatment	0.01	0	47	Y	Woods, Small Lot Residential		Y	Y
17-PR-0012	1	WA4435180	80	I70	Bridge 21112 On I-70/US 11 And Bridge 21113 On I-70/Norfolk Southern Railroad	7	4.1.A.1	NewDev Treatment	0	0	110	Y	No New Impervoius Area		Y	
17-PR-0014	1	BW316	87	MD231	Roadway Widening	POI 5	4.1.A.1	NewDev Treatment	0.02	0	138	Y	Limited ROW, Proximity To Existing Pond And Grass Swale		Y	
17-PR-0018	0	CL4515130	30	MD482	Gorsuch Road And Cape Horn Road	POI 300-1	4.1.A.1	NewDev Treatment	0.06	0.01	0	Y	Esdv Provided By Non-Rooftop Runoff Disconnection		Y	Y

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Variance	Variance Type	ΔAi	ΔQ1	ESDv Shortfall	Stable Outfall	Variance Justification	Notes	Accepted	Granted
17-PR-0019	1	FR6795177	77	I70	East Of MD 75 To Structure 10183 Over Monocacy River	3	4.1.A.1	NewDev Treatment	0.05	0	372	Y	Limited ROW		Y	
17-PR-0019	1	FR6795177	77	I70	East Of MD 75 To Structure 10183 Over Monocacy River	4	4.1.A.1	NewDev Treatment	0.02	0	151	Y	Limited ROW		Y	
17-PR-0023	1	AA4365371	71	MD175	IHB - National Business Parkway To Mccarron Court	12	4.1.A.1	NewDev Treatment	-0.08	-0.2	431	Y	Insufficient space		Y	
17-PR-0023	1	AA4365371	71	MD175	IHB - National Business Parkway To Mccarron Court	8	4.1.A.1	NewDev Treatment	-0.43	-2	93	Y	Insufficient space		Y	
17-PR-0023	1	AA4365371	71	MD175	IHB - National Business Parkway To Mccarron Court	9	4.1.A.1	NewDev Treatment	0.02	-0.2	1216	Y	Steep slopes, environmentally sensitive areas		Y	
17-PR-0027	1	BA0145180	80	I695	Bridge 0312400 Over US 40	3	4.1.A.1	NewDev Treatment	3.9	-6.9	16987	Y	Steep Slope, Limited ROW, Esdv Provided To The Mep	1" Rainfall Storage Variance	Y	
17-PR-0029	1	HA5015187	87	MD24	At MD 755	2	4.1.A.1	NewDev Treatment	0.12	0.47	120	Y	Steep Slope, Limited ROW		Y	
17-PR-0032	0	PG6245171	71	MD924	IHB - College Avenue/Regents Drive To MD 193 (University Boulevard)	18	4.1.A.1	NewDev Treatment	0.14	4.06	379	Y	Limited ROW	MDE transfer	Y	
17-PR-0032	0	PG6245171	71	MD924	IHB - College Avenue/Regents Drive To MD 193 (University Boulevard)	18B	4.1.A.1	NewDev Treatment	0.01	0	86	Y	Limited ROW, Highly Urbanized	Outfall being repaired under another project	Y	
17-PR-0032	0	PG6245171	71	MD924	IHB - College Avenue/Regents Drive To MD 193 (University Boulevard)	3	4.1.A.1	NewDev Treatment	0.03	0	160	Y	Limited ROW	MDE transfer	Y	
17-PR-0032	0	PG6245171	71	MD924	IHB - College Avenue/Regents Drive To MD 193 (University Boulevard)	4	4.1.A.1	NewDev Treatment	0.01	0.13	421	Y	Limited ROW, Highly Urbanized	MDE transfer	Y	
17-PR-0032	0	PG6245171	71	MD924	IHB - College Avenue/Regents Drive To MD 193 (University Boulevard)	5	4.1.A.1	NewDev Treatment	0.03	0	435	Y	Limited ROW	MDE transfer	Y	
17-PR-0032	0	PG6245171	71	MD924	IHB - College Avenue/Regents Drive To MD 193 (University Boulevard)	6	4.1.A.1	NewDev Treatment	0.01	-0.31	172	Y	Limited ROW, Highly Urbanized	MDE transfer	Y	
17-PR-0032	0	PG6245171	71	MD924	IHB - College Avenue/Regents Drive To MD 193 (University Boulevard)	7	4.1.A.1	NewDev Treatment	0.07	0	966	Y	Limited ROW, Highly Urbanized	MDE transfer	Y	
17-PR-0033	1	CE2475179	79	MD222	Cedar Corner Road To St Marks Church Road	1	4.1.A.1	NewDev Treatment	0.03	0.04	269	Y	Limited ROW		Y	

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	POI No.	Variance	Variance Type	ΔAi	ΔQ1	ESDv Shortfall	Stable Outfall	Variance Justification	Notes	Accepted	Granted
17-PR-0036	1	MO5365187	87	MD355	IHB - At West Old Baltimore Road	LOI 3	4.1.A.1	NewDev Treatment	0.01	0	90	Y	Topography, impacts to adjacent properties, excessive earthwork needed		Y	
17-PR-0053	1	AA1245180	80	MD468	Structure 02016X0 Over Lerch Creek	POI 100	4.1.A.1	NewDev Treatment	0	1.3	205	Y	Limited ROW, wetlands	Outfall being repaired under this project	Y	
17-PR-0065	1	XX5345133	33	MD253	ADA Sidewalks In District 5	POI 2	4.1.A.1	NewDev Treatment	0.02	0	179	Y	Limited ROW, Adjacent Development		Y	
17-PR-0065	1	XX5345133	33	MD253	ADA Sidewalks In District 6	POI 5	4.1.A.1	NewDev Treatment	0.03	0.07	269	Y	Limited ROW, Adjacent Development		Y	
17-PR-0065	1	XX5345133	33	MD253	ADA Sidewalks In District 7	POI 8	4.1.A.1	NewDev Treatment	0.01	0	90	Y	Limited ROW, Adjacent Development		Y	
17-PR-0065	4	XX5345133	33	MD450	ADA Sidewalks In District 8	1	4.1.A.1	NewDev Treatment	0.01	0	0	Y	Limited ROW, Adjacent Development		Y	
17-PR-0065	4	XX5345133	33	MD450	ADA Sidewalks In District 12	10	4.1.A.1	NewDev Treatment	0.11	0.15	448	Y	Limited ROW, Adjacent Development		Y	
17-PR-0065	4	XX5345133	33	MD450	ADA Sidewalks In District 13	11	4.1.A.1	NewDev Treatment	0.01	0	0	Y	Limited ROW, Adjacent Development		Y	
17-PR-0065	4	XX5345133	33	MD450	ADA Sidewalks In District 9	2	4.1.A.1	NewDev Treatment	0.01	0.03	126	Y	Limited ROW, Adjacent Development		Y	
17-PR-0065	4	XX5345133	33	MD450	ADA Sidewalks In District 10	4	4.1.A.1	NewDev Treatment	0.01	0.05	108	Y	Limited ROW, Adjacent Development		Y	
17-PR-0065	4	XX5345133	33	MD450	ADA Sidewalks In District 11	8	4.1.A.1	NewDev Treatment	0.01	0	63	Y	Limited ROW, Adjacent Development		Y	
17-PR-0065	5	XX5345133	33	MD435	ADA Sidewalks In District 14	LOI 2	4.1.A.1	NewDev Treatment	0.01	0	63	Y	Limited ROW, Adjacent Development		Y	
17-PR-0065	5	XX5345133	33	MD435	ADA Sidewalks In District 15	POI 3	4.1.A.1	NewDev Treatment	0.01	0	108	Y	Limited ROW, Adjacent Development		Y	

2.3 WATER QUALITY BANK DEBITS

FY 2017 - Debits to the WQ Bank

PRD No.	Phase/Site/Package	Contract No.	Fund	Route	Name	Debit* (ac)	Justification
15-PR-0010	1	BA6855176	76	US40	US 40, Chesaco Ave to Todds Lane, Safety & Spot Improvements	-1.26	Minor Imp Surf Increase
15-PR-0023	1	AA4365471	71	MD175	WEST OF REECE ROAD TO EAST OF DISNEY ROAD	-1.57	ESD facilities insufficient
15-PR-0027	1	CL3045130	30	MD26	AT OAKLAND MILLS ROAD	-0.31	ESD facilities insufficient
15-PR-0033	1	PG8945177	77	MD201	MD 201 from Edmonston Rd to Good Luck Rd	-0.02	Minor Imp Surf Increase
15-PR-0045	1	AA3925629	29	N/A	HANOVER COMPLEX AREA - PAVEMENT RESURFACING AND DRAINAGE IMPROVEMENTS	-0.05	Minor Imp Surf Increase
15-PR-0063	1	MO5805180	80	I495	BRIDGE 1512900 OVER I-495	-0.36	ESD facilities insufficient
15-PR-0108	1	XX3145133	33	MD26	Site 1 Frenbrook Drive to North Rolling Road	-0.21	ESD facilities insufficient
15-PR-0108	3	XX3145133	33	MD542	Site 3 Loch Hill Road to Yakona Road	-0.13	ESD facilities insufficient
15-PR-0108	4	XX3145133	33	MD26	Site 4 Rolling Road to I-695	-0.11	ESD facilities insufficient
15-PR-0108	5	XX3145133	33	MD26	Site 5 Deer Park Road to Pikeswood Drive	-0.25	ESD facilities insufficient
15-PR-0112	1	FR1715184	84	US15	US 15 BU at MD 140	-0.13	ESD facilities insufficient
16-PR-0040	1	CL2145187	87	MD97	SOUTH OF AIRPORT DRIVE TO PLEASANT VALLEY ROAD	-0.16	ESD facilities insufficient
16-PR-0045	1	FR1115179	79	MD17	B STREET TO CENTER STREET	-0.2	Minor Imp Surf Increase
16-PR-0080	1	MO4195287	87	I495	I-495 at MD 650 - Ramp from Inner Loop to Southbound MD 650	-0.12	Minor Imp Surf Increase
16-PR-0095	1	FR1945177	77	US340	IHB - WASHINGTON COUNTY LINE TO MD 17	-0.06	Minor Imp Surf Increase
16-PR-0151	1	PG0425177	77	MD201	DC LINE TO LAWRENCE STREET	-0.01	Minor Imp Surf Increase
17-PR-0011	1	HA4625130	30	MD23	AT GRAFTON SHOP ROAD	-0.02	Minor Imp Surf Increase
17-PR-0048	0	CH2395180	80	MD224	BRIDGE 0801900 OVER THORNE GUT AND BRIDGE 0802000 OVER BRANCH THORNE GUT	-0.04	ESD facilities insufficient
					Total Debits for FY 2017	**-5.01**	

* Debit is applied to WQ Bank upon Final Approval

2.4 PUBLIC AND AGENCY MEETING SUMMARY

PRD/MDE No.	Contract No. Road Description	Meeting Date	Meeting Type	Meeting Summary (See Data Drive for copies of meeting materials)
08-SF-0042	PG6185170 MD 4 At Suitland Parkway	8/17/2016	Agency	An agency update meeting was held on August 17, 2016 at MDOT SHA headquarters. Approximately 48 people attended, including representatives from MDP, DNR, MDE MNCPPC, MHT, FHWA, EPA. USACOE and USFWS. The presentation provided an update on the project and its environmental impacts. EPA requested more information regarding the stream impacts. The project team agreed to provide additional information in the JPA resubmittal. There was also discussion about the potential effect of Practical Design on the project. It was communicated that Practical Design would likely only decrease any potential impacts on the project.
15-PR-0028	FR3905184 MD 180 Jefferson Pike Urban Reconstruction	5/11/2017	Public	A Public Informational Meeting was held on May 11, 2017 at the Jefferson Ruritan Center. Approximately 40 people attended. The project proposes to improve pedestrian safety and drainage within the Jefferson community. The scope of work includes sidewalk construction/reconstruction, ADA improvements, drainage improvements, SWM facility construction, resurfacing, landscaping and installing a pedestrian signal at the Lander Road intersection. The public was supportive of the project. Some citizens had additional requests to include lighting in the project. There were also questions existing utility poles being located close to driveway and properties. MDOT SHA agreed to review locations to ensure they meet design requirements. Several citizens requested that stamped brick pattern be used for the sidewalks on the frontage, if the owners paid the difference in cost. MDOT SHA stated that this is possible and recommended using real bricks for lower maintenance.
15-PR-0111	PG0515177 MD 202 Cheverly	6/8/2017	Public	A community meeting was held on June 8, 2017 at the Cheverly Town Hall. Approximately 30 people attended. The purpose of this workshop was to gather information from the community regarding operational and safety concerns along the corridor to help the MDOT SHA team to focus on specific areas for future study to improve capacity, traffic operations, pedestrian and bicycle connectivity, and safety within the corridor. Items discussed included upgrading the pedestrian crossings and bike compatibility on the existing roadway.
16-PR-0027	PG0465180 MD 381 Over Timothy Branch	9/6/2016	Public	A public meeting was held on September 6, 2016 at Brandywine Elementary School. Thirteen people attended the meeting. The project proposes to replace the existing bridge, improve water flow and provide a safer travel area. The public was generally in favor of the project. The main discussion was on the proposed detour of vehicles during construction. MDOT SHA stated that options of using a temporary signal to maintain one travel lane during construction was considered, but this would extend the construction time and compromise safety.

PRD/MDE No.	Contract No. Road Description	Meeting Date	Meeting Type	Meeting Summary (See Data Drive for copies of meeting materials)
16-PR-0045	FR1115179 MD 17 Brunswick Sidewalk Improvements	9/27/2016	Public	This was a combined meeting with 16-PR-0048. A public meeting was held on 9/27/2016 at the Brunswick Volunteer Fire Department. Approximately 37 people attended the meeting. The projects propose to construct sidewalk and drainage improvements on both roads, add a NB bike lane and SB shared use lane on MD 17 and install SWM on MD 464. The public was in support of the project. Discussion included pending developments along MD 17 and safe crossings for pedestrians, especially children travelling to and from school.
16-PR-0047	HO1415170 MD 32 Dualization MD 108 to North of Linden Church Lane	10/19/2016	Agency	An agency update presentation was held on October 19, 2016. Approximately 46 people attended, including representatives from USFWS, MDE, USACOE, FHWA, EPA and DNR. The purpose was to present the proposed stream restoration to be included in the project. Discussion included MDE asking if the impacts have decreased, MDOT SHA concurred. Also, MDE wanted to be sure to include the stream restoration plans in the project's upcoming Public Hearing, MDOT SHA concurred. There was also discussion from USACOE if the stream restoration should be viewed as self-mitigating, as presented by MDOT SHA. This was agreed to be continued in later discussions, as the stance on temporary vs. permanent impacts vary among the agencies.
16-PR-0047	HO1415170 MD 32 Dualization MD 108 to North of Linden Church Lane	6/28/2017	Public	A public meeting was held on June 28, 2017 in the Dayton Oaks Elementary School cafeteria. Approximately 144 people attended. The project proposes to reconstruct MD 32 to a four-lane highway with an open median. The project will also include SWM, culvert upgrades, stream restoration and reforestation. Many citizens had concerns about increased roadway noise and the need for a noise wall. MDOT SHA completed a noise analysis that confirmed noise increases did not warrant the need for constructing a noise wall.
16-PR-0048	FR1115279 MD 464 Brunswick Sidewalk Improvements	9/27/2016	Public	This was a combined meeting with 16-PR-0045. A public meeting was held on 9/27/2016 at the Brunswick Volunteer Fire Department. Approximately 37 people attended the meeting. The projects propose to construct sidewalk and drainage improvements on both roads, add a NB bike lane and SB shared use lane on MD 17 and install SWM on MD 464. The public was in support of the project. Discussion included pending developments along MD 17 and safe crossings for pedestrians, especially children travelling to and from school.

PRD/MDE No.	Contract No. Road Description	Meeting Date	Meeting Type	Meeting Summary (See Data Drive for copies of meeting materials)
16-PR-0063	MO5245129 Connecticut Ave Salt Barn and I-495 / MD 185 ramp improvements	12/5/2016	Public	A public meeting was held on December 5, 2016 at Grace Episcopal Day School. The project replaces construct a new salt barn near the I-495 / MD 185 interchange, with some ramp modifications included to promote safe access for plows. Approximately 22 people attended the meeting. The public had concerns about potential environmental impacts to Rock Creek. The public questioned whether the SWM facilities would not actually treat the chemical used at the site. There were other concerns relating to the aesthetics, the large amount of construction in the area and traffic concerns.
17-PR-0006	SO2125180 MD 364 Over Dividing Creek	4/5/2017	Public	A public meeting was held on April 5, 2017 at the Pocomoke Library. Approximately 20 people attended the meeting. The project purpose is to replace the existing bridge with a wider structure to improve safety. The public was supportive of the bridge replacement project, but had concerns with the proposed detour during construction. As a result, MDOT SHA is re-evaluating accelerated construction alternatives that would minimize the impact of a detour. Options being considered include full detour on weekends only for a limited duration (6 weeks) with a single lane of alternating traffic on weekdays.
17-PR-0030	AL2975180 MD 36 Over Tributary of Jennings Run	1/12/2017	Public	A public meeting was held on January 12, 2017 at Mount Savage School. There were ten people who attended the meeting. The purpose of the meeting was to inform the public of the design progress on the project, which will include a road closure and detour during replacement of the structure. The public expressed interest over the length of the road closure and detour. MDOT SHA proposes to implement the road closure primarily during the summer months, when school is not in session, to minimize impact on traffic.
17-PR-0053	AA1245180 MD 468 Over Lerch Creek	10/25/2016	Public	A public meeting was held on October 25, 2016 at Galesville Community Center. There were six people who attended the meeting. The project proposes to replace the existing structure, while maintaining traffic with the use of a temporary one-lane signal configuration. The public expressed concern over whether the temporary condition will allow for farm equipment to safely cross the bridge. MDOT SHA solicited input on farm vehicle types and specifications to incorporate proper clearances for them during construction.

PRD/MDE No.	Contract No. Road Description	Meeting Date	Meeting Type	Meeting Summary (See Data Drive for copies of meeting materials)
17-PR-0075	GA6465270 US 219 From I-68 to Old Salisbury Road	9/8/2016 & 9/9/2016	Public	Two public meetings were held on September 8, 2016 (Grantsville Elementary School) and September 9, 2016 (Grantsville Senior Center). Approximately 118 people attended the two meetings. The meeting included seven alternatives for public review to upgrade US 219 to support economic growth and provide improved access in the project area. Input from the public was used to help MDOT SHA reduce the number of alternatives retained for detailed study from 7 to four. Detailed comments were focused on traffic safety near the Pilot Travel Center, near school bus stops and potential property impacts.
17-PR-0075	GA6465270 US 219 From I-68 to Old Salisbury Road	10/19/2016	Agency	An agency meeting was held on October 19, 2016. Approximately 45 people were in attendance, including representatives from USFWS, MDE, USACOE, FHWA, EPA and DNR. The meeting updated the environmental agencies on the ARDS (Alternatives Retained for Detailed Study) for the US 219 PEL study, based on preliminary engineering, environmental impacts, and public input from the September public meetings. MDOT SHA communicated the decision to remove alternatives 5, 6 and 7 from further consideration and proceed with detailed design on Alternatives 1 through 4 in preparation for the upcoming Public Hearing
17-PR-0075	GA6465270 US 219 From I-68 to Old Salisbury Road	2/6/17	Public Hearing	A Joint Public Hearing was held for on February 6, 2017. Approximately 85 people attended the hearing. At the hearing, MDOT SHA presented the results of detailed engineering and environmental studies on the ARDS for the US 219 study. The public expressed concerns with property impacts associated with Alt 2 and safety concerns associated with Alt 3.
17-PR-0088	SM2105171 MD 5 Great Mills Improvement Project	10/19/2016	Agency	An agency update presentation was held on October 19, 2016. Approximately 46 people attended, including representatives from USFWS, MDE, USACOE, FHWA, EPA and DNR. The meeting updated the environmental agencies on the ARDS (Alternatives Retained for Detailed Study) for the MD 5 Planning study, based on preliminary engineering, environmental impacts, and public feedback. The project includes safety improvements and structure upgrades along MD 5 in Great Mills. DNR questioned if existing flooding concerns would be solved by the project. MDOT SHA stated that flooding conditions could be slightly improved, depending on which alternative is chosen.

Appendix D

MDOT SHA IDDE Tracking - Business Flow Diagram

Appendix D

MDOT SHA IDDE Tracking – Business Flow Diagram

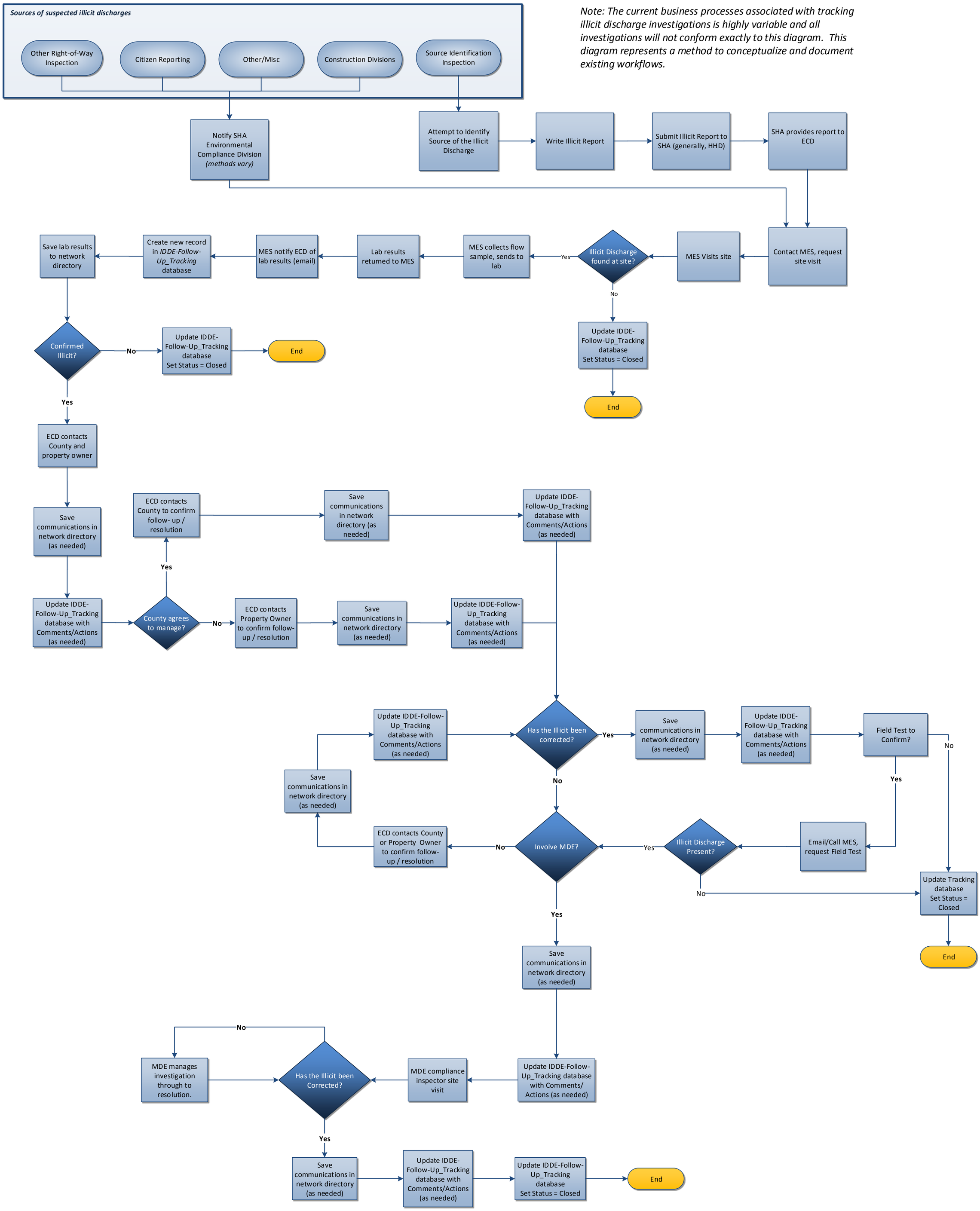
MARYLAND DEPARTMENT OF TRANSPORTATION™

STATE HIGHWAY ADMINISTRATION

SHA IDDE Tracking – Business Process Diagram

Current (As-Is) Workflow

Note: The current business processes associated with tracking illicit discharge investigations is highly variable and all investigations will not conform exactly to this diagram. This diagram represents a method to conceptualize and document existing workflows.



04/05/2016

Appendix E

MDOT SHA Litter Program Attachments

Appendix E

MDOT SHA Litter Program Attachments

- MDOT SHA Litter Report – FY 2017.....E-2
- "Don't Trash Maryland" Op-Ed by Gregory Slater E-12
- 2017 Market Research Study – Pre-Campaign Summary Report.....E-15
- Litter Education Campaign Communication Plan.....E-48

MARYLAND DEPARTMENT OF TRANSPORTATION™

STATE HIGHWAY ADMINISTRATION

MDOT SHA
Litter Report – FY 2017

MDOT SHA LITTER REPORT 2017

STATEWIDE

- MDOT SHA spent $8.1 million in FY 2017 on litter removal operations.
- The number of truckloads of litter removed from MDOT SHA roadways increased from 6,000 in FY 2016 to approximately 6,094 in FY 2017.
- Litter removal operations consumed 7.2% of the District's routine expenditures in FY 2017.
- District 4 (Baltimore and Harford Counties) consumed 9.6% of their routine expenditures on litter operations in FY 2017.
- District 3 (Montgomery and Prince George's Counties) consumed 9.8% of their routine expenditures on litter operations in FY 2017.
- MDOT SHA spent $571,689 in FY 2017 on illegal sign removal. This is down from $618,669 in FY 2016.
- Litter removal operations were accomplished by using MDOT SHA maintenance forces, Inmate labor crews, Contractual forces, Adopt-A-Highway Groups, and Sponsor- A-Highway.
- At 89.4%, the statewide level of service increased in CY17 for the second year in a row.
- Efforts continue to be made in the areas of public awareness through public service messages and community outreach.
- Dialog continues at the local level with Maryland State Police and local government agencies with regards to enforcement issues.
- With the addition of protection vehicles, the cost of litter removal operations on roads posted at 55 MPH and greater will increase by approximately $600 per day per crew.

INMATE LABOR PROGRAM

The number of Department of Public Safety and Correctional Services (DPSCS) inmate labor crews provided to MDOT SHA has fluctuated over the years, from as many as 60 from 2005 to 2009 to the current 42 regular crews. Each of the crews is comprised of four to six inmates, along with a Correctional Officer. The crews work approximately 200 days per year, performing unskilled and semi-skilled labor for MDOT SHA, including litter pick-up, hand mowing, landscaping, and building and grounds maintenance.

- Inmate crews are used to remove litter on interstate medians and roadsides.
- These crews work approximately 200 days per year.
- The number of crews has fluctuated over the years from as many as 60 from 2005 to 2009, but has been reduced recently to the current 42 regular crews.
- Typical crew is made up of 4-6 inmates, a Correctional Officer, and a MDOT SHA Team Leader.
- An inmate labor crew costs between $950 and $1,600 per day per crew, depending upon the addition of a protection vehicle for work on high-speed interstates.

SPONSOR-A-HIGHWAY

In February 2005, MDOT SHA received approval from FHWA to conduct a pilot Corporate Sponsorship Program. Under this program, Corporate Sponsors hire a private company (maintenance provider) that has been pre-approved by MDOT SHA to perform litter pick-up services in the name of sponsors. The maintenance providers are also responsible for fabrication, installation and maintenance of the recognition signs.

Starting in 2008, the program was expanded outward from the Baltimore/Washington Metro area towards Frederick and Harford Counties, the Pennsylvania border to the north of Baltimore and into Southern, MD and the Eastern Shore to Salisbury, MD. This increased the number of available segments by 150% and saw an immediate growth of sponsorships which continued through FY16.

Each sponsor is acknowledged by a sign with a recognition panel that is placed at the beginning of the highway segment they are sponsoring. MDOT SHA does not receive any reimbursement from the sponsor or maintenance provider. MDOT SHA's primary role is to ensure litter removal is properly performed, recognition signs are installed to MUTCD standards, manage the inventory of segments available for sponsorship, review additional areas for inclusion in the program, and approve artwork submitted for sponsor panels.

The pilot took place on I-97 from the Baltimore Beltway to US 50, MD Route 100 from US 29 to I-97, I-95 from the Baltimore Beltway to North of the Virginia line and US 50 from the DC line to the Severn River.

- Currently, 382 out of 532 available segments, or 72%, have been sponsored. This is consistent to the percentage of sponsored segments in in FY16.
- Listed below are the current roadways in this program:
  - ✓ Anne Arundel County –MD 295, MD 10, MD 695, I-695, MD 32, US 50, I- 595, and I-97, MD 100
  - ✓ Baltimore County –I-795, I-695, I-70, I-95, I-83, MD 702, and MD 695
  - ✓ Calvert County – MD 4
  - ✓ Carroll County – I-70
  - ✓ Charles County – MD 5, MD 301
  - ✓ Dorchester County – US 50
  - ✓ Frederick County – I-270, I-70
  - ✓ Harford County – MD 24
  - ✓ Howard County –US 29, MD 32, I-70, and I-95
  - ✓ Montgomery County –I-270, I-495 and US 29
  - ✓ Prince George's County – I-95, I-495, I-595, US 50, MD 5
  - ✓ Queen Anne's County – US 50
  - ✓ St. Mary's County – MD 4, MD 5
  - ✓ Talbot County – US 50Washington County – I-70, I-81
  - ✓ Wicomico County – US 13 and US 50

- This program covers over 570 roadway miles, with approximately 415 sponsored.
- Since its inception in the spring of 2006 through December of 2017, approximately 116,500 bags of trash have been picked up as part of the program. As a result, approximately $3.6 million was available for use on safety-related maintenance work instead of litter removal.
- Litter pick-up is performed on bi-weekly in the Baltimore/Washington Metro area. Areas to the West and Eastern Shore have a reduced cleaning schedule requiring 1 clean per month during the winter months of the year and bi-weekly cleaning the rest of the year.
- The program has sustained its momentum from the private sector even with the downturn in the economy.
- Small business owners continued sponsoring segments during FY17. Previously, most of the sponsorships were all large businesses or national corporations.
- This program costs zero dollars to the MDOT SHA.

ADOPT-A-HIGHWAY

In 1989 MDOT SHA created the Adopt-A-Highway Program. This program allows volunteer groups to pick-up litter along non-interstate roadways as a community service. Any family, business, school or civic organization can adopt a state maintained highway. Since the program began these volunteer groups have picked up over 250,000 bags of litter resulting in a cost savings $3.9 million for MDOT SHA.

- MDOT SHA currently has 137 groups participating in the program. This is down from 198 in CY16. Because of the new protection vehicle policy effective January 1, 2017, Maintenance Shops removed groups from roads with speeds greater than 50 mph. In addition, Maintenance Shops have been removing groups that are inactive and adopting the roads to new groups, thereby helping to maintain the number of active groups and increase litter removal by volunteers statewide.
- In CY17, AAH groups picked up nearly 40 truckloads of trash across 160 miles of secondary roadways in Maryland. This is down from 53 truckloads in CY16.
- The AAH program saved MDOT SHA $63,500 in CY17. However, this savings is somewhat offset by the cost of materials and supplies borne by the Shops and Districts to sustain the program.
- The program has gained some interest from small businesses and non-profit organizations that cannot afford Sponsor-A-Highway during CY17 and CY16.
- Many groups are removing all their bags to the dumps themselves or they are separating out recyclables (according to their county recycling practices) and taking that portion to recycling areas. This has helped to reduce the amount of litter going to landfills and decreased the tipping fees MDOT SHA has to pay.

CONTRACT SUPPORT

- Litter pick up requirements are now included in MDOT SHA tractor and hand mowing contracts.
- There are currently 16 litter removal contracts across the state.
- These contracts are worth over $3.1 million.
- The contracts including litter removal are mostly advertised as Small Business Reserve contracts.
- The bulk of these contracts use a 2-man crew and a truck and cost, on the average, $250 - $500 per day.

Litter Program

Litter expenditures include all expenditures for removing litter from continuous sections and/or isolated locations, along the right-of-way, including pick-up, hauling, loading and disposal. Figure 1 includes expenditures by MDOT SHA personnel, temporary agency employees, DPSCS inmates, and Contractors. Figure 2 shows the cost per day for each of the five different types of litter pick-up crews.

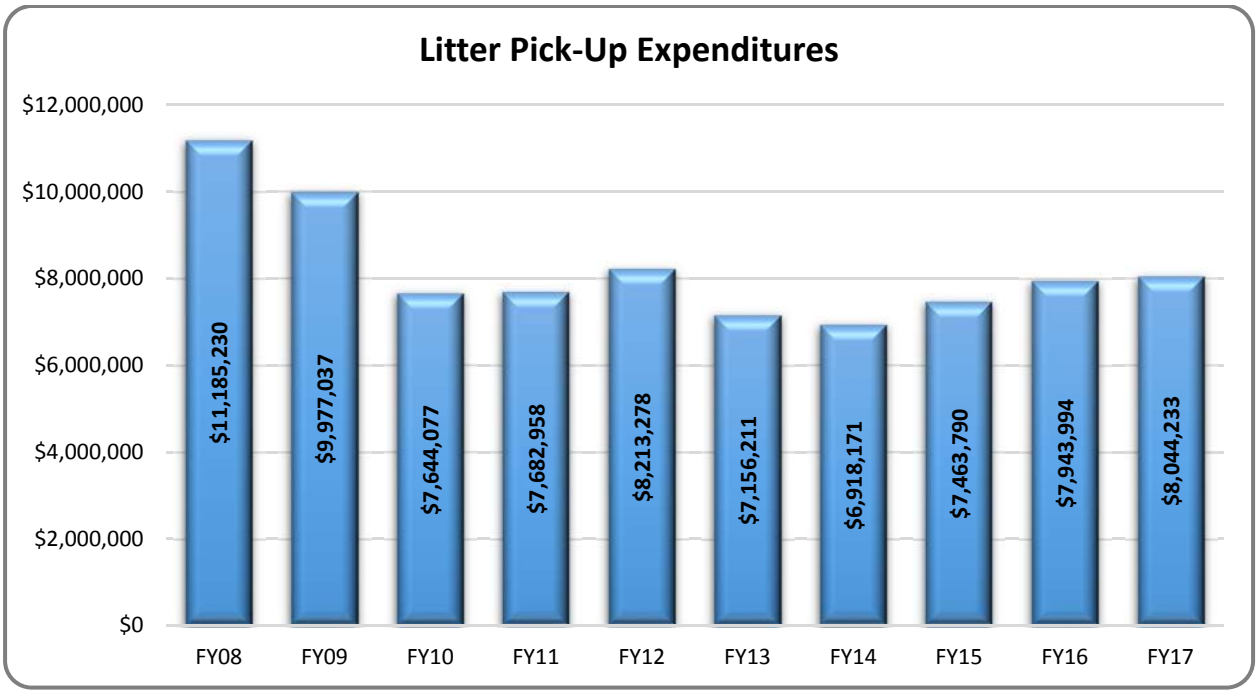


Figure 1

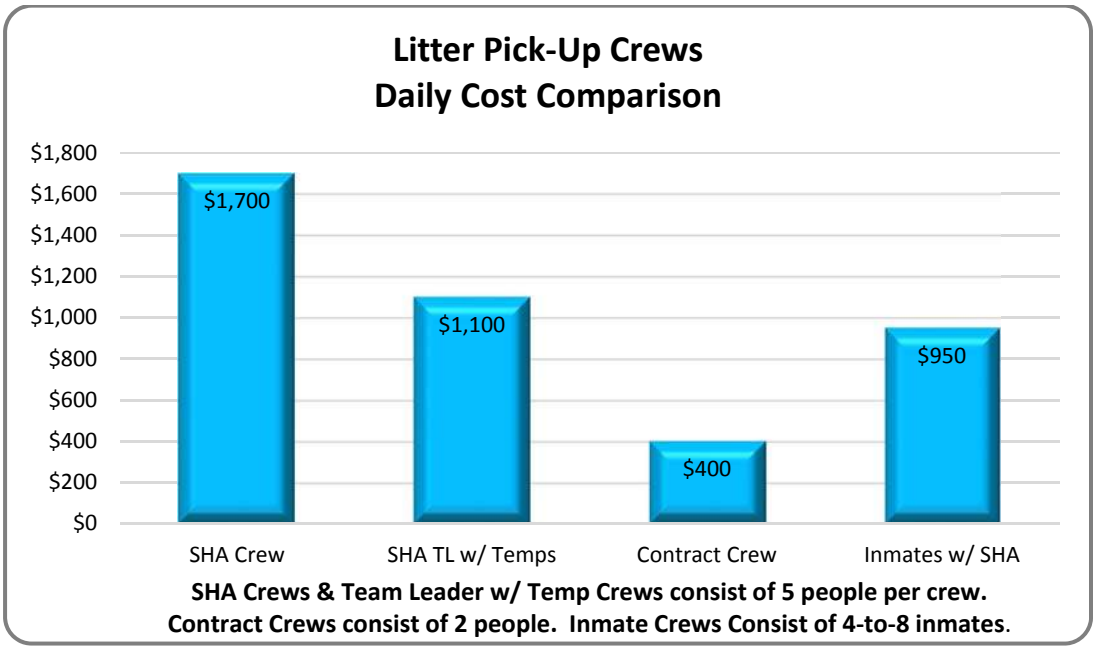


Figure 2

Litter Removal by the Numbers

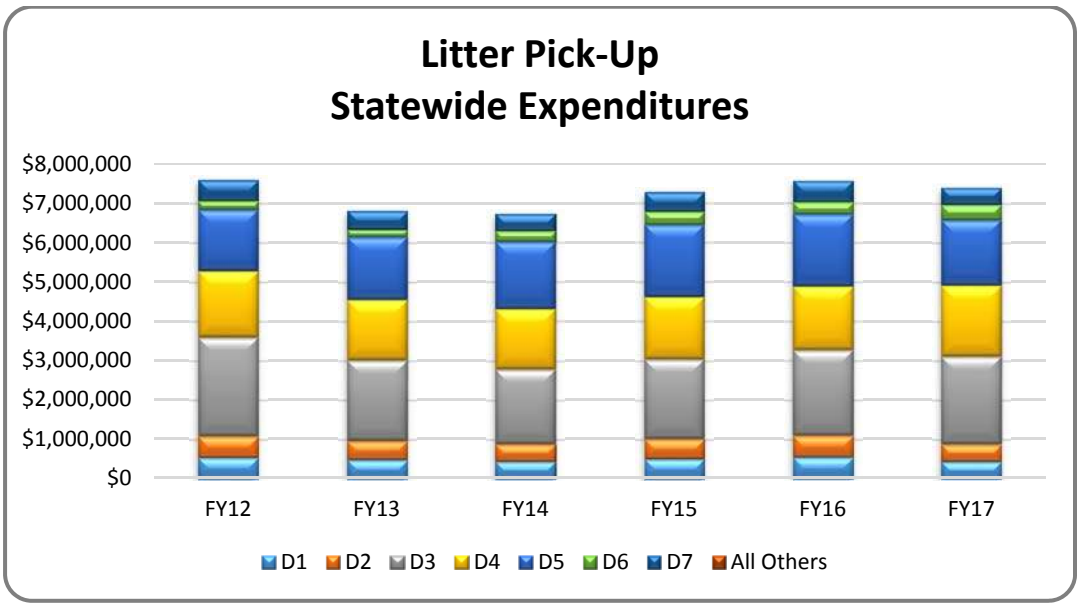


Figure 3

This graph demonstrates the expenditures, by district, for litter removal over the past six fiscal years.

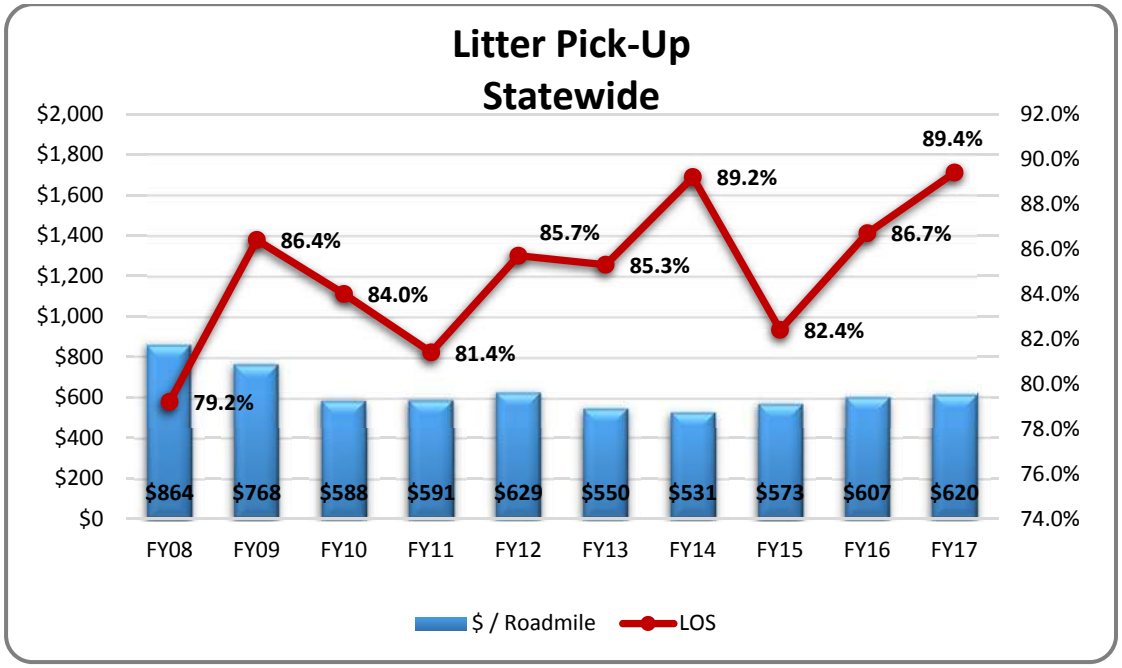
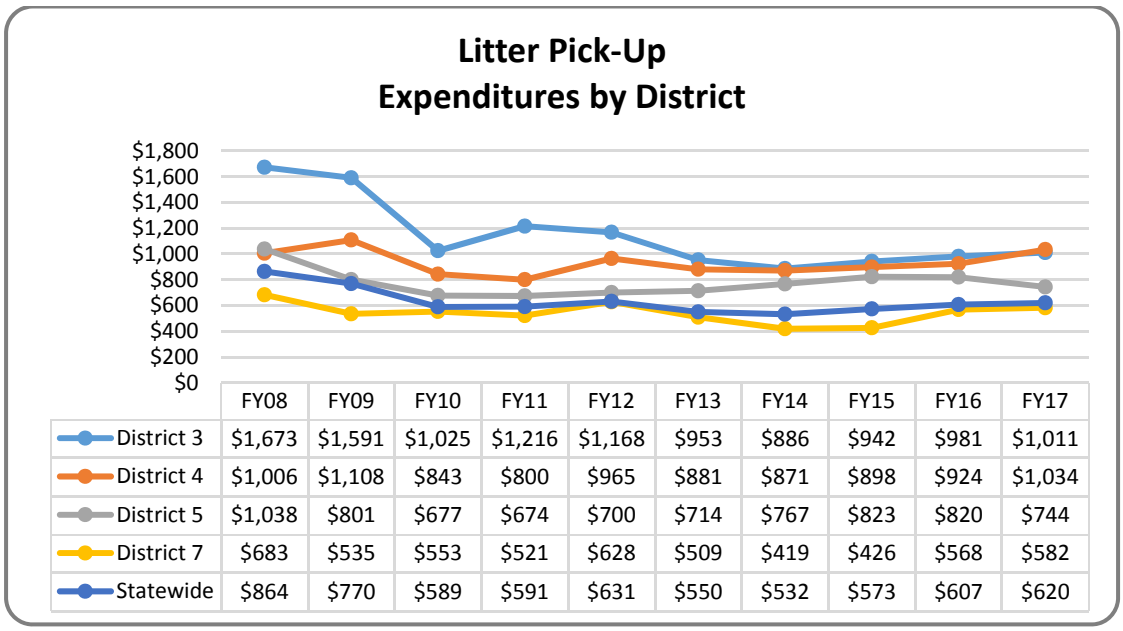


Figure 4

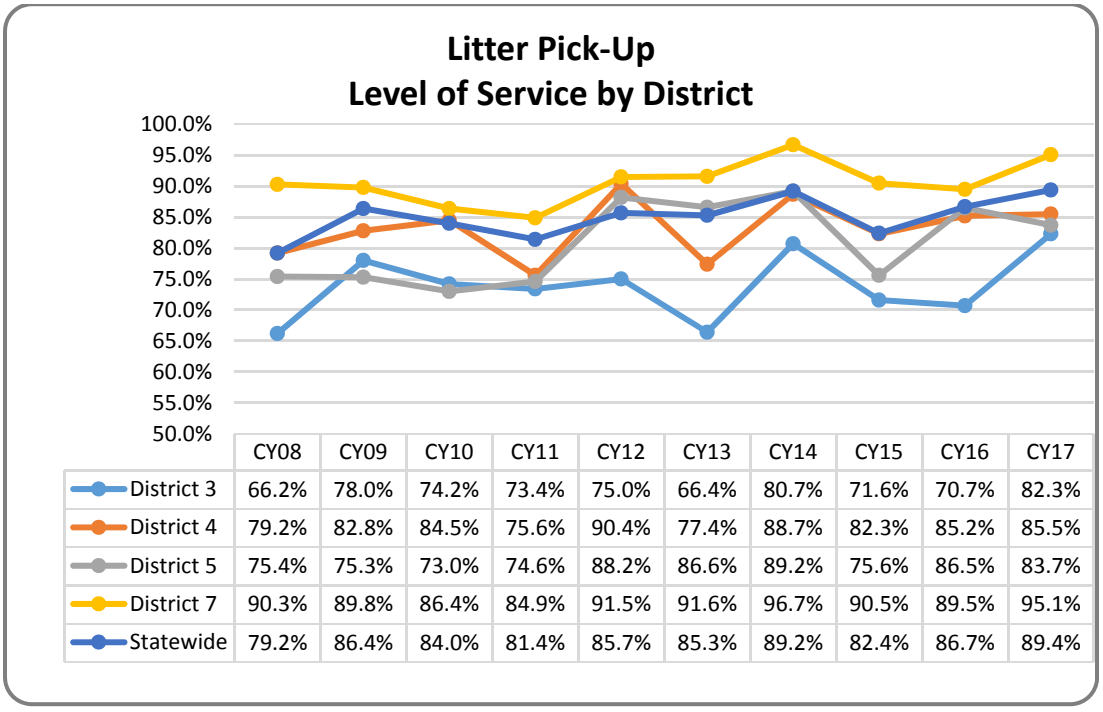
This graph shows the statewide expenditures per roadside mile (shown in blue) for the ten fiscal years. The red line indicates the statewide level of service as determined through MDOT SHA's Maryland Condition Assessment Review Program (MCARS). MCARS is based on an annual field review of approximately 3,000 randomly selected ½ mile segments of state-maintained roadways.



	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17
District 3	$1,673	$1,591	$1,025	$1,216	$1,168	$953	$886	$942	$981	$1,011
District 4	$1,006	$1,108	$843	$800	$965	$881	$871	$898	$924	$1,034
District 5	$1,038	$801	$677	$674	$700	$714	$767	$823	$820	$744
District 7	$683	$535	$553	$521	$628	$509	$419	$426	$568	$582
Statewide	$864	$770	$589	$591	$631	$550	$532	$573	$607	$620

Figure 5

The graph above shows litter pick-up expenditures per roadside mile by district. It includes litter pick-up on all state maintained roads in the districts.



	CY08	CY09	CY10	CY11	CY12	CY13	CY14	CY15	CY16	CY17
District 3	66.2%	78.0%	74.2%	73.4%	75.0%	66.4%	80.7%	71.6%	70.7%	82.3%
District 4	79.2%	82.8%	84.5%	75.6%	90.4%	77.4%	88.7%	82.3%	85.2%	85.5%
District 5	75.4%	75.3%	73.0%	74.6%	88.2%	86.6%	89.2%	75.6%	86.5%	83.7%
District 7	90.3%	89.8%	86.4%	84.9%	91.5%	91.6%	96.7%	90.5%	89.5%	95.1%
Statewide	79.2%	86.4%	84.0%	81.4%	85.7%	85.3%	89.2%	82.4%	86.7%	89.4%

Figure 6

The graph above shows the level of service for litter removal, as determined through MDOT SHA's MCARS Program, for the metropolitan districts.

Don’t Trash Maryland

Op-Ed by MDOT SHA Administrator Gregory Slater
Appeared in the Baltimore Sun (5/24/2017)

Don't trash Maryland

By **Greg Slater**

MAY 24, 2017, 2:44 PM

When you discard trash from your vehicle on one of Maryland's highways, do you ever wonder where it goes? One cigarette butt flicked out of the window, a fast food bag, a small plastic wrapper.

Take a moment and think about where it goes. It has to go somewhere. Now I ask you to think about the cost savings of one moment of restraint. One moment of selfless responsibility and love for the beauty of this great state.

The Maryland Department of Transportation State Highway Administration (MDOT SHA) has a record amount of highway construction projects underway across the state to reduce congestion and improve safety. We maintain 2,500 bridges and 17,000 miles of non-toll state roads, the interstate, and U.S. and state numbered routes in Maryland's 23 counties.

On top of all that, MDOT SHA spends nearly $8 million every year to remove litter along Maryland highways. That's $8 million of taxpayer money. Your money. My money. Every single year. Litter removal also pulls skilled MDOT SHA workers away from other functions like highway repairs. This requires funds that could otherwise be used to repave roads, install traffic signals and lighting, or assist with other safety critical activities.

Most importantly, littering is extremely harmful to our environment, with trash typically carried by stormwater to streams and rivers, and in some cases entering drinking water reservoirs and the Chesapeake Bay. Maryland is a maritime state, a beautiful state. The cleanliness of our waterways and our Chesapeake Bay is a major part of our identity and reputation.

Last month, MDOT SHA launched the "We Live Here, Too" education effort in conjunction with Earth Day to reinforce the message about the harmful impacts of litter on our roadsides and natural resources. April has come and gone. Memorial Day weekend is upon us — one of the busiest travel weekends of the year. As you get on the road over Memorial Day weekend or any time during the summer travel season, we urge you to treat every day like Earth Day and think about where that trash goes when you throw it out of the vehicle and onto the highway. Think about where it goes and what it costs.

Maryland is your home. It is my home. Let's all work collectively to treat our roads and roadsides as we would our own homes. Let's keep our roads and this beautiful state litter-free. Gov. Larry Hogan said it best last August as he unveiled the "Maryland Proud" license plates at the Chesapeake Bay Bridge: "You would be hard pressed to find another state that has more pride than our great state of Maryland."

MDOT SHA has Maryland pride. With that as our guiding principle, we will continue to make environmental protection a top priority. We owe that to Marylanders and all the visitors who travel our roads. But we need

your help in that effort, too. Have Maryland pride. Don't litter.

Greg Slater is a native Marylander and administrator of the Maryland Department of Transportation State Highway Administration; Twitter: @MDSHA.

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This article is related to: Maryland Department of Transportation

2017 Market Research Study
Pre-Campaign Summary Report

MARYLAND DEPARTMENT OF TRANSPORTATION

STATE HIGHWAY ADMINISTRATION

integrated designs INCORPORATED

2017 Litter Study
Phase I Pre-Campaign Evaluation
Summary Report

February 2017

Maryland Marketing Source, Inc.

Purpose and Methodology

- The Maryland Department of Transportation's State Highway Administration (SHA) has been working with Integrated Designs (ID) to establish a statewide Anti-litter Program that Maryland continuously grow to remain current and translate easily in partnership with other state agencies as well as public and private organizations and businesses.

- In order to raise awareness about the negative environmental impact of littering along Maryland's roads and highways, Integrated Designs needed to investigate residents' awareness of the negative impacts of littering, the costs associated with littering, people's perceptions about littering, people's motivations for littering, and motivations to stop littering. ID partnered with Maryland Marketing Source, Inc., to conduct a strategic, multi-phase market research study research across the State of Maryland so as to be able to formulate an appropriate and effective marketing campaign.

- Phase I of this research endeavor includes:
  - Qualitative data collection via online, bulletin board focus groups (completed Fall of 2016), and
  - Follow-up quantitative data collection via online surveying, results herein.

- This wave of research is the first to be conducted in a series of online surveys testing concepts, perceptions, beliefs, and levels of subject awareness. Results of future waves will be compared to this baseline wave.

Purpose and Methodology (cont.)

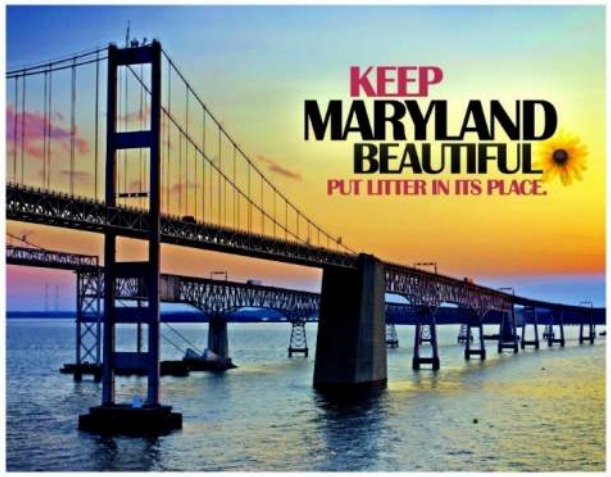
- A total of 1,200 surveys were completed among Maryland residents and segmented by geographic regions close or connected to local waterways. For reporting purposes, these segments were then consolidated into metropolitan areas as follows:

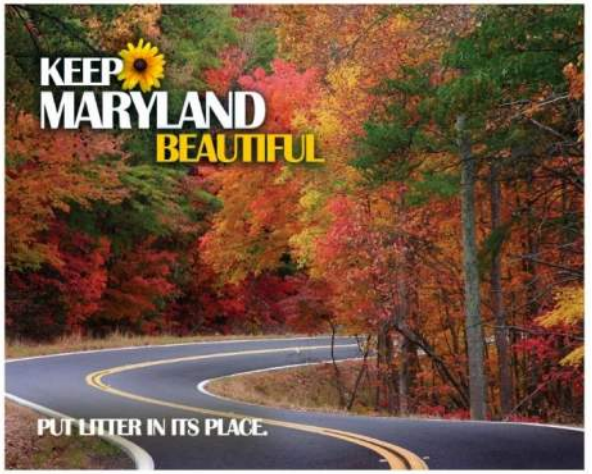
Baltimore Metro Area	Washington Metro Area	Other
• Anne Arundel County • Baltimore City • Baltimore County • Carroll County • Harford County • Howard County	• Charles County • Frederick County • Prince George's County • Montgomery County	• St. Mary's County • Washington County

- Base sizes should be considered when reviewing all statistical analyses. Results are reported at a 95% confidence level, with a sampling error of +/- 2.8% overall.

Key Findings

- While 'Litter/Trash' isn't a major concern among Maryland residents overall, Baltimore Metro Area respondents did indicate a higher level of concern compared to residents of other regions.
- More than half of the study participants admitted to having littered at some point, accidentally or otherwise.
- Overall awareness of the Adopt-a-Highway program was much higher than it was of the Sponsor-a-Highway program.
- The below advertising concepts were most preferred by respondents:

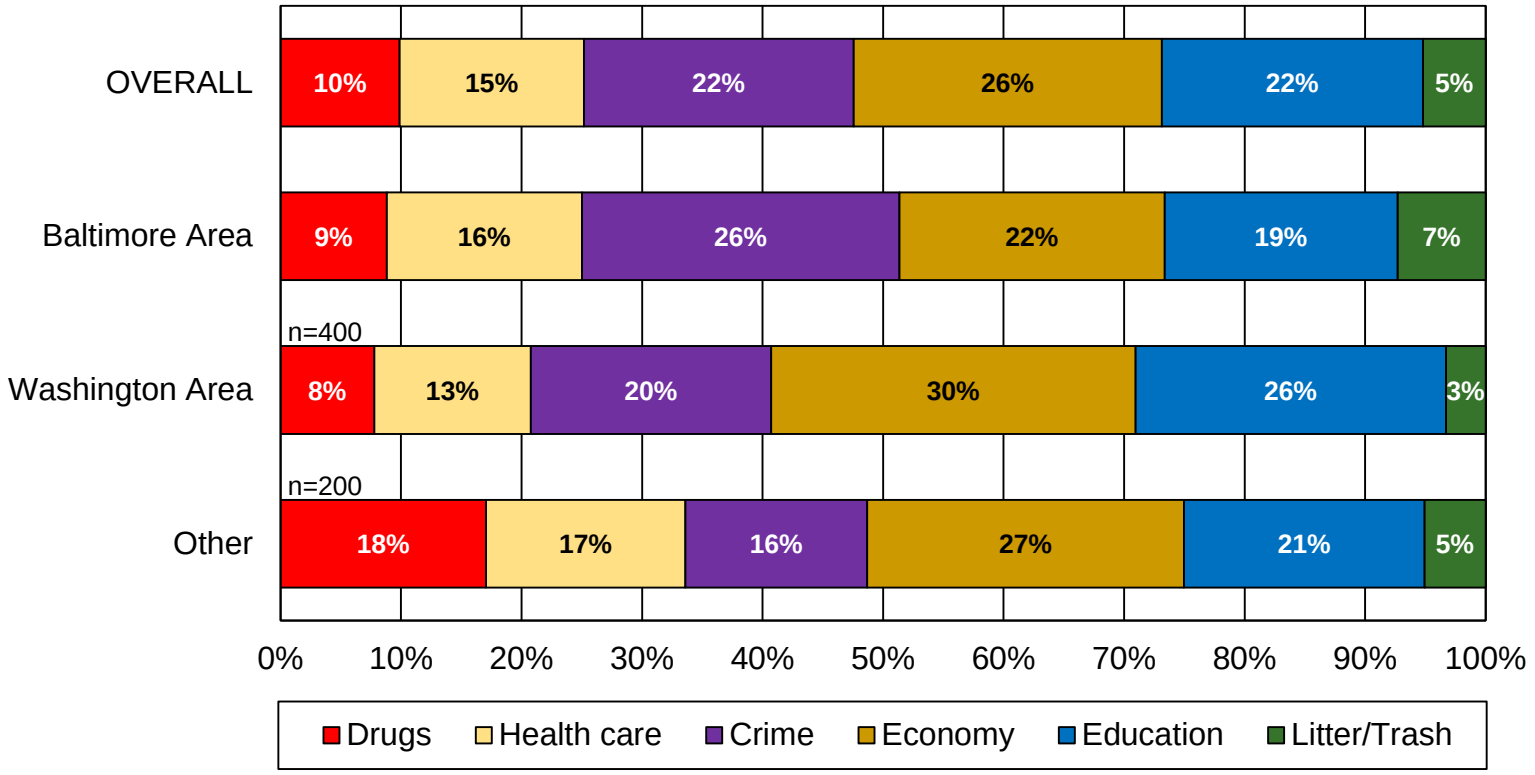




Detailed Findings

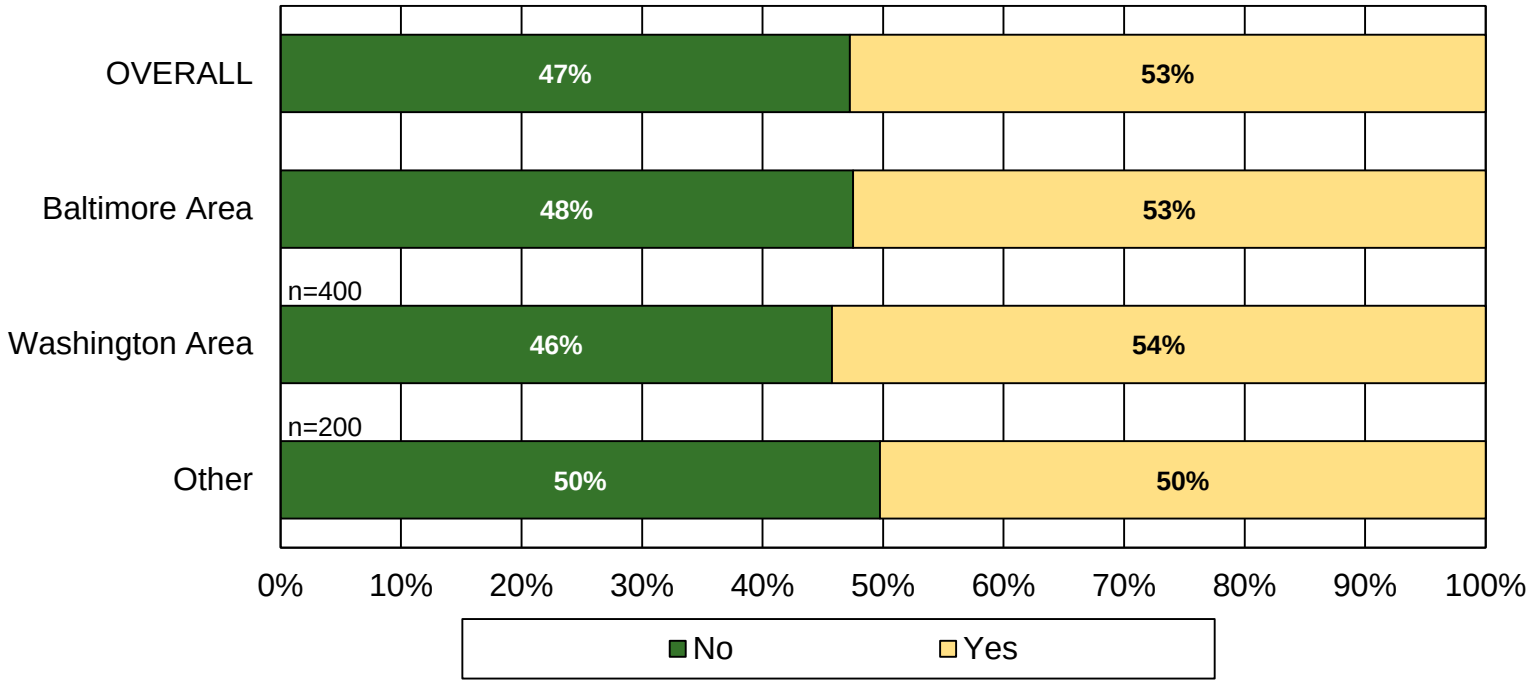
Current Issues of Concern

- Overall, 'Litter/Trash' was the issue with which respondents were least concerned.
- Baltimore Metro Area respondents reported a higher concern about 'Litter/Trash' than did Washington Metro Area participants.



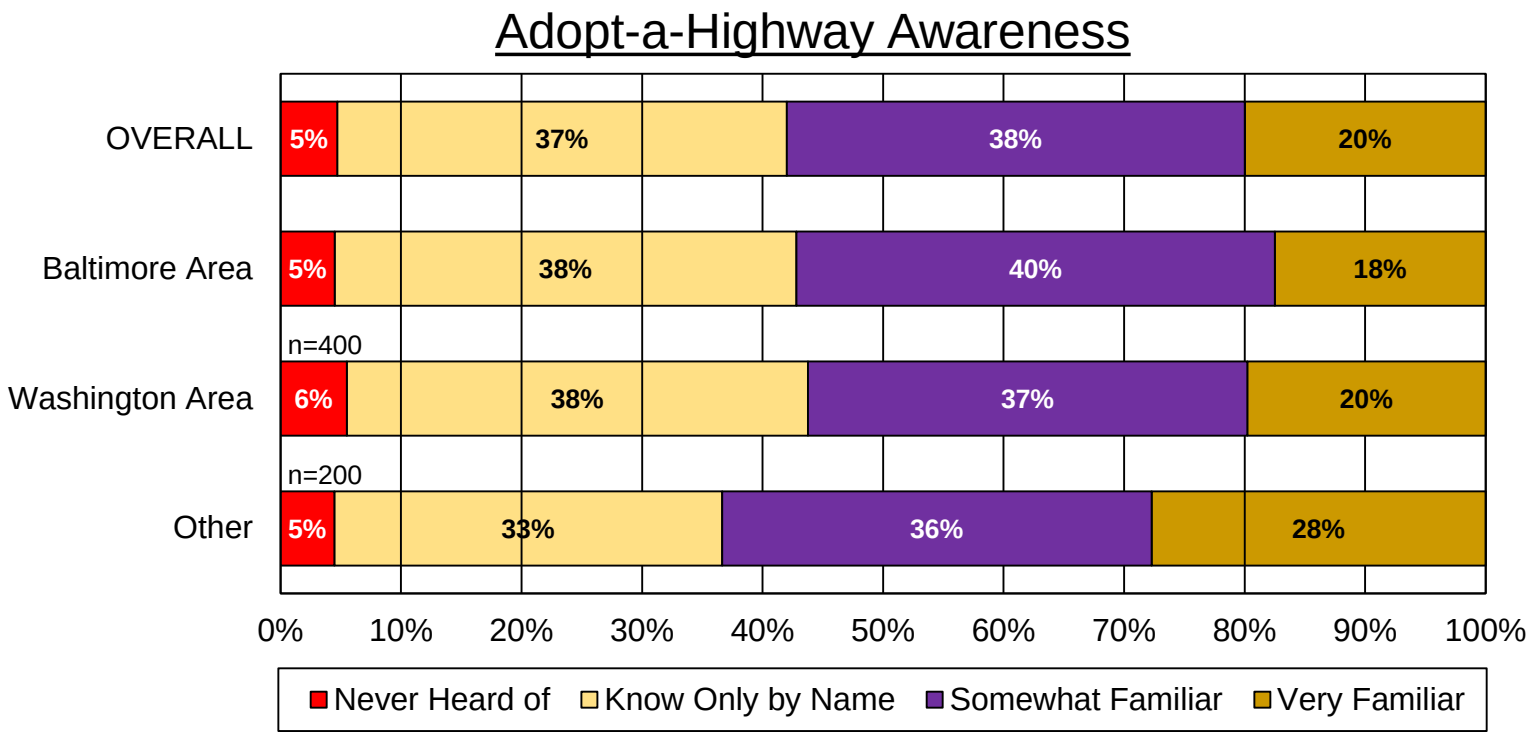
Littering Habits

- Just over half of the study participants admitted to having littered at some point, either accidentally or on purpose. Items most commonly littered include:
  - Food (40% BMA, 44% WMA, 33% Other),
  - Receipts (29% BMA, 32% WMA, 33% Other)
  - Paper fast food napkins (26% BMA, 31% WMA, 41% Other),
  - Sweet snack wrappers (24% BMA, 28% WMA, 27% Other), and
  - Cigarette butts (24% BMA, 21% WMA, 33% Other).



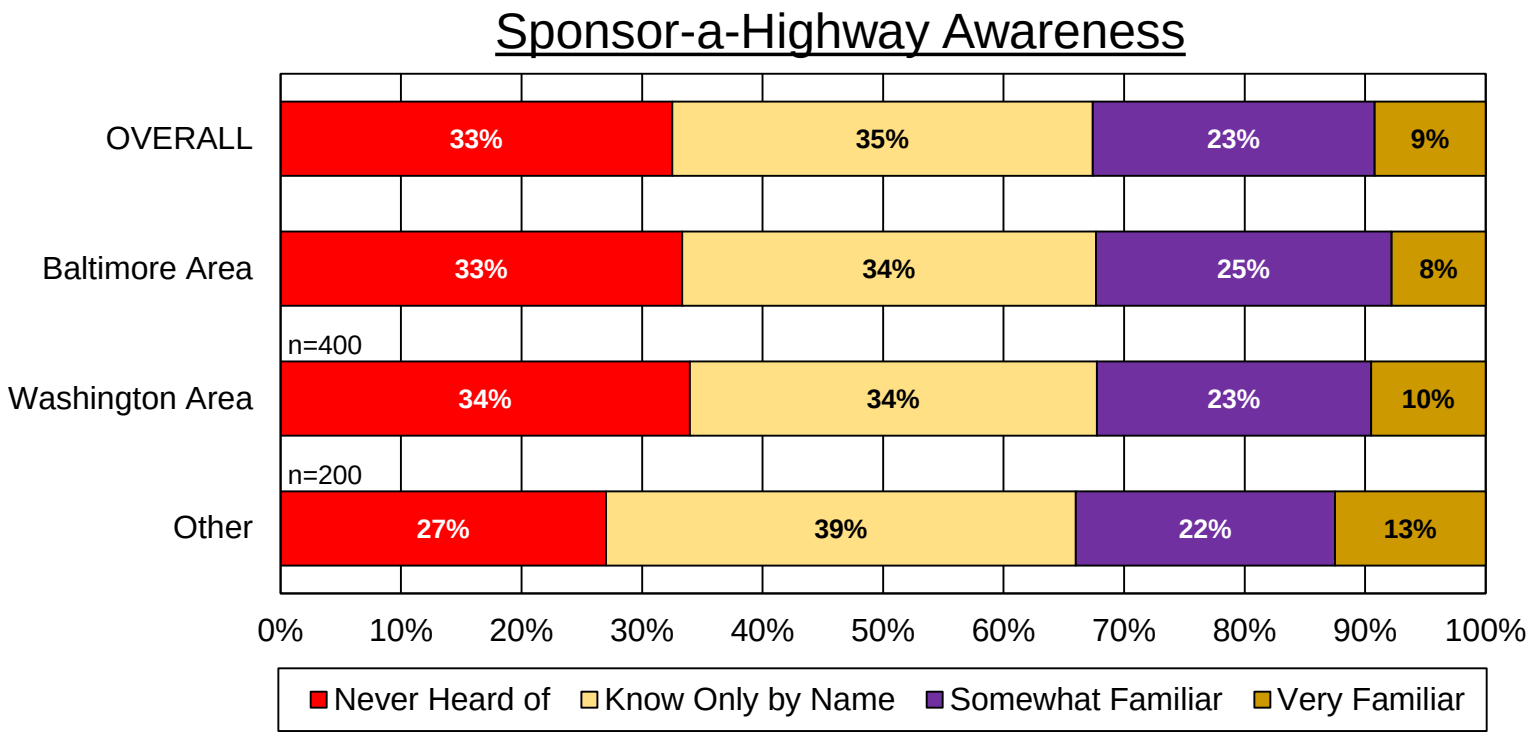
Programs: Adopt-a-Highway

- Overall, more than half study participants were at least 'Somewhat Familiar' with the Adopt-a-Highway program.
- Respondents in St. Mary's and Washington Counties (Other) reported the highest levels of familiarity, with more than one quarter (28%) stating they are 'Very Familiar' with the program.



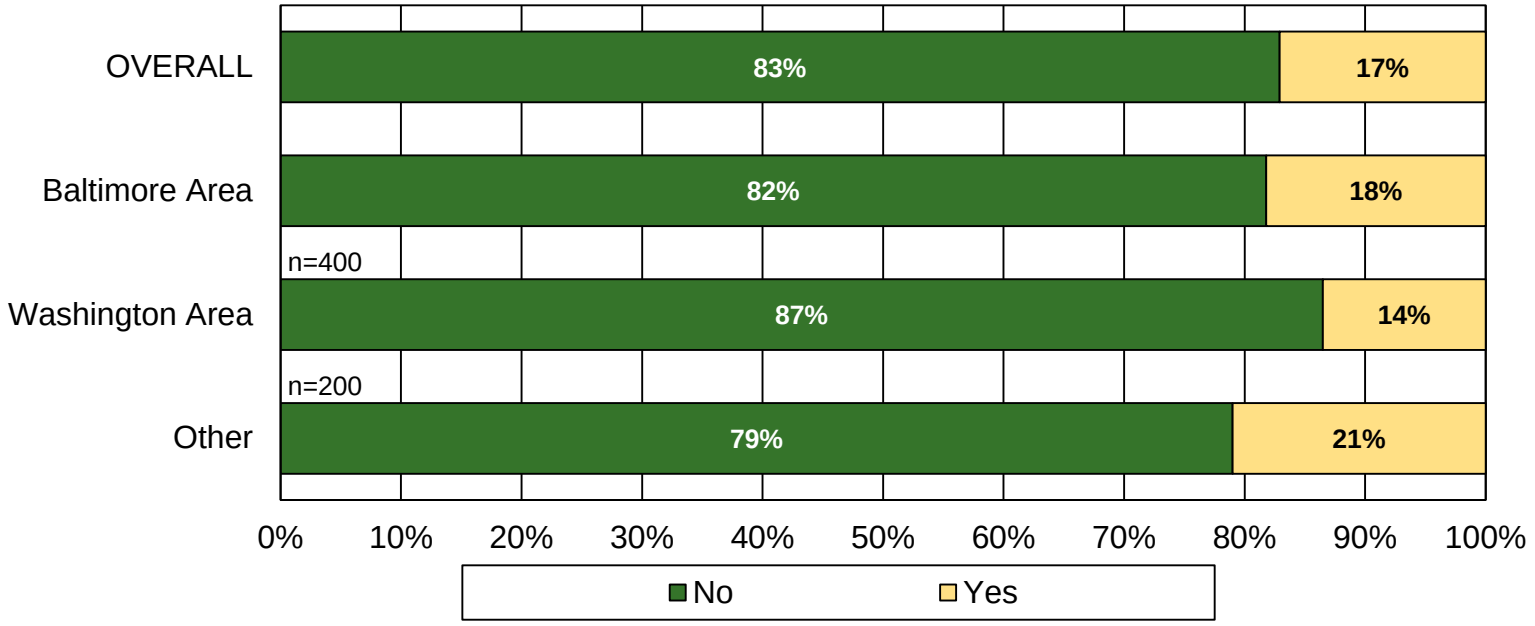
Programs: Sponsor-a-Highway

- Awareness of the Sponsor-a-Highway program was much lower overall than it was of the Adopt-a-Highway program, with one third (33%) of respondents saying they are at least 'Somewhat Familiar'.
- Again, respondents in St. Mary's and Washington Counties (Other) reported slightly higher levels of familiarity, with more than one quarter (28%) stating they are 'Very Familiar' with the program.



Advertising Messages about Litter

- The majority of respondents (83% Overall) report that they have not seen, heard, or read any advertising messages about litter or trash in the State of Maryland within the past 6 months.
- Those who say they have seen such advertising messages mostly cited the following media:
  - TV/TV News (57% BMA, 33% WMA, 43% Other),
  - Billboard (39% BMA, 33% WMA, 43% Other),
  - Poster (28% BMA, 19% WMA, 19% Other),
  - Radio (22% BMA, 17% WMA, 24% Other), and
  - Newspaper (27% BMA, 17% WMA, 19% Other).

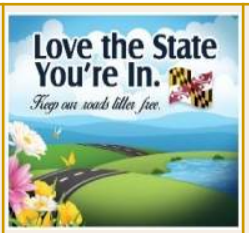


Overall Ad Awareness

- The below chart highlights which advertisements were recalled best by respondents in each regional area.

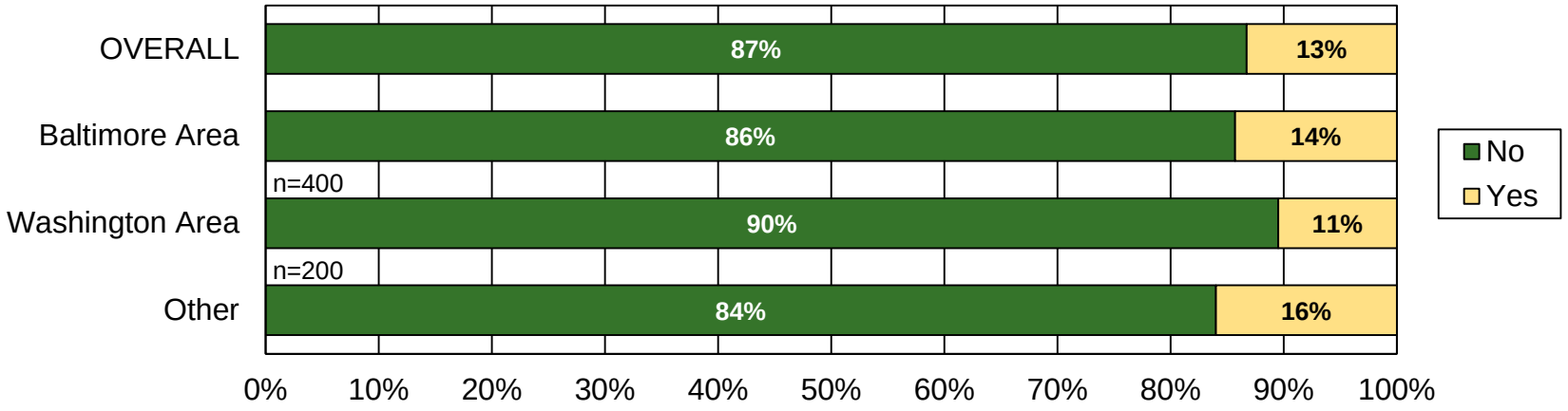
Highest Overall Recall

Lowest Overall Recall

						
OVERALL	13%	11%	9%	8%	7%	4%
Baltimore Metro Area	14%	11%	10%	9%	6%	4%
Washington Metro Area	11%	9%	7%	7%	8%	4%
Other	16%	15%	9%	8%	9%	8%

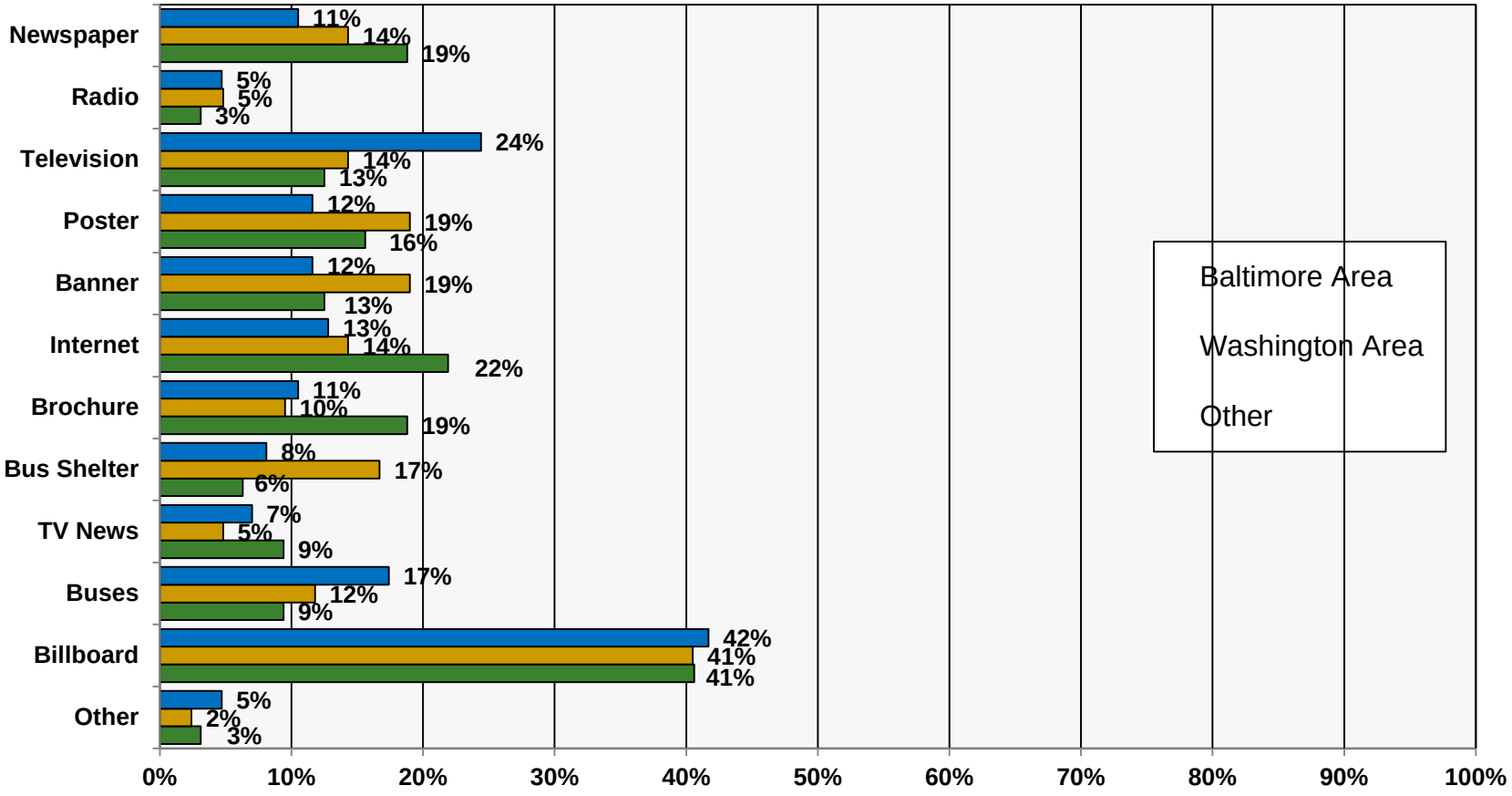
Advertising Messages about Litter (cont.)

- The majority of respondents did not recall seeing the below ad within the past 6 months.



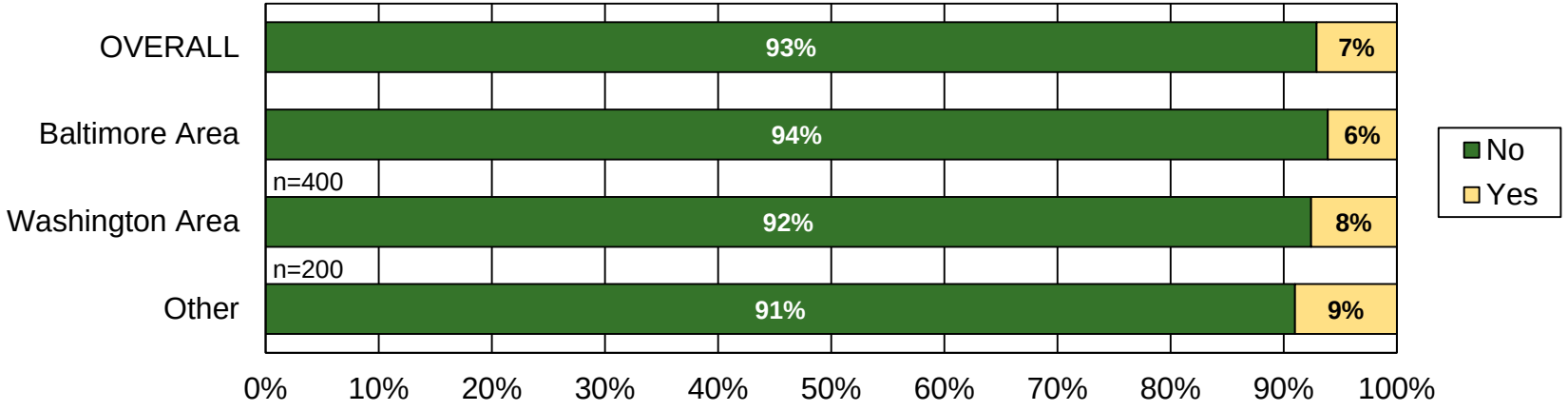
Advertising Messages about Litter (cont.)

- Among the few respondents who reported having seen the previously shown ad, a 'billboard' is where most of them said to have seen it.



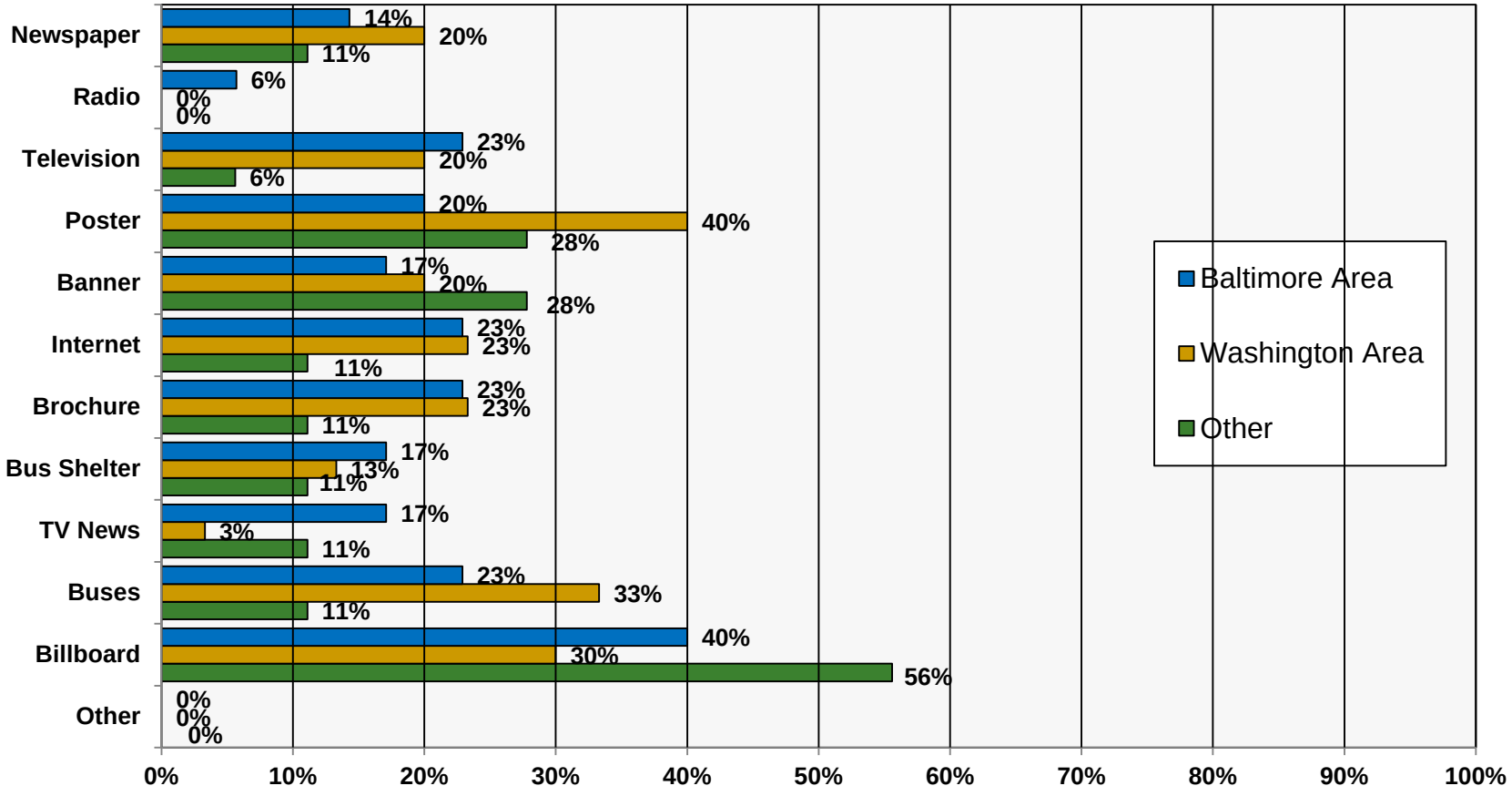
Advertising Messages about Litter (cont.)

- Nine out of ten respondents do not recall seeing the below ad within the past 6 months.



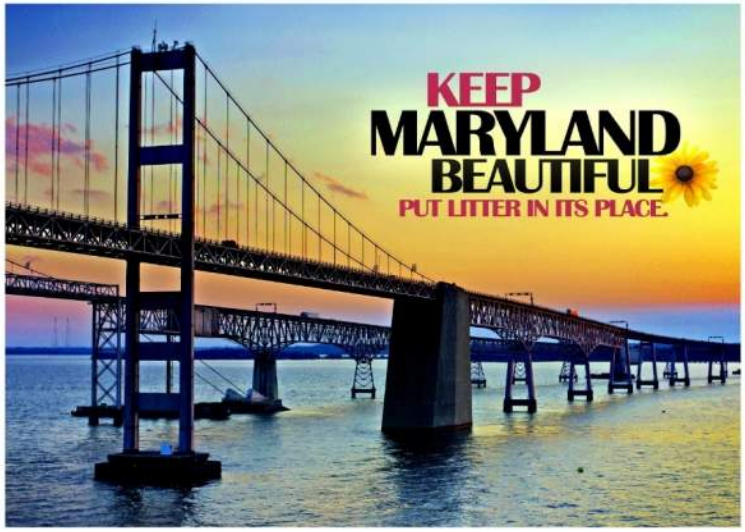
Advertising Messages about Litter (cont.)

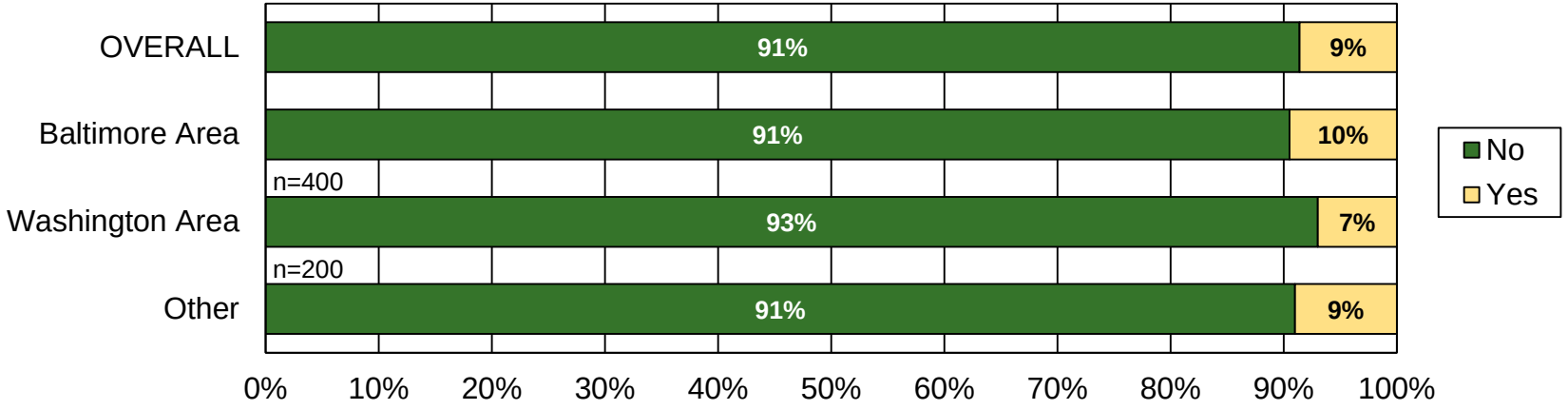
- Again, the few participants who said to have seen the previous ad claimed to have done so on a 'billboard' or in a 'poster'.



Advertising Messages about Litter (cont.)

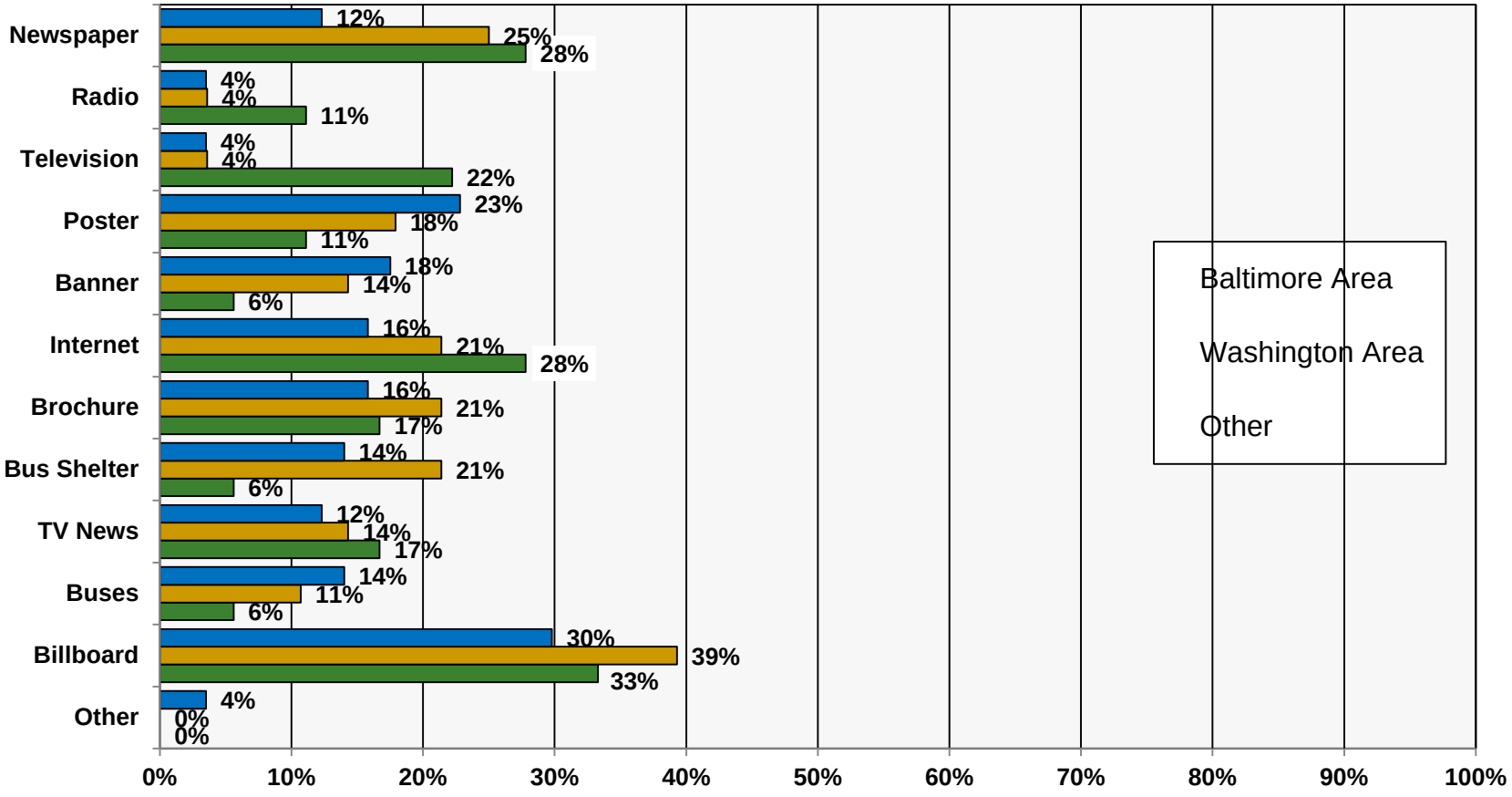
- The vast majority of study participants do not recall seeing the below ad within the past 6 months.





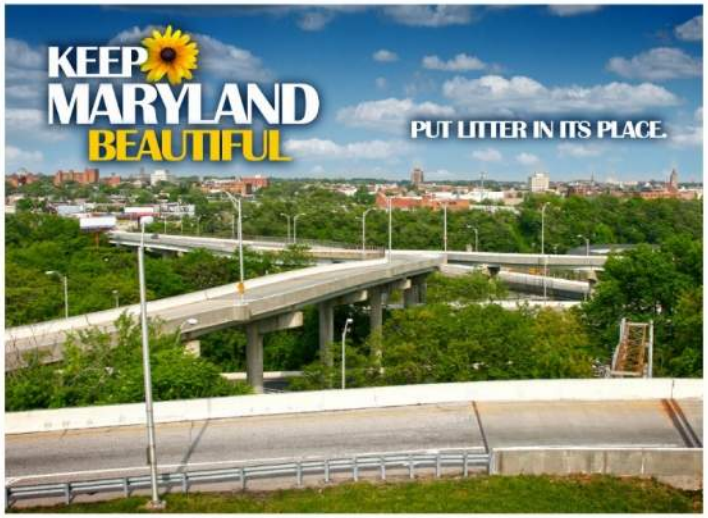
Advertising Messages about Litter (cont.)

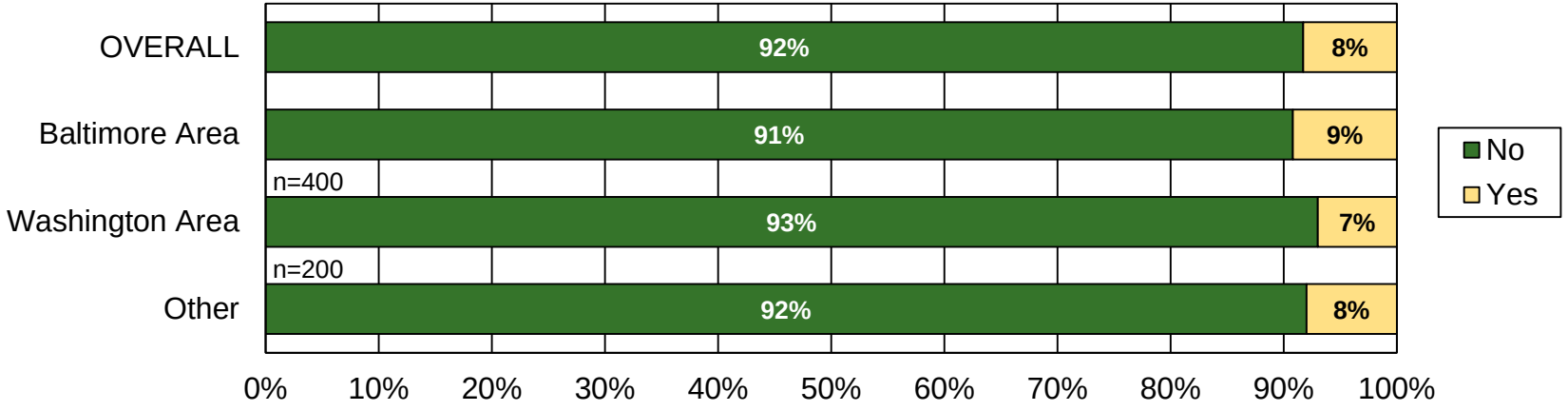
- Among the few respondents who reported having seen the previously shown ad, a 'billboard' is where most of them said to have seen it.



Advertising Messages about Litter (cont.)

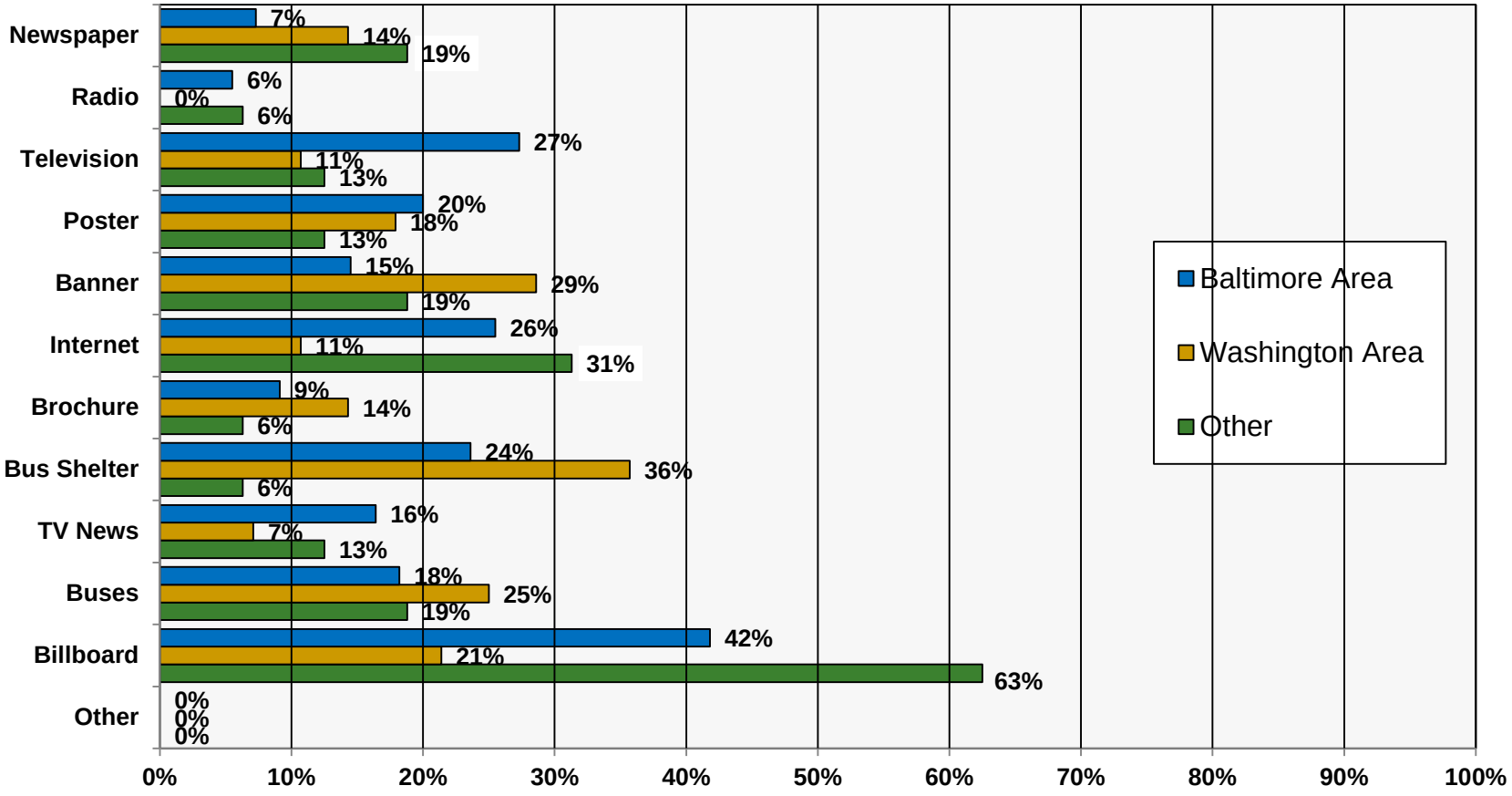
- The majority of participants do not remember seeing the below ad.





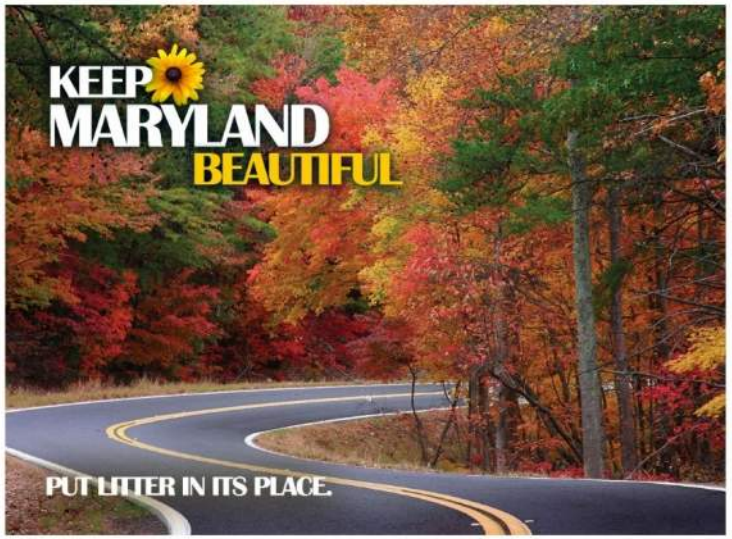
Advertising Messages about Litter (cont.)

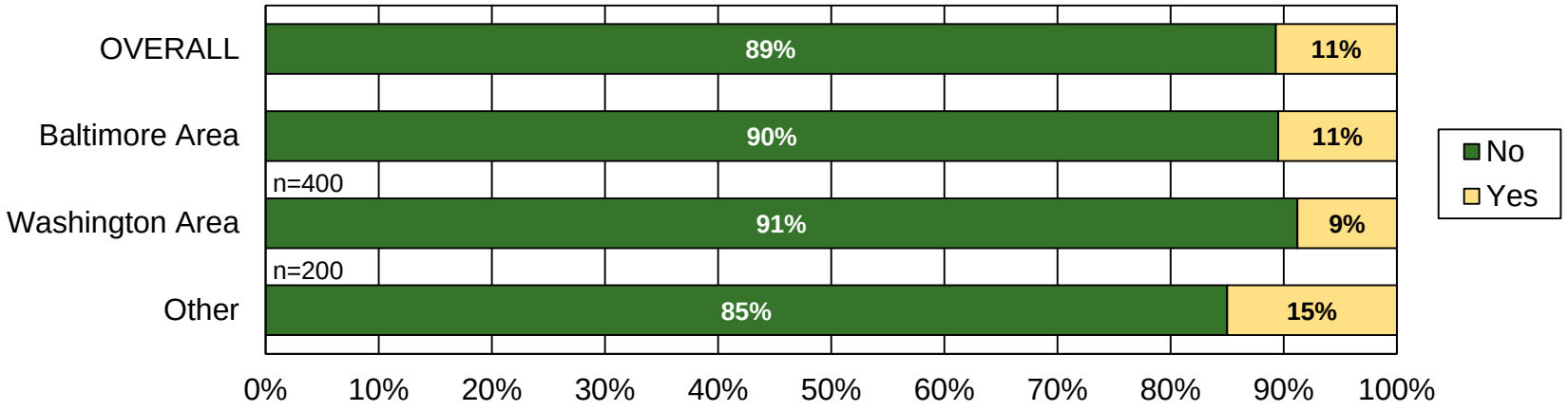
- Respondents who think they may have seen this ad mostly think they saw it on a ‘billboard’, on a ‘bus shelter’, or on a ‘banner’.



Advertising Messages about Litter (cont.)

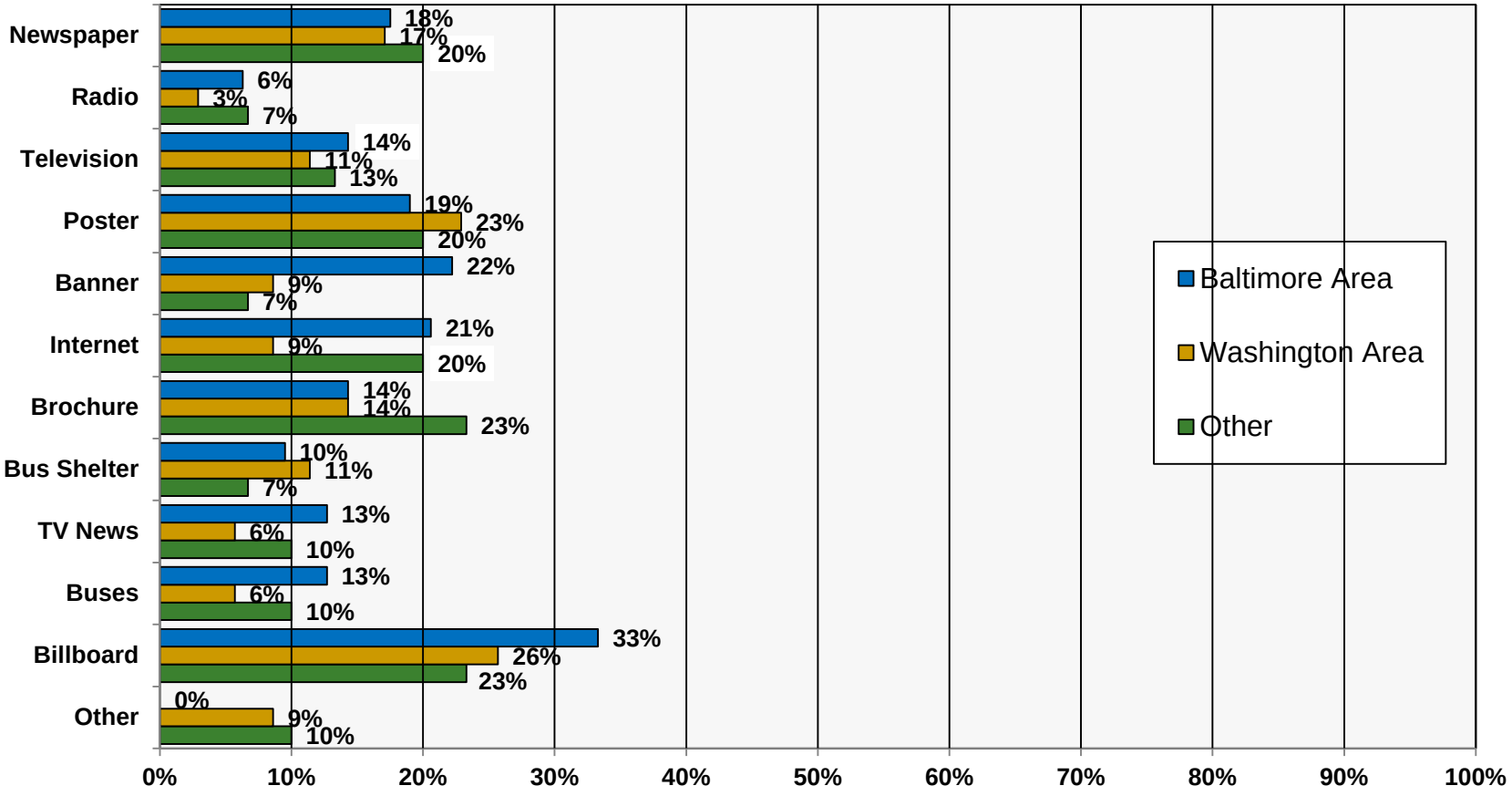
- The below ad was recalled more by St. Mary's and Washington County (Other) residents.





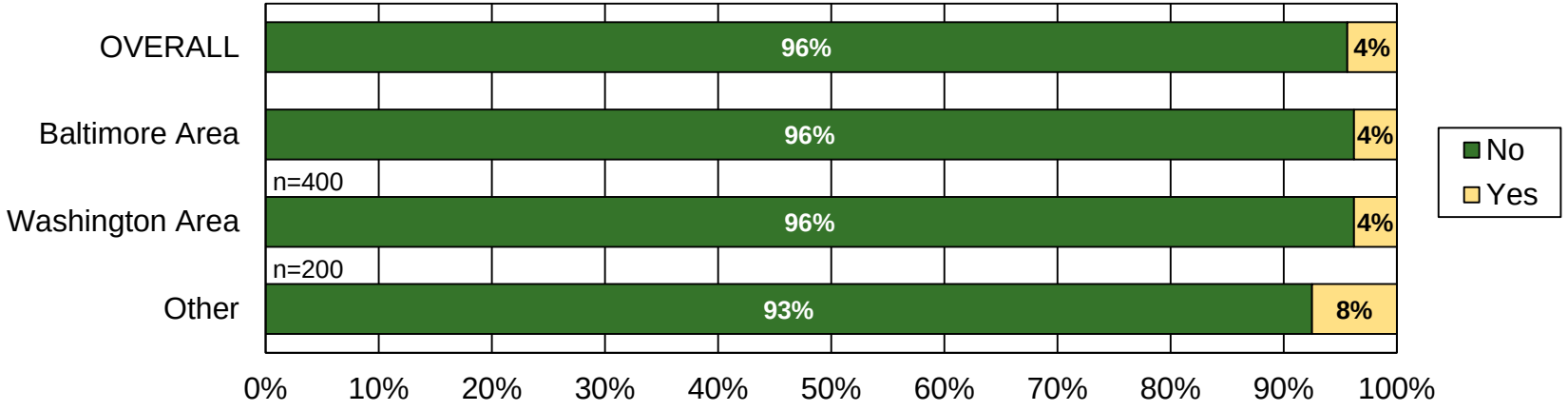
Advertising Messages about Litter (cont.)

- Respondents who think they may have seen this ad mostly think they saw it on a ‘billboard’, on a ‘brochure’, or on a ‘poster’.



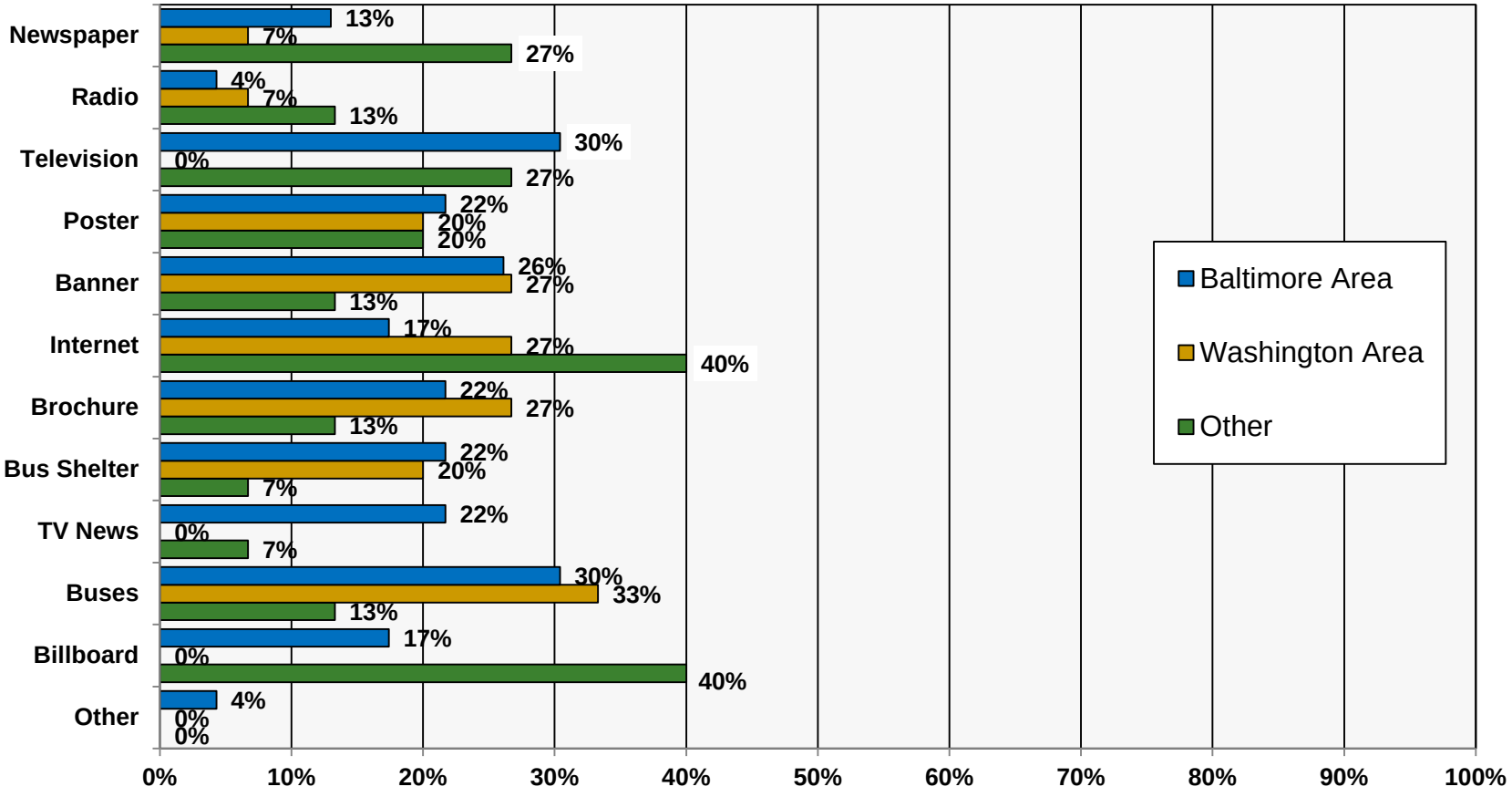
Advertising Messages about Litter (cont.)

- The below ad was not recognized by study participants.



Advertising Messages about Litter (cont.)

- The very few respondents stating they have seen this ad mostly think it was on a ‘billboard’ or on the ‘Internet’.

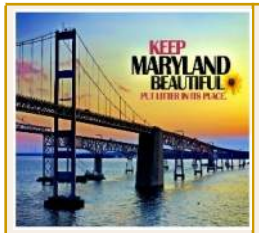


Overall Ad Preferences

- There was universal consensus among respondents regarding which advertisements they liked the best and which they liked the least.

Highest Ranked Ad

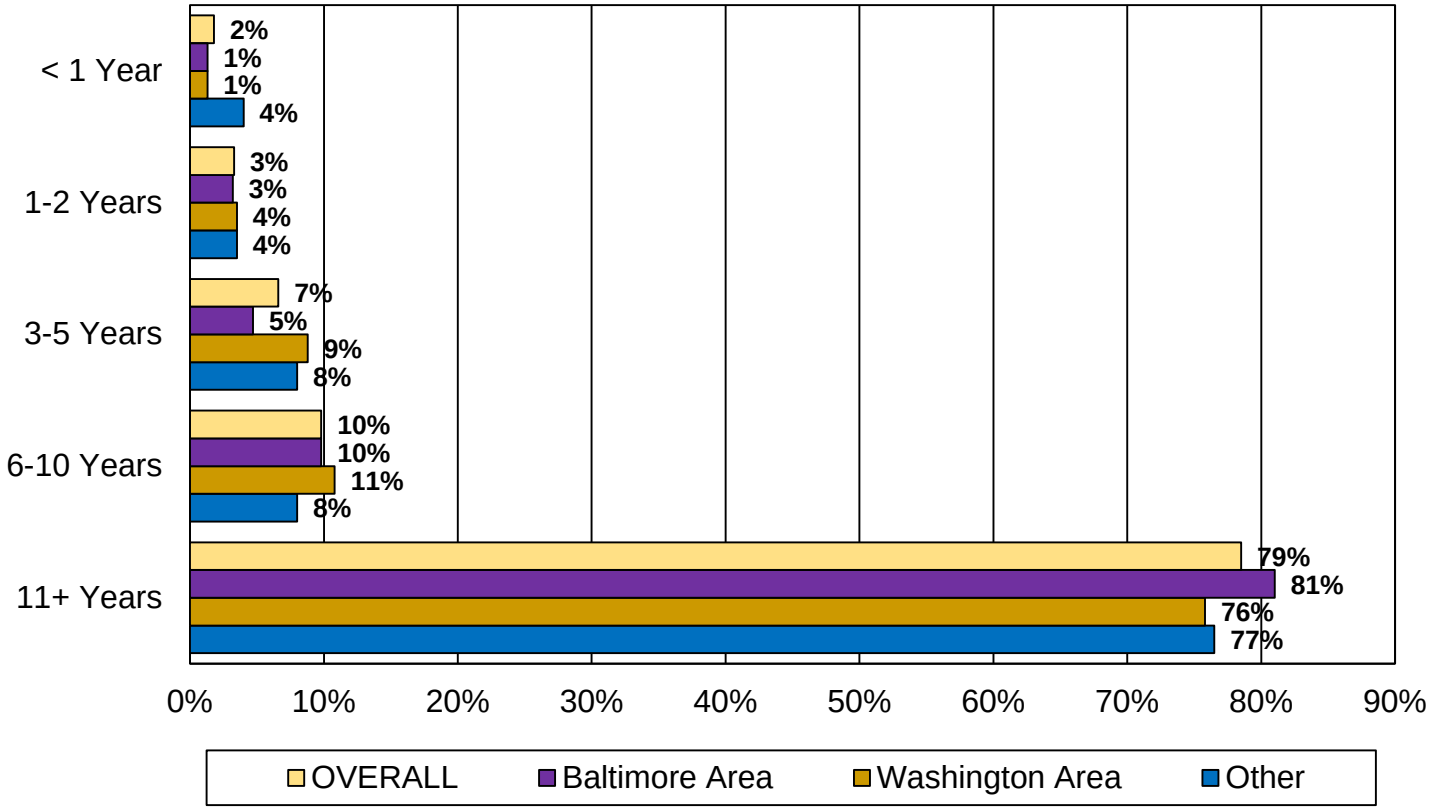
Lowest Ranked Ad

						
OVERALL	1st	2nd	3rd	4th	5th	6th
Baltimore Metro Area	1st	2nd	3rd	4th	5th	6th
Washington Metro Area	Tied for 1st	Tied for 1st	3rd	4th	5th	6th
Other	2nd	1st	3rd	4th	5th	6th

Demographics

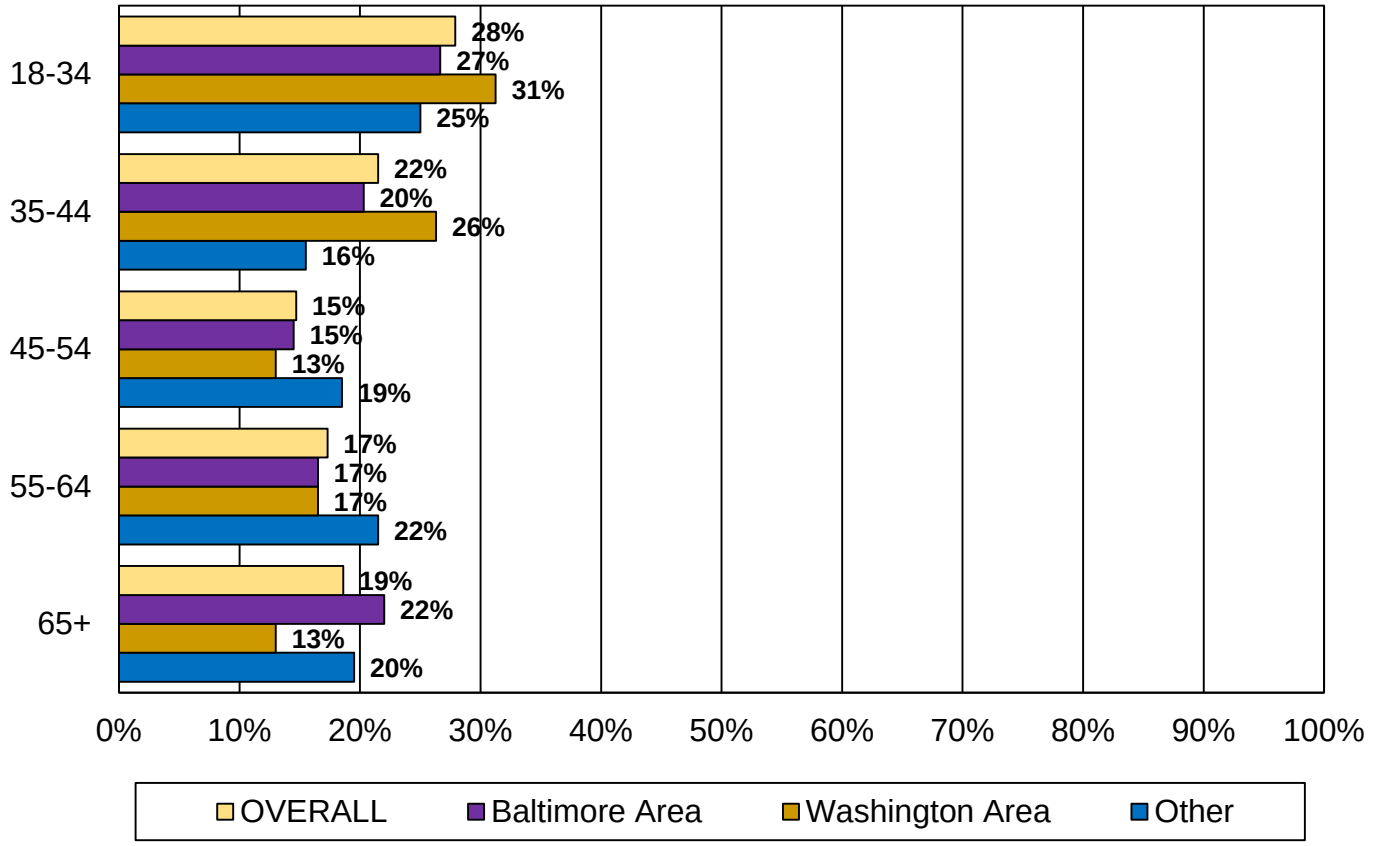
Residency in Maryland

- More than three quarters of residents from each metropolitan area have lived in Maryland longer than 10 years.



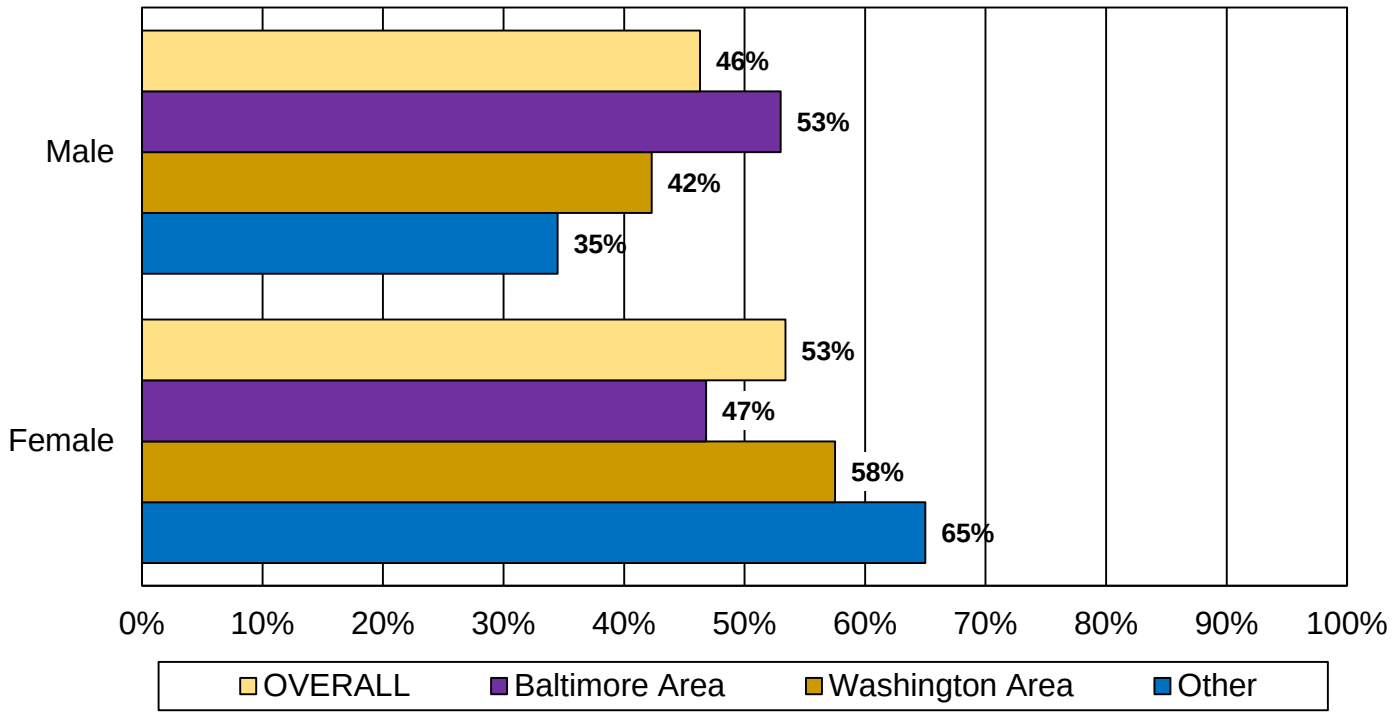
Age

- A broad range of ages were represented within this study.



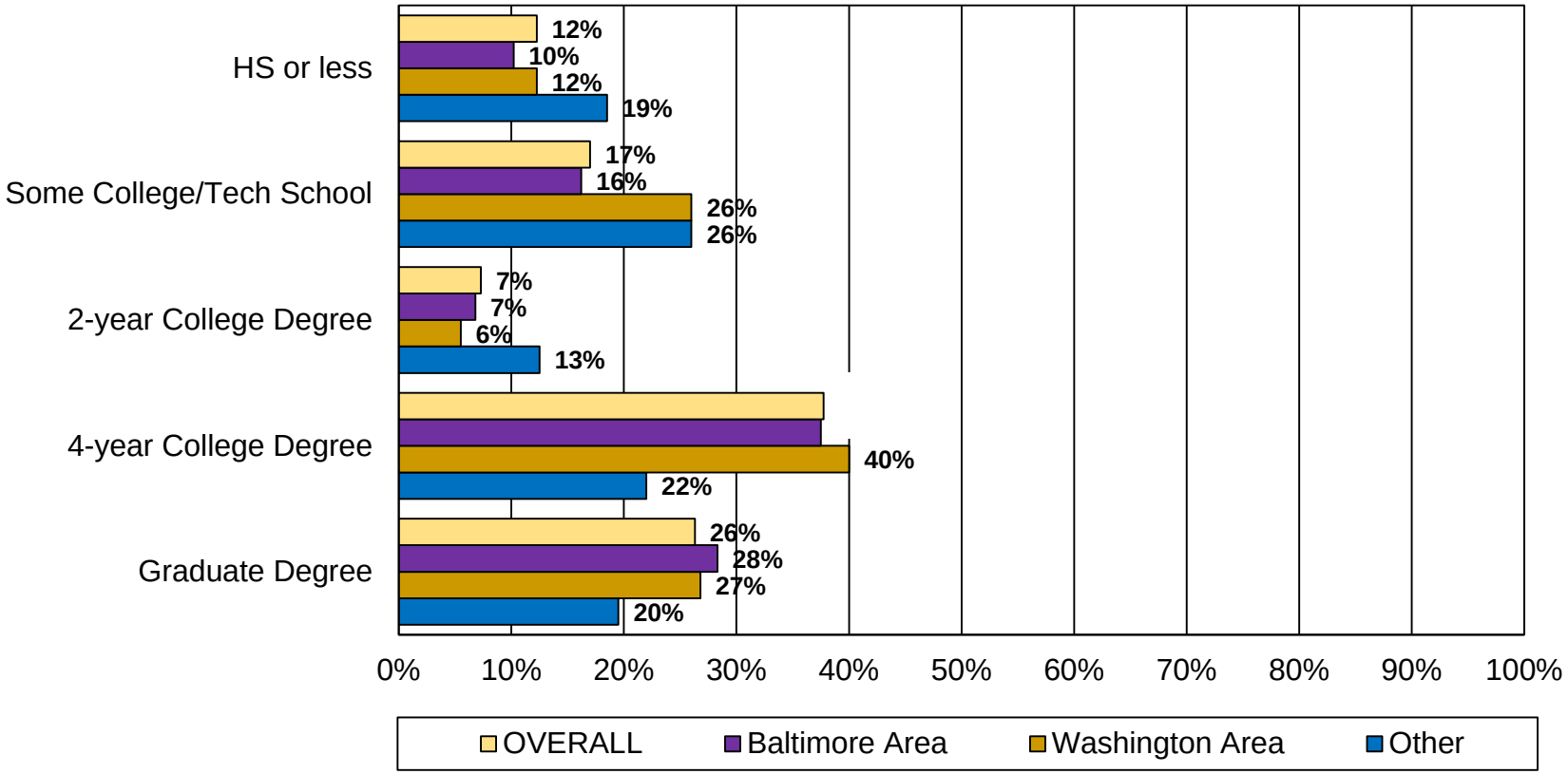
Gender

- The overall gender spread was equitable.



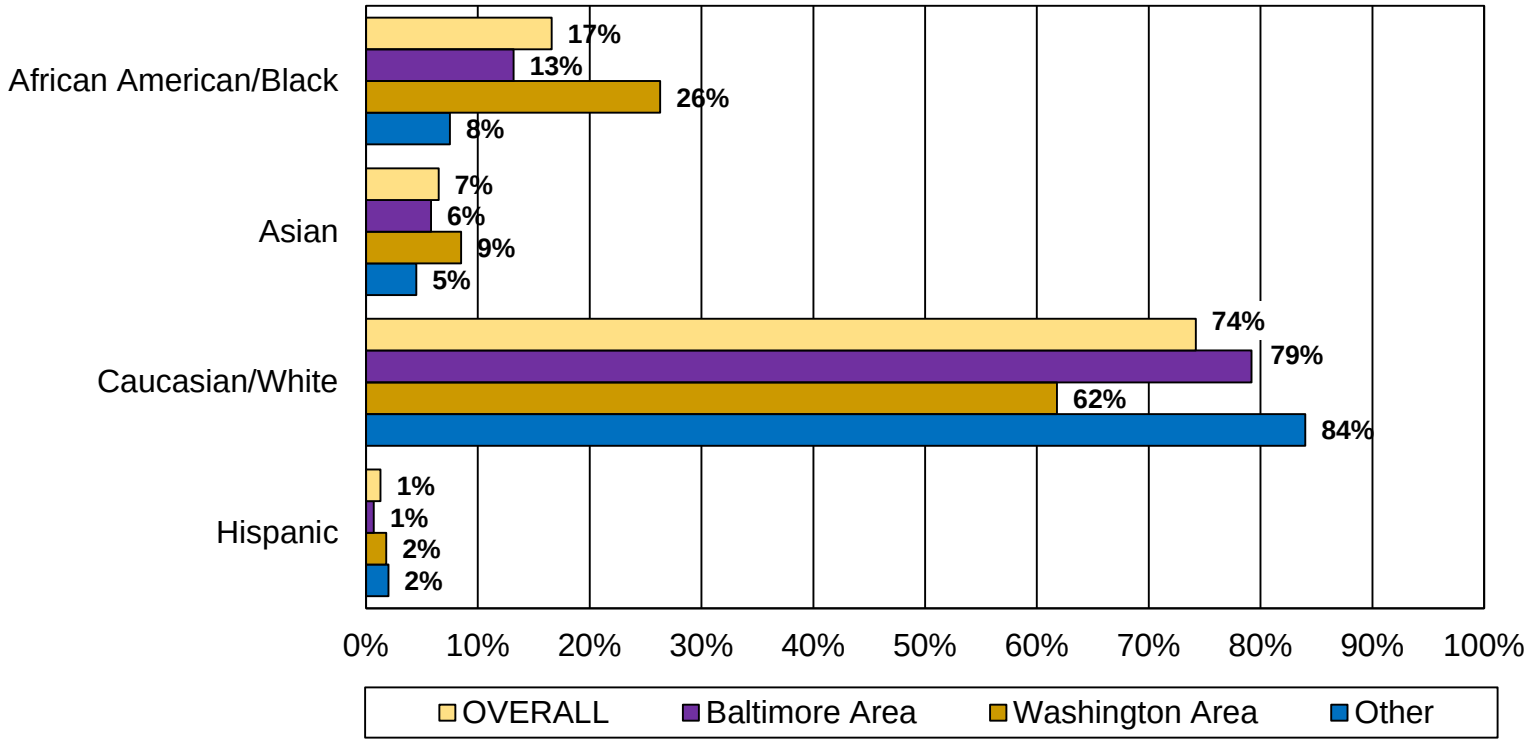
Education

- Respondents reported a wide range of education levels.



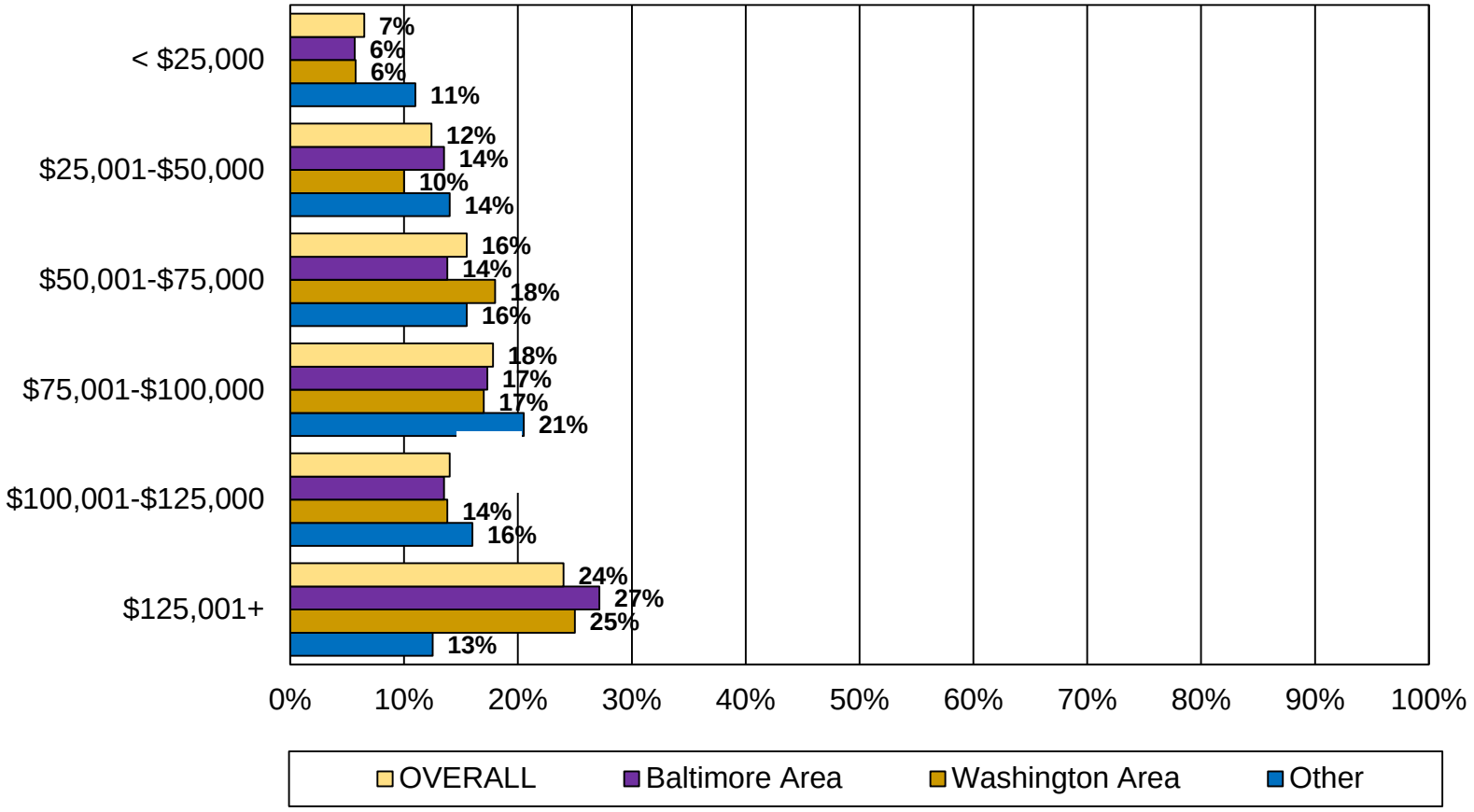
Ethnicity

- Ethnicity rates followed those of Maryland's state census.



Household Income

- A broad range of household income levels were represented by the participants in this study.



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Litter Education Campaign Communication Plan

Maryland Department of Transportation State Highway Administration
Litter Education Campaign
Communication Plan

EXECUTIVE SUMMARY:

Every day in Maryland, litter is tossed and blown onto our interstates, state and county roads. It creates an eyesore for motorists, harms wildlife and their habitats and is a potential hazard for motorists and pedestrians who may be struck by anything from a lit cigarette to a soda bottle. Many of us would never consider littering. Some of us litter most of the time. Almost half of us litter occasionally, but can be persuaded not to.

A critical aspect of year-round highway maintenance is the removal of litter from shoulders and drainage systems. MDOT SHA uses various methods to control litter by utilizing MDOT SHA employees, state workers, contractors as well as labor donated through the Sponsor-A-Highway program and partnerships with Adopt-A-Highway volunteers.

As part of the Municipal separate storm water sewer system discharge permit (MS4), the MDOT SHA is required to address problems associated with litter and floatables in waterways that adversely affect water quality. Increases in trash discharges to receiving waters have become a growing concern both nationally and within Maryland and cannot be ignored.

MDOT SHA needs to evaluate current litter control problems associated with discharges from its storm drain system and develop and implement a public outreach and education program as needed. MDOT SHA has had a multi-faceted existing public education program in place with goals to educate the public on environmental stewardship and reduce littering. This plan presents a recommended three-year marketing strategy to help reduce intentional littering on roadways. It is designed to reach a broad audience to raise and maintain awareness, and to reach targeted audiences contributing to a majority of the problem. It relies heavily on the partnership and involvement of state agencies, local governments and (litter) tax-paying businesses. It plans for media sponsorships and leverages their advertisers. It includes a system to measure campaign outcomes and implementation processes.

RESEARCH:

To raise awareness about the negative environmental impact of littering along Maryland's roads and highways, research was conducted to investigate residents' awareness of littering, the costs associated with littering, people's perceptions about littering, people's motivations for littering, and motivations to stop littering. A strategic, multi-phase market research study research across the State of Maryland was conducted to formulate an appropriate and effective marketing campaign.

Phase I of the research endeavor included qualitative data collection via online, bulletin board focus groups (completed Fall of 2016). Phase II of the research included Follow-up quantitative data collection online surveys. A total of 1,200 surveys were completed among Maryland residents and segmented by geographic regions close or connected to local waterways.

Thematic takeaways produced by this study include the following:

- Litter is a moderate problem where they live.

- Concern for the Chesapeake Bay and other local waterways.
- Certainty that laziness and not caring are why most people who litter do so, which is incredibly frustrating to participants.
- Belief that the responsibility for a clean environment falls upon everyone – cleaning up after ourselves and cleaning up after each other.
- Disgust with the rats and other wildlife that are attracted to the debris.
- Most of the participants also were unaware of what, if any, fines or other punishments could be received for littering upon Maryland's roadways.

AIMS AND OBJECTIVES:

The goal of MDOT SHA is to help people of all ages understand the devastating effects litter has on Maryland's economic development, tourism and quality of life through our educational efforts. Educational awareness prompts behavioral change, which is the only way to permanently prevent littering. We have established the following aims and objectives to affect change:

- Incite behavioral change for waste reduction in the public and business community.
- Promote and support local volunteers and volunteer networks to lead Civic Pride initiatives in their local areas through Adopt a Highway and Sponsor a Highway initiatives.
- Create a sense of ownership among local communities and individuals in waste reduction, waste management and recycling.
- Promote public health through increased community engagement and community involvement in local and regional communities.

The Anti-litter campaign will achieve the above aims by encouraging the following four key changes:

- Awareness: Increase awareness of littering and its impacts.
- Attitudes: Change attitudes toward littering/environmentally damaging activities, increase civic pride and change perceptions of littering and its impacts on the ground.
- Behavior: Reduce the likelihood of littering/environmentally damaging activities.
- Action: Inspiring the public to act to make Maryland cleaner.

Desired Change	Aim	Outcome
Awareness	To raise awareness of littering and other environmentally damaging activities and their impacts and costs To capture the hearts and minds of people across Maryland	Reach at least 60% of the population in Maryland
Attitudes	To change people's attitudes and behavior toward their local environment so that they look after it in a positive way	Establish after a baseline survey is conducted
Behavior	To promote and nurture a sense of civic pride within communities so that everyone takes responsibility for their local environment	Increase levels of litter collected by 25% Increase levels of litter collected through AAH and SAH programs

Desired Change	Aim	Outcome
Action	To create a movement of people who care about where they live and actively demonstrate this through volunteer action as part of opportunities provided	Increased involvement in Adopt a Highway and Sponsor a Highway programs by 20%

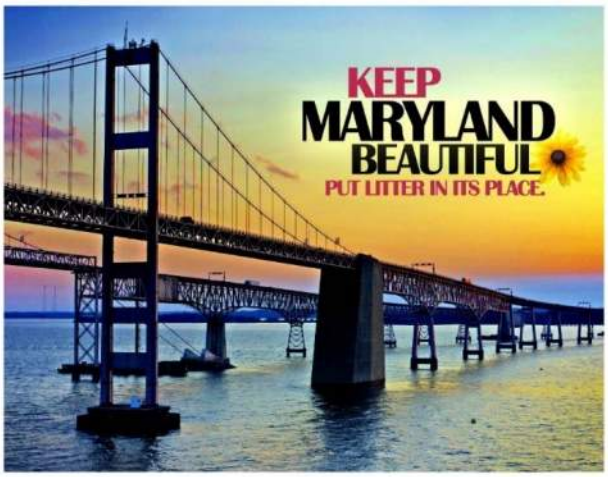
KEY AUDIENCES:

Target audiences for littering include the five segments creating the majority of intentional litter on roadways: motorists or passengers who toss cigarette butts, alcoholic beverage containers, food wrappers and other beverage containers out the window and those who drive pickup trucks and are not properly covering and securing their loads and not cleaning out the back of their pickup trucks prior to driving on roadways. This campaign aims to reach the following audiences:

Audience	Tactic
General public and commuters	Radio, Outdoor, Digital/Social Media, Transit Ads (shelters, interiors)
Business owners	Radio, Outdoor, Outreach to businesses with fleet vehicles
Long-haul dumpers (companies taking trash to landfills)	Posters in offices that utilize landfills; Radio
MDOT SHA employees and other state agencies	Newsletter, email campaign, posters for Earth month and ay to serve support
Schools, Further Education Colleges and Universities	Campus signage and distribution of materials at events with colleges which MDOT SHA has established relationships, AAH and SAH sponsorship with Fraternities and Sororities
Media	Letters to the Editor and on-air interviews with Television and Radio stations
Schools	Contest
Truck drivers	Truck stops, Digital Media
Vacationers	Welcome center displays and messaging, Outdoor, Radio
Volunteer organizations	Phone call and email campaign to garner support and commitment to clean-up/action dates
Stores and other Businesses	Installation of materials in stores (door/window clings, floor graphics) to remind customers about putting litter in its place
Churches Faith Based groups	Phone call and email campaign to garner support and commitment to clean-up/action dates
Sporting, affiliated clubs	Phone call and email campaign to garner support and commitment to clean-up/action dates
Boy and Girl Scout troops	Partnership with Girl Scouts of Central Maryland – design and produce a patch for troops to participate in litter clean up

CAMPAIGN MESSAGING:

Messaging in all aspects of the *Anti-Litter* campaign will be consistent with common elements being "Love the State You're In" and "Put Litter in its Place". These messages impart a sense of personal responsibility to keep the state you are living in clean and beautiful. Based on the research results, photo-realistic imagery was most preferred and the two concepts below were selected by the respondents:



TARGET AREAS:

Based on the conducted research, target areas will be segmented into metropolitan areas as follows:

Baltimore Metro Area	Washington Metro Area	Other
Anne Arundel County Baltimore City Baltimore County Carroll County Harford County Howard County	Charles County Frederick County Prince George's County Montgomery County	St. Mary's County Washington County

TRADITIONAL AND GRASS ROOTS TACTICS:

The primary media strategy will be to build awareness through frequency. To affect behavioral change, the message must be seen and heard many times. The program will focus on two segments: Adults, 18-54 as well as school aged children.

A multi-pronged approach will be implemented:

- Radio (primarily morning and afternoon drive time spots) will be used to build frequency with a mix of :30's and :15 second spots
- Television
- MVA's digital CTM display
- Outdoor – static and digital billboards
- Carvertise – vinyl wrapped vehicles to promote the message to the traveling public while they are in their cars.

- Transit Shelters
- Welcome Centers/ Rest Areas
    - Displays for traveling public
- Social/Digital Media – development of a social and digital media partner toolkit. A dedicated information web page should be created for this campaign.
    - Facebook
    - Twitter
    - Instagram
    - Web Banners
    - Infographics
- Grassroots/Public Outreach
    - Schools
        - Contest for middle and high school kids
            - Unusual litter contest
                - Establish partnership with a business to promote the contest (sports team, environmental type business)
                - Take photos of unusual litter found while participating in an organized cleanup.
            - Video PSA contest
                - Establish a partnership with a local television station to promote the contest or a local sports team (Orioles, Ravens)
    - Litter bag production and distribution – Partnership with a local business for production and distribution of litter bags
    - Fairs and Festivals
        - Participate in events to promote Anti-Litter message, conduct surveys and distribute educational materials and information.
            - State Fair – distribute litter bags, promote Adopt a Highway and Sponsor a Highway programs
            - Sporting events (distribution of litter bag to tailgaters)
            - sponsor sites: fast food restaurants, gas stations, minimarts
            - state agencies/staff: state patrol cars, emission testing stations, licensing facilities, transfer stations and landfills, truck weigh stations, fish and wildlife areas, state parks and recreation areas
            - Events: sports, truck shows, auto shows, concert venues, fairs;
            - Locations associated with driving: car rentals, car washes, automotive supply stores, etc.
    - Community Outreach – actively promote the Adopt a Highway and Sponsor a Highway programs through scout troops and volunteer organizations.
        - Create new materials for these programs

Added Value Opportunities:

Added value opportunities provide a tremendous value to campaigns and are negotiated with all media outlets as a requirement of the buy. Most common added value opportunities are bonus PSAs, events, literature distribution, web banners, on air interviews, talk shows, and promotions. After the buy has been negotiated, Integrated Designs prepares an added value summary outlining the added value elements offered by each station and a list of items that the stations require to execute these elements (i.e., tag copy, interviewees, copy points for news shows/interviews, etc.).

BUDGET:

The proposed budget for the 3-year campaign period is $1,000,000.

CAMPAIGN PERIOD:

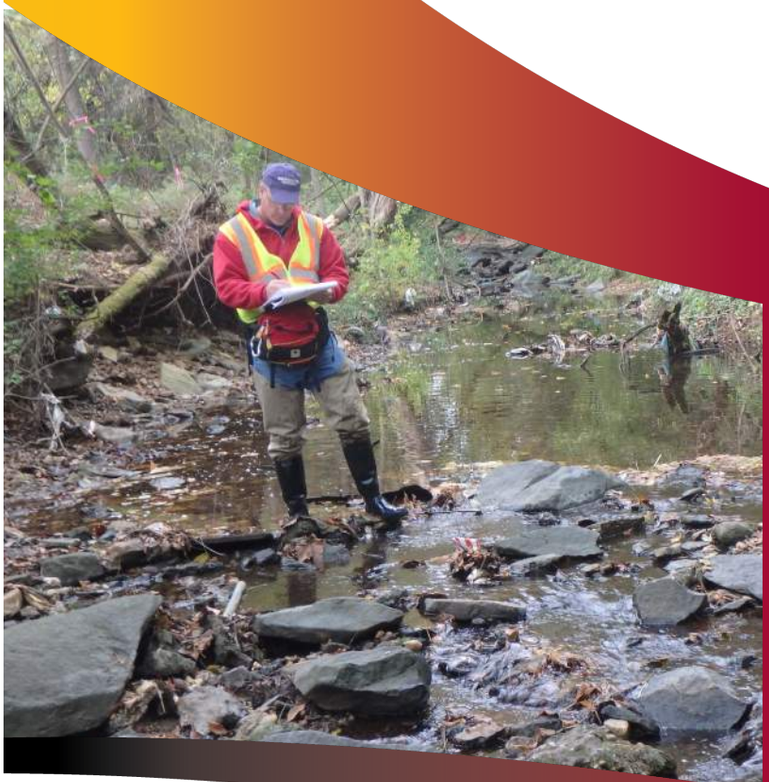
This campaign will be implemented over a year period with first-year efforts concentrating on awareness building. Years two and three will sustain this effort. Advertising periods over the 3-year period will primarily take place in the spring and the fall.

EVALUATION:

Several additional important measurements of efforts are recommended including quantifiable reporting on: reach and frequency data from media; sponsorship and in-kind contributions; press coverage; amount of litter collected through programs; and participation levels of other state agencies. Several of these measures will then be combined with other campaign data to create overall numbers of campaign "impressions" with target audiences. Surveys will also be utilized to measure evaluation of the campaign to evaluate the program and its effectiveness at reaching the target audience, and potentially changing behaviors. A pre-and post-evaluation will be conducted before and after each year to establish baselines and progress toward the goals.

Desired Change	Goal	Results/Outcome
To raise awareness of littering and other environmentally damaging activities and their impacts and costs To capture the hearts and minds of people across Maryland	Reach at least 60% of the population in Maryland	
To change people's attitudes and behavior toward their local environment so that they look after it in a positive way (pre-and post-survey to be conducted)	X% of litter and reporting decreasing likelihood of littering and other behavior	
To promote and nurture a sense of civic pride within communities so that everyone takes responsibility for their local environment	A decrease in litter collected through AAH and SAH programs. (Percentage TBD)	
To create a movement of people who care about where they live and actively demonstrate this through volunteer action as part of opportunities provided	Increased involvement in AAH and SAH programs by 20%	

Appendix F



Research Activity

Appendix F

Research Activity

- Assessment of Stream Restoration Projects F-2
- Meeting Local TMDLs for PCBs F-68
- Inlet Cleaning Pollutant Characterization Study F-85
- Assessment of Bioswale Performance F-93
- Use of Compost to Establish Permanent Vegetation F-159
- Turfgrass – Experimental Field Trials F-171

MARYLAND DEPARTMENT OF TRANSPORTATION™

STATE HIGHWAY ADMINISTRATION

APPENDIX F
RESEARCH ACTIVITY

ASSESSMENT OF STREAM RESTORATION PROJECTS IN MARYLAND

2016-2017 MONITORING REPORT

Assessment of Stream Restoration Projects in Maryland

2016-2017 Report

Prepared for:

Maryland Department of Transportation
State Highway Administration
Highway Hydraulics Division
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June 2017

Table of Contents

Introduction 3
Rationale 3
Project Objective 4
Materials and Methods 5
Site Locations 5
Benthic Macroinvertebrates 5
Benthic Field Sampling Protocols 5
Benthic Laboratory Protocols 6
Benthic Macroinvertebrate Statistical Protocols 6
Physical Habitat Assessment 7
Water Quality 8
Results and Discussion 12
Deep Run (DER) 13
Fahrney Branch (FAB) 23
Israel Creek (ISC) 28
Little Gunpowder River – Unnamed Tributary (UTLGR) 33
Long Draught Branch (LDB) 38
Watkins Mill Road - Unnamed Tributary to Seneca Creek (UTSC) 47
SHA Site Water Chemistry 57
Literature Cited 63

Introduction

The Maryland Department of Transportation, State Highway Administration (SHA) receives state and federal funding for assessment of their stream restoration projects in Maryland. SHA requires scientific support (primarily biological and stream physical habitat) to assess and/or to monitor a selected set of stream restoration projects already completed, or projected to be done in the future, by SHA. Information collected from these studies, undertaken by the Appalachian Laboratory of the University of Maryland Center for Environmental Science, provides a framework and historical database of recommendations for future SHA stream restoration projects, and for the assessment and potential revitalization of existing SHA restoration projects throughout the State of Maryland.

Rationale

Stream restoration is of critical importance to the State of Maryland, as well as to the entire Chesapeake Bay watershed, and beyond. The overall quality of life, now and in the future, is highly dependent on aquatic ecosystem integrity for both the quantity and quality of freshwater resources (Simon 1999). The integrity of surface water resources is dependent on chemical variables, flow regimes, biotic factors, energy sources and habitat structure (Karr et al. 1986). Over the last quarter century, numerous surveys of fish and benthic communities assessed general freshwater ecosystem health (see Simon 1999). Significant advances in this arena led to the development of integrative ecological indices, such as the Indices of Biotic Integrity (IBIs), which relate fish communities to both biotic and abiotic ecosystem components (Karr 1981, Karr et al. 1986). Coupled with chemical-physical water quality attributes, habitat quality (and often quantity) is important to consider when examining fish and benthic communities, especially for any and all derived IBIs (Yoder and Smith 1999).

Stream restoration strongly focuses on the revitalization of physical habitat. However, indices of habitat quality to assess post-restoration processes have lagged behind both fish and benthic IBI development. In part, this is because of the difficulty in developing accurate, precise and complete methodologies that quantitatively and qualitatively assess habitat characteristics (Platts 1976, Platts et al. 1983). The impetus for including stream habitat as an important field measure came initially from many western U.S. restoration activities (reviewed in Platts et al. 1983). For example, Binns (1979) developed a Habitat Quality Index for trout streams in Wyoming, soon to be followed by Habitat Evaluation Procedures models (HEP) and Habitat Suitability Index models (HSI) for use with the U. S. Fish and Wildlife Service instream flow models. Important improvements in more generalized stream habitat models came with the development of the EPA Rapid Bioassessment Protocols (Plafkin et al. 1989) and the Ohio EPA Qualitative Habitat Evaluation (Rankin 1989).

Wallace (1990) points out that there are a number of factors to consider in looking at stream recovery, especially in light of recent restoration attempts for lotic systems. Recolonization of a

disturbed or restored area is a function of many factors, often depending on stream size. Implicit in restoration is that long-term stream physical stability eventually recovers. However, benthic macroinvertebrates respond to many disturbances, and restoration processes directed towards only the physical habitat may not take into account other critical stressors present within the watershed. The importance of nearby biotic refugia, as a source for recolonization is also critical, especially upstream refugia and potentially the presence of either downstream or nearby lateral watershed refugia (Wallace 1990).

Hall et al. (1999, 2002) initially developed a Physical Habitat Index for Maryland using data collected from the first round of the Maryland Biological Stream Survey (MBSS), soon followed by the development of a revised Physical Habitat Index for Maryland (Paul et al. 2002). Coupled with the development of fish IBIs (Roth et al. 1998) and benthic IBIs (Stribling et al. 1998) from the MBSS data set, powerful analytical tools are now available to assess stream integrity in Maryland, and to examine efficiency of stream restoration. These biotic indices were robust, and allowed inferences on stream integrity and stability, either regionally, statewide or at site-specific levels. In addition, these indices were even more refined with additional MBSS rounds completed, especially with the development of coldwater fish IBIs and a finer level of benthic IBIs (Southerland et al. 2005, 2007).

Functional rehabilitation of degraded streams is critical, since streams provide multiple environmental benefits, as well as critical ecological services (Morris and Moses 1999, National Research Council 1992). Functional rehabilitation is the major key to stream restoration since a return to pre-colonization stream status is impossible, especially in Maryland, where complex spatial and temporal patterns of land use have evolved since pre-colonial days (and perhaps even before European colonization). However, careful analytical evaluation of stream restoration or enhancement projects is often lacking (Downs and Kondolf 2002, Morgan 2005, Roberts et al. 2016). Monitoring these stream projects often serves as an important “first step” in evaluating effectiveness, and is essential to adaptive resource management (Bash and Ryan 2002). Downs and Kondolf (2002) and Morgan (2005) noted that post-project appraisals, or evaluations of restoration effectiveness, are critical to assess both the short-term and long-term performance attainment of stream restoration projects. Often, this critical step is lacking in the majority of stream restoration projects (Downs and Kondolf 2002).

For SHA stream restoration activities, project analyses completed from 1998 to 2010 were discussed in Morgan et al. (2010). Within this 2010 report, eight key recommendations for the assessment improvement of SHA stream restoration projects were described.

Project Objective

The overall project objective is to assess and monitor completed and proposed SHA stream restoration projects and to make recommendations for future restoration projects, as well as for

the improvement and revitalization of current restoration projects. In addition, a monitoring schedule for examining all completed stream restoration projects in the long-term (5, 10, and 25 years) was developed based on results for each SHA stream restoration site, and is in constant refinement with new sites added as needed, and older sites revisited (Morgan et al. 2010).

Materials and Methods

Site Locations

Site details for each SHA restoration location are described in the results and discussion section. Control sites are often very difficult to find in highly developed urban watersheds or in headwater streams. We always attempted to find control sites upstream of pre-restoration or post-restoration sites; however, many of these restoration sites were in the extreme upper part of a watershed and did not reflect the restoration area, or there were changes in control sites during the study. To compensate for this problem, we employed data from all rounds of the MBSS for comparison to the restoration site. Normally, one would try to collect samples where the condition is present and where it is absent, with all other factors being the same (Green 1979). This approach determines an effect at a site relative to a control. However, there is so much anthropogenic activity in the landscape of the coastal plain and Piedmont, as well as other physiographic provinces of Maryland, that watersheds are strongly altered through time and space. It may be necessary at some sites to move downstream into the lower part of a watershed and then determine current conditions to assess the upstream site, or to assess if refugia are present for recolonization. However, this is not the preferred approach.

Benthic Macroinvertebrates

Assessment of benthic macroinvertebrates at each sampling site followed benthic macroinvertebrate protocols for MBSS sampling (Kazyak 1996, Stranko et al. 2010). At each pre-construction or post-construction project, two benthic samples (~ 10-20 sweeps each with D-nets depending on stream size) were taken within the project boundary after site surveys (lower and middle sections, if possible). One sample was always collected near the lower (downstream boundary) of the project. The middle sample was collected approximately one-third to one-half of the distance from the upper upstream boundary of the project (benthic sampling was frequently modified dependent on specific stream site characteristics). One or two additional samples, serving as replicate controls, were collected upstream of the stream restoration project, assuming that the upstream area served as a suitable control area. If no suitable upstream control was present, one or two site samples were taken downstream. For any pre-construction sites, two benthic samples were taken within the proposed project boundaries, along with one or two control samples from an upstream area (or downstream area) if possible. We also identified a number of MBSS reference streams to provide biotic baselines for benthic invertebrate quality for the stream restoration project.

Benthic Field Sampling Protocols

A series of D-net samples (a total of ~ 1-2 m^2 sampling area each) were taken at every sampling

location (Kazyak 1996), with an emphasis on selecting riffle/run habitat. Benthic macroinvertebrate sampling was conducted in order to qualitatively describe the community composition and relative abundance in favorable habitats. All survey methods for benthic macroinvertebrates followed MBSS protocols (Kazyak 1996), with benthic samples, as often as possible, collected from stream riffle areas because this is typically the most productive habitat in stream ecosystems. When riffle habitat was not present, other habitats sampled in the following order of preference were: gravel/broken peat and/or clay lumps in run areas; snags/logs that create partial dams or are in run habitat; undercut banks and associated root mats in moving water; submerged aquatic vegetation and associated bottom substrate in moving water; and detritus/sand areas in moving water. In the field, samples were carefully transferred to polyethylene bottles and preserved in denatured ethanol. These benthic samples were collected during the MBSS spring index period and during the MBSS fall index period (Kazyak 1996), weather conditions permitting.

Benthic Laboratory Protocols

In the laboratory, benthic samples were washed and picked, with the sorted organisms stored in 70% isopropyl alcohol. The first 300 organisms (to the nearest grid) were picked for identification to the lowest taxon possible (Plafkin et al. 1989), with the first 100 organisms separated for the calculation of the MBSS BIBI. Only the 100 organism sample was used for MBSS metric calculations since the development of the MBSS BIBI was based on this sample number. The first 300 organisms were used for the EPA RBP III calculations. If the sample contained less than 300 organisms, the sample was picked completely. In any report table, an asterisk (or a mention in the report) denotes either a lack of 100 organisms in the benthic sample for the MBSS BIBI, or a lack of 300 organisms for the EPA RBP III protocol.

Benthic Macroinvertebrate Statistical Protocols

MBSS - A revised Maryland benthic index of biotic integrity (BIBI) was employed for all SHA stream restoration projects (Southerland et al. 2005, 2007). The new BIBI was broken into the Coastal Plain, Eastern Piedmont and Combined Highlands strata (Table 1). For any of these three MBSS strata, BIBI scores were determined by adding the threshold score for each benthic metric, and then dividing by the number of metrics for each stratum. The BIBI determined at each station was compared to all control sites as well as to any MBSS reference stations located in the vicinity of the SHA project. A BIBI score range of 4.0 - 5.0 was rated as good, 3.0 - 3.9 was fair, 2.0 - 2.9 was poor, and 1.0 - 1.9 was very poor (Table 2).

EPA RBP III – Benthic metrics were also derived using the EPA RBP III procedures, employing a 300 + organism count (Plafkin et al. 1989, Klemm et al. 1990, Barbour et al. 1999). The derived metrics are: taxa richness = the total number of taxa recognized; Hilsenhoff Biotic Index = the tolerance value of each macroinvertebrate multiplied by the number of those individuals and then the sum of the products divided by the total number of specimens (see Table 3); the ratio of scraper and filtering collector functional feeding groups; the ratio of the shredder

functional feeding group to total number of individuals; the ratio of total number of Ephemeroptera, Plecoptera, and Trichoptera (EPT) individuals to total Chironomidae; the EPT Index equals the number of distinct taxa present within the orders Ephemeroptera, Plecoptera and Trichoptera; and the percent contribution of the dominant taxon in the riffle community. BIBI scores were not calculated for the EPA RBP III 300 + procedure, since this metric was not developed for this benthic assessment protocol, and would require rescaling of the scoring criteria.

Physical Habitat Assessment

Stream physical habitat data is an essential component of any stream biological assessment program. Habitat data is normally used to assess trends in water quality and to investigate the influence of land use practices that may affect stream water quality. Habitat assessments, based on an earlier MBSS protocol (Kazyak 1996), were performed at all SHA sites in order to determine biological integrity and fishability. Although there are now revised physical habitat metrics for the MBSS (Paul et al. 2002), the Maryland physical habitat index (MPHI), as developed by Hall et al. (1999, 2002) based on MBSS fish IBI data sets, was calculated and compared to control areas and to MBSS reference data in the vicinity of the SHA project. This approach was used to maintain consistency in the physical habitat index measurement over time, especially for those SHA sites being revisited since the earliest SHA site assessments were initiated in the of Fall 1998 (Morgan et al. 2010).

A number of variables were assessed qualitatively at each site. These include the following: instream habitat, epifaunal substrate, velocity/depth diversity, pool/glide/eddy quality, riffle quality, channel alteration, bank stability, embeddedness, channel flow status, and shading (scores assigned for each metric). Observations of the surrounding area were used to evaluate aesthetic value (based on amounts of human refuse) and remoteness (based on ease of access and presence of human activity). The presence, or absence, of other stream habitat features (i.e., morphological characteristics, stream channelization, woody debris, and land uses visible from each site) was also recorded for each site. In the field, physical habitat assessments were integrated across controls and across the stream restoration areas.

Physical habitat metrics with the best discriminatory power for SHA coastal plain sites were: instream habitat, velocity/depth diversity, pool/glide/eddy quality, embeddedness, maximum depth and aesthetic rating. The final index calculations for the coastal plain weighed all metrics equally except embeddedness, maximum depth, and aesthetics that were weighted ½. The final equation used for the coastal plain habitat index (CPPHI) was:

CPPHI= (instream habitat + velocity/depth diversity + pool quality
– embeddedness/10+ maximum depth/10+ aesthetics/2)/ 6.

Physical habitat metrics with the best discriminatory power for SHA non-coastal plain sites (primarily Piedmont sites) were: instream habitat, velocity/depth diversity, riffle/run quality, embeddedness, number of rootwads and aesthetic rating. All metrics were weighted equally except embeddedness (weighted ½) and aesthetics (weighted $^1/_3$). The final equation used for the non-coastal plain habitat index (NCPHI) was:

NCPHI= [instream habitat + velocity/depth diversity + riffle/run quality – embeddedness/10 + 3(number of rootwads) + aesthetics/3]/ 6.

Each metric was calculated by site (metrics were integrated across the controls and the restoration sites) and a statistically based algorithm was used to convert the physical habitat score to centiles (Hall et al. 1999, 2002). Physical habitat categories were defined as: good being > 72 (> 50th centile), fair 42-72 (30th to 50th centile), poor 12-42 (10th to 30th centile) and very poor < 12 (10th centile).

In addition, digital images were often taken at each site to document selected stream habitat features; these images were periodically forwarded to SHA for archiving. All site maps and coordinates were generated through Google^{TM}earth and MS PowerPoint.

Water Quality

Baseflow water quality samples were taken at each SHA site for the determination of water quality parameters following the standard analyses performed for the MBSS, in addition to some new MBSS analytes for the fourth round of random sampling. These samples were taken following current MBSS protocols during the Spring and Fall sampling at each site, with samples transported to the Appalachian Laboratory for laboratory analyses. We calculated the 10th – 90th percentile range for each analyte based on the data base for all random sites in the MBSS program taken during the first three random site rounds.

For CY 2016 and 2017, we installed an Onset HOBO® U24 temperature-conductivity probe in the uppermost section (south side of I-270) of the unnamed tributary to Seneca Creek (Watkins Mill) to estimate temporal changes in conductivity that were potentially related to road salt usage along I-270. Data from the probe was downloaded monthly and transferred to an Excel spreadsheet for graphical analysis using Statistica.

Table 1. MBSS BIBI for Maryland by stratum and with metric scoring thresholds.			
Stratum and Metric	**Thresholds**		
	1	**3**	**5**
Coastal Plain (7)			
Number of taxa	< 14	14-21	≥ 22
Number of EPT taxa	< 2	2-4	≥ 5
Number of Ephemeroptera taxa	< 1	1-1	≥ 2
Percent intolerant to urban	< 10	10-27	≥ 28
Percent Ephemeroptera	< 0.8	0.8-10.9	≥ 11
Number of scraper taxa	< 1	1-1	≥ 2
Percent climbers	< 0.9	0.9-7.9	≥ 8
Eastern Piedmont (6)			
Number of taxa	< 15	15-24	≥ 25
Number of EPT taxa	< 5	5-10	≥ 11
Number of Ephemeroptera taxa	< 2	2-3	≥ 4
Percent intolerant to urban	< 12	12-50	≥ 51
Percent Chironomidae	> 63	4.7-63	≤ 4.6
Percent clingers	< 31	31-73	≥ 74
Combined Highlands (8)			
Number of taxa	< 15	15-23	≥ 24
Number of EPT taxa	< 8	8-13	≥ 14
Number of Ephemeroptera taxa	< 3	3-4	≥ 5
Percent intolerant to urbanization	< 38	38-79	≥ 80
Table 1 Continued.			

Percent Tanytarsini	< 0.1	0.1-3.9	≥ 4
Percent scrapers	< 3	3-12	≥ 13
Percent swimmers	< 3	3-17	≥ 18
Percent Diptera	> 50	27-49	≤ 26

Table 2. Narrative descriptions of stream biological integrity associated with each of the BIBI (or FIBI) scores.

Good	BIBI score 4.0 - 5.0	Comparable to reference streams considered to be minimally impacted. Fall within the upper 50% of reference site conditions.
Fair	BIBI score 3.0 - 3.9	Comparable to reference conditions, but some aspects of biological integrity may not resemble the qualities of these minimally impacted streams. Fall within the lower portion of the range of reference sites.
Poor	BIBI score 2.0 - 2.9	Significant deviation from reference conditions, with many aspects of biological integrity not resembling the qualities of these minimally impacted streams, indicating some degradation.
Very Poor	BIBI score 1.0 - 1.9	Strong deviation from reference conditions, with most aspects of biological integrity not resembling the qualities of these minimally impacted streams, indicating severe degradation.

Table 3. Descriptions for the Hilsenhoff Biotic Index scores (Hilsenhoff 1987).

Biotic Index Range	Water Quality
0.00 - 3.50	Excellent
3.51 - 4.50	Very Good
4.51 - 5.50	Good
5.51 - 6.50	Fair
6.51 - 7.50	Fairly Poor
7.51 - 8.50	Poor
8.51 - 10.0	Very Poor

Results and Discussion

Each current SHA stream restoration project evaluated in 2016-2017 (FY17) will be reviewed, discussed and synthesized into the context of regional Maryland values, as derived from the Maryland Biological Stream Survey (all rounds). Basic field information collected at each SHA site for FY17 is included within each site summary. In addition, water quality data collected at each SHA site is discussed in a separate section.

In past reports, summary lists of all benthic invertebrates collected at each SHA restoration site (all controls plus the middle restoration and lower restoration samples) were included within each discussion for that site, and then attached as appendices in later reports. However, these benthic taxa data lists are not included in this FY17 report, as well as will not be included in any future reports to SHA, in order to reduce excessive tables within the report itself. These benthic data lists are physically and electronically archived at the Appalachian Laboratory, as well as site samples along with any voucher specimens for benthic macroinvertebrates (a specimen voucher set is maintained for all AL benthic macroinvertebrate projects). All benthic samples for a SHA site are retained for three years.

Any cell within the benthic summary tables marked with an asterisk indicates that fewer than 100 organisms (MBSS protocol) were present in the benthic sample for that site. For the EPA RBP III 300 + samples, metric calculations were not done if less than 100 organisms were present in the sample. Within each sampling year (FY), there were frequently benthic samples with greater than 100 organisms but less than 300 organisms present.

Deep Run (DER)

Site Description - Deep Run is a second order stream at the restoration and control sites sampled using MBSS field methods (Figure DER 1). Deep Run eventually becomes a third order tributary of the Patapsco River, which then directly inputs into the Chesapeake Bay through Baltimore Harbor. Deep Run is located within the Patapsco River watershed, which extends from the Chesapeake Bay south of Baltimore, MD northward to Westminster, MD. The Deep Run basin lies within both the Piedmont and Coastal Plain Physiographic Regions of Maryland.

The restoration site was located about 5 meters downstream of O'Connor Drive (Figure DER 1). Above O'Connor Drive, the stream flows through a culvert under the railroad tracks. Most of the banks along this section of stream were in poor to fair condition. Some stream restoration work that was conducted on this section of Deep Run has been altered or otherwise damaged by high flow events due to the high percentage of urban land use in the upper watershed.

Deep Run Site Coordinates:

Site coordinates (in degrees) for Deep Run (Figure DER 1).			
Station	Latitude (N)	Longitude (W)	Comments:
Middle	39.179152	-76.744361	Middle restoration site.
Lower	39.179238	-76.743249	Lower restoration site.
Alpha Control	39.179326	-76.745764	Upstream Control One.
Beta Control	39.179542	-76.746400	Upstream Control Two.

Figure DER 1. Site locations for sampling of Deep Run (DER) in Anne Arundel County during FY 17.

Fall 2016 DER Benthic Community: For the MBSS subsamples with a 100 + macroinvertebrate count, taxa richness, the number of ephemeropteran taxa, and percent Ephemeroptera were moderate at all four stations on Deep Run (Table DER 1). The total EPT taxa were high at Alpha Control and moderate at the three remaining stations, with *Cheumatopsyche* sp. larvae dominating the EPT collections at all sites. The number of scraper taxa was high at the Beta Control site and moderate at the remaining sites. The clam *Ferrissia* sp. was the most commonly collected scraper. The percent of climbers was high, while the percent of macroinvertebrates intolerant of urban conditions was low at all stations. Baetid nymphs were the dominant climbers collected. The BIBI ranged from 3.0 at the two restoration sites to 3.3 at the two control sites in FY17 – all values in the fair range.

Table DER 1. Data summary of benthic macroinvertebrates collected in D-frame samples on September 2016 at four stations on Deep Run.

Coastal Plain Metrics	Deep Run Riffle Community (MBSS 100 + subsample)			
	Alpha Control	Beta Control	Lower Restoration	Middle Restoration
Taxa Richness	20	18	20	16
Total EPT Taxa	6	4	4	4
Ephemeroptera taxa	1	1	1	1
% Intolerant Urban	0.10%	0.0%	0.0%	0.0%
% Ephemeroptera	6.7%	1.0%	3.9%	7.0%
Number of Scraper Taxa	1	2	1	1
% Climbers	13.5%	15.7%	8.8%	9.0%
BIBI	3.3	3.3	3.0	3.0

For benthic subsamples with a RBP III 300 + count, abundance was low at the Lower Restoration site so less than 300 macroinvertebrates were obtained from the entire sample (Table

DER 2). Taxa richness ranged from 23 at the Beta Control to 25 at the three remaining sites. The Hilsenhoff Index ranged from 5.7 at Alpha Control and Middle Restoration to 6.0 at Beta Control. The ratio of scrapers to filtering collectors was lowest (0.04) at the Middle Restoration site and highest (0.36) at Beta Control. *Ferrissia* sp. and *Stenelmis* sp. were the most dominant scrapers while *Cheumatopsyche* sp. larvae were the most abundant filtering collector seen. Various dipteran larvae were the dominant shredders collected at all four sites. The ratio of shredders to total individuals was lowest (0.01) at the Alpha Control and highest (0.08) at the Lower Restoration. The number of EPT taxa collected at Alpha Control was five while four were collected at the remaining stations. *Cheumatopsyche* sp. larvae were the dominant EPT macroinvertebrate collected. The percent contribution of the dominant taxon, *Cheumatopsyche* sp. was 30.7%, 30.0%, and 26.9% at Alpha Control, Beta Control, and Middle Restoration sites, respectively. Chironomidae larvae, too immature for further identification, were the dominant macroinvertebrate (23.0%) collected at the Lower Restoration site on Deep Run.

Table DER 2. Data summary of benthic macroinvertebrates collected in D-frame samples on September 2016 in Deep Run.

Metrics	Deep Run Riffle Community (RBP III 300 + subsample)			
	Alpha Control	Beta Control	Lower Restoration	Middle Restoration
Taxa Richness	25	23	25*	25
Hilsenhoff Biotic Index	5.7	6.0	5.8*	5.7
Ratio Scrapers to Filtering Collectors	0.10 (9.6%)	0.36 (36%)	0.15 (15%)*	0.04 (4.3%)
Ratio Shredders to Total Individuals.	0.01 (1.2%)	0.04 (4.2%)	0.08 (7.7%)*	0.03 (3.2%)
Total EPT Individuals to Total Chironomids.	1.58 (158%)	2.32 (232%)	1.48 (148%)*	1.57 (158%)
EPT Index	5	4	4*	4
Percent Contribution of Dominant Taxon	30.7%	30.0%	23.0%*	26.9%

Spring 2017 DER - For subsamples with a MBSS 100 macroinvertebrate count, taxa richness and percent climbers were moderate at all stations (Table DER 3). Chironomid larvae (*Polypedilum* sp. and *Tanytarsus* sp.) were the dominant climbers. No ephemeroptera taxa or intolerant macroinvertebrates were found at any of the stations in Spring 2017. The number of

total EPT taxa was low at the Beta Control site and moderate at the three remaining sites. The dominant EPT taxa were hydropsychid larvae (*Cheumatopsyche* sp. and *Symphytopsyche* sp.). Scraper taxa were high at the Lower Restoration site and moderate at the remaining stations. Elmid larvae were the most commonly collected scraper taxon. The BIBI ranged from 1.9 at the Beta Control site to 2.4 at the Lower Restoration site.

Table DER 3. Data summary of benthic macroinvertebrates collected in D-frame samples on March 2017 at stations in Deep Run.

Coastal Plain Metrics	Deep Run Riffle Community (MBSS 100 + subsample)			
	Alpha Control	Beta Control	Lower Restoration	Middle Restoration
Taxa Richness	14	16	15	18
Total EPT Taxa	2	1	3	3
Ephemeroptera taxa	0	0	0	0
% Intolerant Urban	0.0%	0.0%	0.9%	0.0%
% Ephemeroptera	0.0%	0.0%	0.0%	0.0%
Number of Scraper Taxa	1	1	2	1
% Climbers	5.9%	5.6%	4.8%	2.8%
BIBI	2.1	1.9	2.4	2.1

For subsamples with a RBP III 300 + count, taxa richness ranged from 21 at Alpha Control to 26 at the Lower Restoration site (Table DER 4). The Hilsenhoff Index ranged from 5.7 at the two control stations to 6.3 at the Lower Restoration station. The ratio of scrapers to filtering collectors was lowest, 0.05 (5.0%), at the Alpha Control site and highest, 0.53 (53.5%), at the Lower Restoration site. Elmid larvae were the dominant scrapers while *Cheumatopsyche* sp. and *Symphytopsyche* sp. larvae were the most abundant filtering collectors seen. Dipteran larvae

were the dominant shredders collected at all sites. The ratio of shredders to total individuals ranged from 0.01 (0.6%) at the Middle Restoration station to 0.02 (1.8%) at Alpha Control. The number of EPT taxa collected was lowest (2) at Beta Control and highest (4) at the two restoration sites. *Cheumatopsyche* sp. and *Symphytopsyche* sp. larvae were the dominant EPT macroinvertebrates collected. *Orthocladius* sp. larva was the dominant taxon collected at all the sites.

Table DER 4. Data summary of benthic macroinvertebrates collected in D-frame samples on March 2017 in Deep Run.

Metrics	Deep Run Riffle Community (RBP III 300 + subsample)			
	Alpha Control	Beta Control	Lower Restoration	Middle Restoration
Taxa Richness	21	23	26	23
Hilsenhoff Biotic Index	5.7	5.7	6.3	5.9
Ratio Scrapers to Filtering Collectors	0.05 (5.0%)	0.33 (33.3%)	0.53 (53.3%)	0.13 (12.5%)
Ratio Shredders to Total Individuals.	0.02 (1.8%)	0.01 (1.3%)	0.01 (0.7%)	0.01 (0.6%)
Total EPT Individuals to Total Chironomids.	0.04 (4.3%)	0.03 (2.5%)	0.05 (4.7%)	0.09 (8.6%)
EPT Index	3	2	4	4
Percent Contribution of Dominant Taxon	57.9%	63.0%	35.1%	41.5%

Physical Habitat Assessment - Deep Run is located within the Patapsco River basin, which extends from the Chesapeake Bay south of Baltimore, MD north to Westminster, MD, and spans both the Piedmont and Coastal Plain Physiographic Regions. IN FY17, the MPHI for the Alpha Control was 35.2 (Poor), with an MPHI of 60.7 (Fair) for the Middle Restoration site (Table DER 5). The control sites were influenced by commercial and industrial operations, as well as the railroad. Exotic vegetation was commonly observed throughout the control site.

The Middle Restoration site was also influenced by local commercial operations, as well as being bordered on the west side of Deep Run by an open grass field, which happened to have a sewer line running in very close proximity to the stream. In the lower restoration section of Deep Run, there was better buffer along with numerous deciduous trees. Shading in this area was good to excellent.

There was the presence of past overland flow, as evidenced by material deposition above the bank (Figure DER 2). Most of this material was silt and fine sand, with some gravel and small cobble present. This area was slightly downstream of O'Connor Drive on the east bank of Deep Run, and was the only major section with this deposit present. Many of the constructed stream structures were found throughout the restoration area, and many were still functioning, assisting in stabilizing the stream (Figure DER 3). There was some breakdown of the woody material employed, but these structures were stable.

Table DER 5. Summary of Fall and Spring benthic, earlier Summer fish sampling and Spring physical habitat for Deep Run from Fall 1998 through Spring 2017. In previous work, fish were collected at both control areas, with the MPHI taken in the same area as the fish samples.

Station	Fall BIBI	Spring BIBI	FIBI	MPHI
Control Site No. 1	3.6 (98-99)	1.9 (98-99)	3.75 (98-99)	32.9 (98-99)
	2.1 (99-00)		3.25 (99-00)	38.3 (99-00)
Alpha Control	**3.3 (16-17)**	**2.1 (16-17)**		**35.2 (16-17)**
Control Site No. 2	2.7 (99-00)	1.9 (99-00)		
	3.3 (00-01)	2.1 (00-01)	3.75 (00-01)	70.4 (00-01)
	3.9 (01-02)	1.3 (01-02)	3.50 (01-02)	78.9 (01-02)
	3.0 (02-03)	2.4 (02-03)	3.75 (02-03)	77.4 (02-03)
	NS	1.6 (03-04)	4.00 (03-04)	27.2 (03-04)
	2.7 (04-05)	2.4 (04-05)	3.75 (04-05)	41.2 (04-05)
Beta Control	**3.3 (16-17)**	**1.9 (16-17)**		
Lower Restoration Site	4.1 (98-99)	1.3 (98-99)		
	2.1 (99-00)	1.3 (99-00)		
	3.9 (00-01)	2.4 (00-01)		
	3.0 (01-02)	1.3 (01-02)		
	3.0 (02-03)	2.1 (02-03)		
	NS	1.3 (03-04)		
	2.7 (04-05)	1.9 (04-05)		
	3.0 (16-17)	**2.4 (16-17)**		
Middle Restoration Site	4.4 (98-99)	1.3 (98-99)	4.50 (98-99)	73.0 (98-99)
	1.6 (99-00)	1.3 (99-00)	3.75 (99-00)	87.0 (99-00)
	3.0 (00-01)	2.3 (00-01)	3.25 (00-01)	79.0 (00-01)
	2.7 (01-02)	1.6 (01-02)	3.75 (01-02)	75.2 (01-02)
	2.4 (02-03)	2.4 (02-03)	3.75 (02-03)	50.5 (02-03)
	NS	1.6 (03-04)	4.50 (03-04)	80.3 (03-04)
	1.9 (04-05)	2.4 (04-05)	4.50 (04-05)	82.7 (04-05)
	3.0 (16-17)	**2.1 (16-17)**		**60.7 (16-17)**

Figure DER 2. Example of overland flow on the east bank of Deep Run in the Middle Restoration area, noting fine material deposition mixed with gravel and small cobble.

Figure DER 3. Extant stream restoration structures along the bank of Deep Run showing physical stability over time. Note the deep pool area with stream shading and an undercut bank.

Summary: The Deep Run stream restoration site appears to be relatively stable in spite of multiple urbanization (and industrial) influences from within the upper watershed. There is evidence, as observed in depositional bars on the eastern bank high above full bank height, that flows during extreme flow events may have altered the stream, although many of the in-stream restoration structures have remained intact and stable, and physically functioning. In addition, there are concerns that all Spring benthic assemblages were influenced by high flows (and perhaps water quality issues such as road salt and sewage leakage) since the Fall benthic assemblages at Deep Run had higher BIBI scores than the Spring scores – this pattern was also observed for a number of other SHA sites assessed earlier (Morgan et al. 2010).

In the future, it is also suggested that one Fall and Spring benthic survey be made in Piney Branch (joining Deep Run just below the SHA stream restoration area) to determine if its water quality is influencing the downstream benthic assemblages below the confluence of Deep Run and Piney Branch. The overall recommendation is that the Deep Run stream restoration site be placed on either a 10 year cycle or a 25 year cycle, with a suggested revisit in either FY27 or FY42.

Fahrney Branch (FAB)

Site Description: Fahrney Branch is a first order stream at the proposed SHA restoration site, crossing under Green Valley Road south of New Market, MD. It flows westward and joins Bennett Creek which then flows into the Monocacy River. The two control sites were upstream of Green Valley Road, with the two restoration sites downstream (Figure FAB 1). Although the Fahrney Branch watershed is influenced by periurban development and limited agriculture, the upper watershed (above Green Valley Road) has a significant buffer zone around the stream.

The proposed restoration area (downstream of Green Valley Road) was an unused, fenced pasture area that was fallow. Most of the vegetation in this area reflects a transitional old pasture with only a few trees present along the stream banks. On the north side of the stream, there were numerous spring seeps along the stream as well as wetland plants. There were a few areas showing bank slumping, probably a result of past agricultural practices since the upstream control areas did not show unusual bank incision.

The owner of the property decided not to follow through with the proposed SHA stream restoration project. Consequently, Fahrney Branch was sampled in Fall 2016, and was deleted for the Spring 2017 sampling work.

Fahrney Branch Site Coordinates:

Site coordinates (in degrees) for Fahrney Branch (Figure FAB 1).

Station	Latitude (N)	Longitude (W)	Comments:
Middle	39.340148	-77.272135	Middle restoration site.
Lower	39.340617	-77.274481	Lower restoration site.
Alpha Control	39.339433	-77.269834	Upstream Control One.
Beta Control	39.339163	-77.269043	Upstream Control Two.

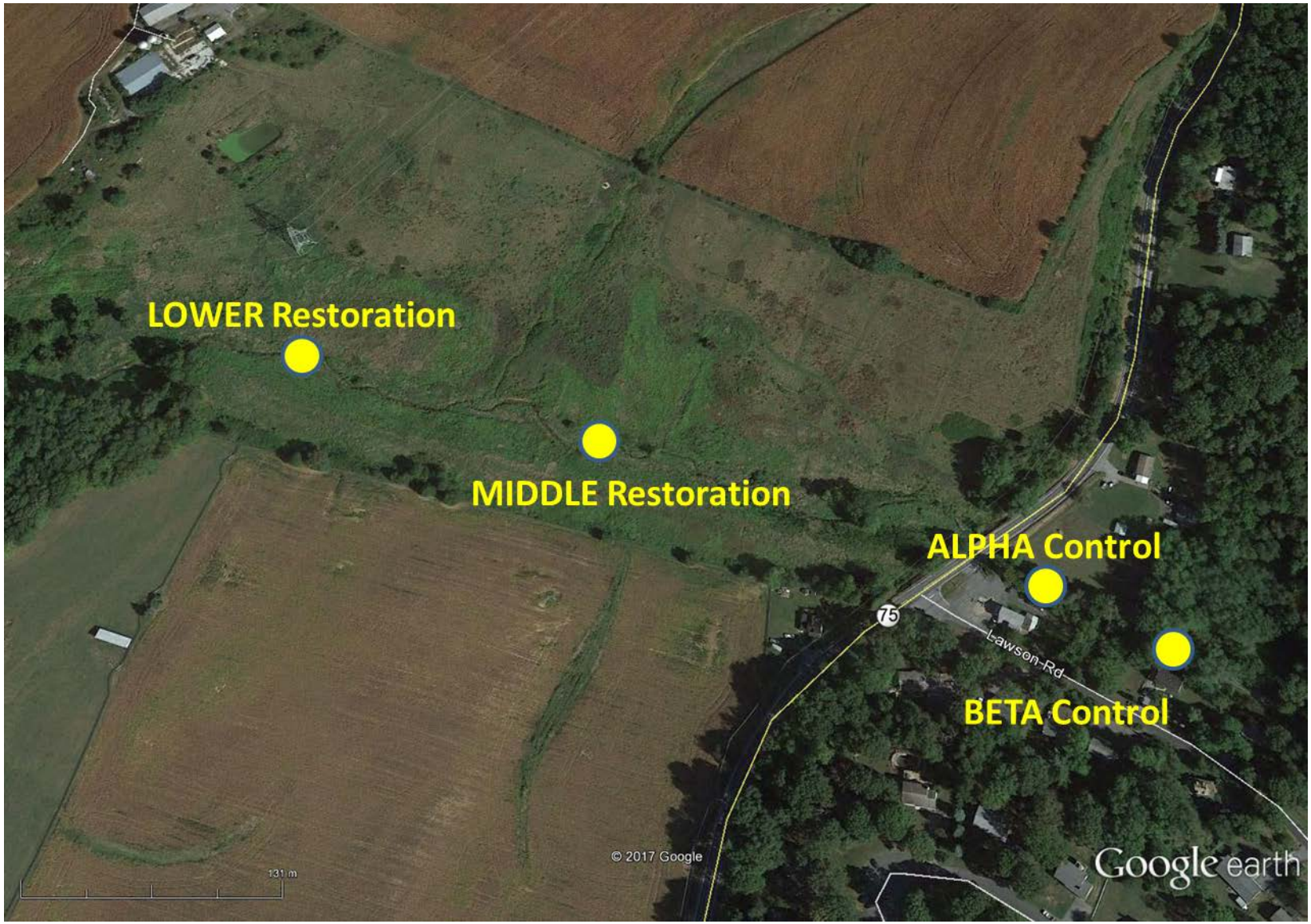

Figure FAB 1. Site locations for sampling of Fahrney Branch (FAB) in Frederick County.

Fall 2016 Benthic Community (FAB) - The MBSS 100 + subsample benthic macroinvertebrate counts showed moderate richness at both restoration sites as well as the Alpha Control (Table FAB 1). Numbers of EPT taxa ranged from a low of 5 in the Beta Control to an impressive 13 taxa in the Alpha Control with the dominant taxa being *Isonychia* sp. and *Cheumatopsyche* sp. - both indicators of good water quality. The Alpha Control site scored good on the BIBI, while the Beta Control and both restoration sites were lower, scoring in the fair range. The clinger functional group dominated the insect composition at all sites.

Table FAB 1. Data summary of benthic macroinvertebrates collected in D-frame samples on September 2016 at stations in Fahrney Branch.

Piedmont Metrics	Fahrney Branch Riffle Community (MBSS 100 + subsample)			
	Alpha Control	Beta Control	Lower Restoration	Middle Restoration
Taxa Richness	29	16	22	21
Total EPT Taxa	13	5	10	10
Ephemeroptera Taxa	4	1	4	4
% Intolerant Urban	29.0%	25.7%	7.8%	12.5%
% Chironomidae	10.3%	21.8%	12.7%	36.5%
% Clingers	83.2%	78.2%	77.5%	62.5%
BIBI	4.3	3.0	3.3	3.3

Site rankings changed somewhat with the 300 + count subsamples. Taxa richness ranged from 33–39 – one of the highest richness indexes across all sites ever observed for all SHA sites. All four sites were ranked as good by the Hilsenhoff Index - a measure of organic pollution - and ranged from the best score of 4.3 in the Beta Control to the lowest score of 5.0 in the Middle Restoration reach; both restoration sites scored slightly lower than either of the controls (Table FAB 2). The ratio of EPT to Chironomidae was substantially above 1 for all sites except the

Alpha Control, which was still 0.33. The EPT index values were all above 10 for each of the sites and indicate higher EPT richness than many of other SHA stream sites.

Table FAB 2. Data summary of benthic macroinvertebrates collected in D-frame samples on September 2016 at stations in Fahrney Branch.

Metrics	Fahrney Branch Riffle Community (RBP III 300 + subsample)			
	Alpha Control	Beta Control	Lower Restoration	Middle Restoration
Taxa Richness	37	39	33	33
Hilsenhoff Biotic Index	4.4	4.3	4.8	5.0
Ratio Scrapers to Filtering Collectors	0.43 (43.2%)	0.70 (69.6%)	0.68 (68.1%)	0.75 (74.7%)
Ratio Shredders to Total Individuals	0.03 (2.9%)	0.03 (2.9%)	0.01 (1.1%)	0.01 (0.9%)
Total EPT Individuals to Total Chironomids.	0.33 (33.3%)	3.6 (361%)	3.2 (316%)	1.37 (137%)
EPT Index	16	13	12	13
Percent Contribution of Dominant Taxon	13.9%	19.2%	18.8%	14.8%

Physical Habitat Assessment – The Fahrney Branch stream restoration site was basically an unused, fenced pasture area that was fallow. Most vegetation in this area reflects a transitional old pasture with only a few scattered trees present along the stream banks. On the north side of the stream, there were numerous spring seeps along the stream bank as well as numerous wetland plants. There were a few areas showing some bank slumping, probably a result of past agricultural practices since the upstream control areas did not show any unusual bank incision.

The upstream control area was well shaded although the riparian buffer was poor on the north side of the stream. As mentioned earlier, there was adequate buffer and shading, with good instream habitat present. The MPHI for the proposed stream restoration area was 41.2 (poor) and for the control 59.5 (fair).

Summary: The benthic assemblage in Fahrney Branch is fair to good, based on the BIBI scores, as well as taxa richness. In addition, there were numerous fishes present in the

proposed stream restoration area, but fishes were not sampled to determine either species or abundance. It is interesting to note that the conversion of the pasture land to fallow land by fencing has resulted in the presence of a good benthic community. Fahrney Branch will not be resampled unless the site becomes an active SHA stream restoration site in the future.

Israel Creek (ISC)

Site Description – The Israel Creek stream restoration site lies to the east of Woodsboro, MD (Figure ISC 1). Currently, it is listed as a SHA pre-restoration site (2017 TMDL Stream Project). This projected stream restoration site itself is one of the longest (if not the longest) studied since 1998, with a total estimated length of 1,500 m. It is bounded on the north by Coppermine Road, and extends below Route 550 (Woodsboro Road) for about 750 m. Near the southern edge of the site, the Woodsboro sewage treatment plant discharges into Israel Creek.

The upper section of the restoration site above Route 550 flows through the Woodsboro Park (controlled by the Town of Woodsboro). Within the park itself, there are numerous structures (ballfields, paths, etc.) present right above Route 550. In addition, there is a large grass area near the uppermost boundary of the site (west side of stream).

Israel Creek Site Coordinates:

Site coordinates (in degrees) for Israel Creek (Figure ISC 1).			
Station	Latitude (N)	Longitude (W)	Comments:
Middle	39.536101	-77.309070	Middle restoration site.
Lower	39.532669	-77.307556	Lower restoration site.
Alpha Control	39.538048	-77.309156	Upstream Control.
Beta Control - Fall	39.527626	-77.309449	Downstream Control.
Beta Control - Spring	39.537542	-77.309336	Upstream Control.
Gamma Control - Spring	39.527626	-77.309449	Downstream Control.

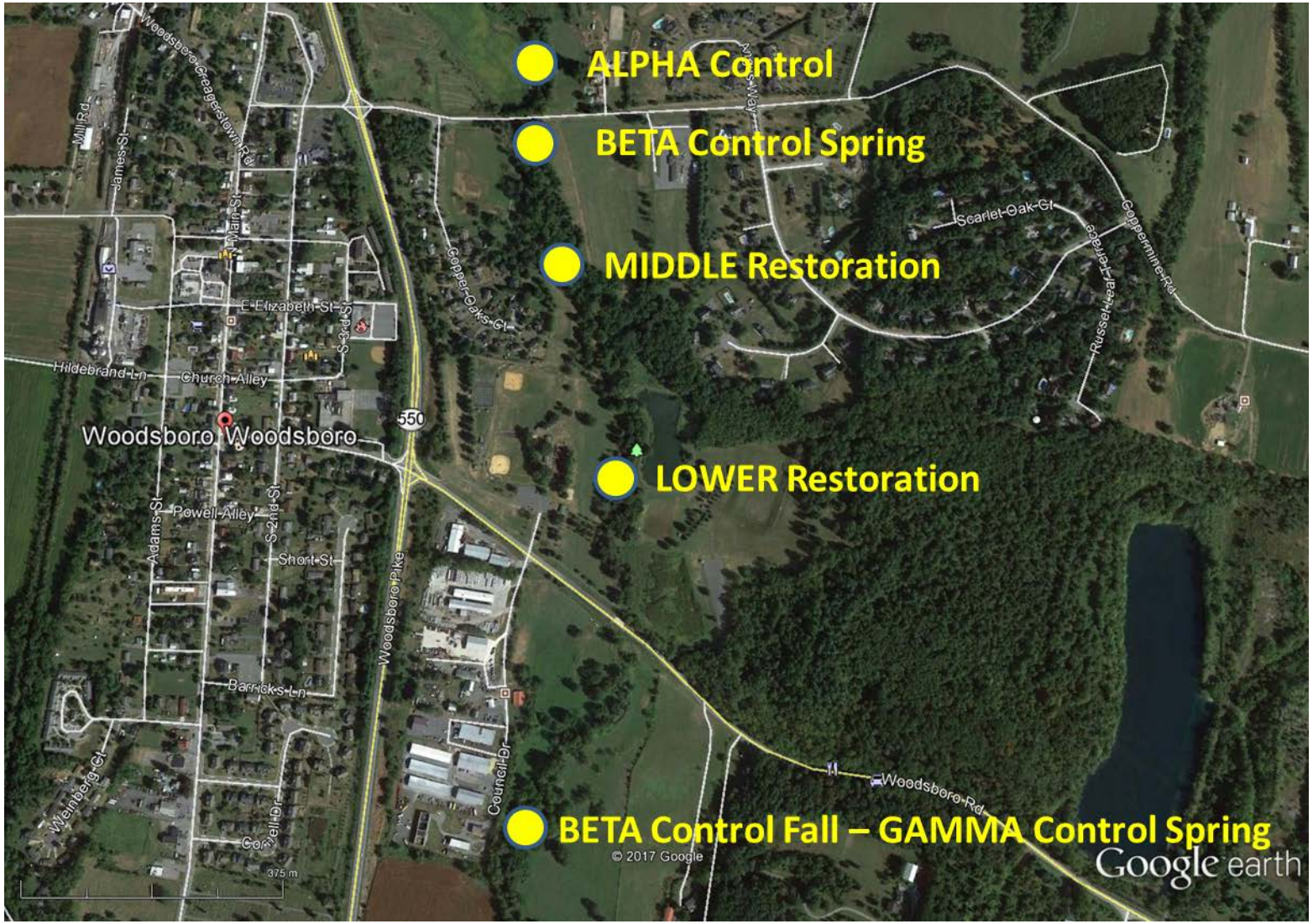

Figure ISC 1. Site locations for sampling of Israel Creek (ISC) in Frederick County, with changes in BETA control in Spring and Fall Sampling, with GAMMA replacing the downstream control.

Fall 2016 ISC Benthic Community – The MBSS 100 + macroinvertebrate count data show taxa richness at 20 and 12 genera for the Lower and Middle Restoration section respectively, and 17 and 15 genera for the Alpha and Beta Controls (Table ISC 1). Both the total EPT taxa and Ephemeroptera taxa were low across all sites as was the percentage of intolerant taxa. The clinger functional group dominated the composition at all sites with the riffle beetle, *Stenelmis* sp., being the most common genus at all sites. BIBI scores ranged between poor and the bottom end of fair in both the control and restoration sections.

Table ISC 1. Data summary of benthic macroinvertebrates collected in D-frame samples on September 2016 at stations in Israel Creek.

Piedmont Metrics	Israel Creek Riffle Community (MBSS 100 + subsample)			
	Alpha Control	Beta Control	Lower Restoration	Middle Restoration
Taxa Richness	17	15	20	12
Total EPT Taxa	4	6	6	4
Ephemeroptera Taxa	3	3	4	3
% Intolerant Urban	1.0%	1.9%	1.9%	1.9%
% Chironomidae	13.0%	18.1%	15.2%	2.9%
% Clingers	59.0%	76.2%	60.0%	86.5%
BIBI	2.3	3.0	3.0	2.7

The RBP III 300 + benthic macroinvertebrate count showed similar patterns to the MBSS 100 + count in the Israel Creek Fall benthic macroinvertebrates (Table ISC 2). Taxa richness ranged from 20 genera in the Middle Restoration section to 30 in the Lower Restoration section with richness in the Alpha and Beta Controls being 25 and 26 respectively. The Hilsenhoff Biotic Index rated each site as fair (Middle Restoration) to poor in the remaining stations. The ratio of scrapers to filtering collectors was highly skewed compared to other streams and reflects the numerical dominance of riffle beetles in all of the samples at this site. The EPT Index reflected a

limited number of EPT taxa present at the site.

Table ISC 2. Data summary of benthic macroinvertebrates collected in D-frame samples on September 2016 at stations in Israel Creek.

Metrics	Israel Creek Riffle Community (RBP III 300 + subsample)			
	Alpha Control	Beta Control	Lower Restoration	Middle Restoration
Taxa Richness	25	26	30	20
Hilsenhoff Biotic Index	6.2	6.1	5.8	5.6
Ratio Scrapers to Filtering Collectors	29.0 (2900%)	15.25 (1515%)	23.6 (2357%)	22.3 (2225%)
Ratio Shredders to Total Individuals	0.00 (0.9%)	0.02 (2.0%)	0.00 (0.30%)	0.00 (0.31%)
Total EPT Individuals to Total Chironomids.	2.30 (230%)	0.32 (32%)	1.09 (109%)	1.33 (133%)
EPT Index	4	7	10	5
Percent Contribution of Dominant Taxon	48.7%	61.2%	42.6%	61.4%

Spring 2016 ISC Benthic Community – The MBSS 100 + macroinvertebrate count spring samples of Israel Creek showed slightly lower ecological conditions than the Fall samples (Table ISC 3). BIBI scores for every station were lower in spring compared to fall: the Alpha, Beta, and Gamma controls scored 2.0 (poor), 2.3 (poor), and 1.7 (very poor), respectively, while both restoration sections scored as poor. Scores were lower despite slight increases in taxa richness for the Alpha and Beta Controls and the Middle Restoration; all stations had proportionally fewer clingers and a somewhat reduced EPT or Ephemeroptera taxa. Benthic samples had numerous riffle beetles, *Stenelmis* sp.

Table ISC 3. Data summary of benthic macroinvertebrates collected in D-frame samples on March 2017 at stations in Israel Creek.

Piedmont Metrics	Israel Creek Riffle Community (MBSS 100 + subsample)				
	Alpha Control	Beta Control	Gamma Control	Lower Restoration	Middle Restoration
Taxa Richness	18	22	19	16	19
Total EPT Taxa	2	5	2	3	4
Ephemeroptera Taxa	1	4	1	0	3
% Intolerant Urban	2.9%	3.6%	1.0%	4.9%	3.6%
% Chironomidae	52.9%	63.6%	47.1%	14.6%	34.5%
% Clingers	40.4%	29.1%	21.2%	53.4%	42.7%
BIBI	2.0	2.3	1.7	2.0	2.3

The Israel Creek spring 300 + count macroinvertebrate samples ranked all sites as poor with the Hilsenhoff Biotic Index (Table ISC 4). While the EPT Index for each section was slightly greater than Fall samples, the ratio of Total EPT to Total Chironomidae was lower across all sites. The riffle beetle, *Stenelmis* sp., was again the most prominent taxon in samples, but it was not as numerically dominant as it was in the Fall samples. Various taxa of Chironomidae comprised most of each benthic sample, but none of the various genera were dominant.

Table ISC 4. Data summary of benthic macroinvertebrates collected in D-frame samples on March 2017 at stations in Israel Creek.

Metrics	Israel Creek Riffle Community (RBP III 300 + subsample)

	Alpha Control	Beta Control	Gamma Control	Lower Restoration	Middle Restoration
Taxa Richness	31	32	42	31	32
Hilsenhoff Biotic Index	6.0	6.3	6.9	7.2	6.2
Ratio Scrapers to Filtering Collectors	3.04 (304%)	4.55 (455%)	2.16 (216%)	6.47 (645%)	7.83 (783%)
Ratio Shredders to Total Individuals	0.04 (3.8%)	0.04 (4.0%)	0.01 (1.3%)	0.04 (3.5%)	0.05 (5.3%)
Total EPT Individuals to Total Chironomids.	0.11 (10.8%)	0.09 (9.5%)	0.08 (8.0%)	0.39 (38.5%)	0.23 (23.3%)
EPT Index	6	6	7	10	6
Percent Contribution of Dominant Taxon	20.4%	16.3%	10.2%	33.7%	23.2%

Physical Habitat Assessment – The Israel Creek stream restoration site was basically sited in a parkland setting, except for the area below Route 550 where the stream courses through old pasture land. One notable feature was the presence of large trees along the stream with woody debris and root wads very prominent throughout the entire restoration site. In addition, there were a number of gravel bars in the upper area, indicating input from upstream sources. Throughout Israel Creek, there were abundant signs of beaver activity along the stream. A paved walking path borders the west side of Israel Creek – the east side of the stream was highly incised. The MPHI for the proposed stream restoration area was 49.3 (fair) and for the control 39.3 (poor).

Summary: This is a pre-restoration stream site, with the overall recommendation for benthic and physical assessment to continue until construction.

Little Gunpowder River – Unnamed Tributary (UTLGR)

Site Description – The unnamed tributary to the Little Gunpowder River is located near Lynch Lane, just off Baldwin Mill Road (Rte. 165) in Baltimore County (Figure UTLGR 1). This site was only sampled in Spring 2017 since it was a replacement for the Fahrney Branch site. Below Lynch Lane, the lower end of the stream runs through private land and then flows through land owned by MD DNR. The restoration site is upstream of Lynch Lane.

Unnamed Tributary to the Little Gunpowder River Site Coordinates:

Site coordinates (in degrees) for the unnamed tributary to the Little Gunpowder River (Figure UTLGR 1).			
Station	Latitude (N)	Longitude (W)	Comments:
Middle	39.514363	-76.486957	Middle restoration site.
Lower	39.515436	-76.484118	Lower restoration site.
Alpha Control	39.513969	-76.489609	Upstream Control.
Beta Control	39.516137	-76.479695	Downstream Control.

Figure UTLGR 1. Site locations for sampling of unnamed tributary to Little Gunpowder River (UTLGR) in Baltimore County.

Spring UTLGR Benthic Community – For the benthic macroinvertebrates, the MBSS 100 + count spring samples of UTLGR show all sampled sites to be in fair to good condition as assessed by the BIBI (Table UTLGR 1). Taxa richness ranged between 19 and 22 genera with the total EPT taxa slightly lower in the control sections compared to the restoration sections. However, all stream sections sampled contained four ephemeropteran taxa. The composition of the Ephemeroptera indicates a reasonably good stream condition as evidenced by the BIBI scores. In fact, Ephemeroptera comprised the most of the MBSS 100 + count subsample. The Percent Intolerant Urban taxa ranged between 40% and 52%, while Chironomidae comprised 20% or less of the total individuals in any sample.

Table UTLGR 1. Data summary of benthic macroinvertebrates collected in D-frame samples on March 2017 at stations in an unnamed Tributary to the Little Gunpowder River.

Piedmont Metrics	Long Draught Branch Riffle Community (MBSS 100 + subsample)			
	Alpha Control	Gamma Control	Lower Restoration	Middle Restoration
Taxa Richness	19	21	22	21
Total EPT Taxa	8	9	11	10
Ephemeroptera taxa	4	4	4	4
% Intolerant Urban	46.2%	44.5%	52.0%	40.0%
% Chironomidae	16.3%	20.0%	19.6%	13.3%
% Clingers	86.5%	78.2%	83.0%	88.6%
BIBI	3.7	3.7	4.3	3.7

The RBP III 300 + benthic macroinvertebrate subsample for UTLGR similarly shows a stream in reasonable ecological condition, both within and across sections. The Hilsenhoff Biotic Index rates all of the sections as very good, while Taxa Richness shows between 29 and 34 genera (Table UTLGR 2). Roughly, a third of the taxa at each site was composed of EPT and maintains an EPT to Chironomidae ratio ranging between 3 and 5.2 across sites. Finally, the dominant taxon was an ephemeropteran at each site and comprised 25% to 33% of the sample.

Table UTLGR2. Data summary of benthic macroinvertebrates collected in D-frame samples on March 2017 at stations in Unnamed Tributary Little Gunpowder River.

Metrics	Little Gunpowder Falls Sampling Sites (RBP III 300 + Subsample)			
	Alpha Control	Gamma Control	Lower Restoration	Middle Restoration
Taxa Richness	32	34	33	29
Hilsenhoff Biotic Index	3.7	4.0	3.6	3.8
Ratio Scrapers to Filtering Collectors	0.48 (48%)	0.58 (58%)	0.24 (24%)	0.22 (22%)
Ratio Shredders to Total Individuals.	0.04 (3.8%)	0.01 (1.3%)	0.02 (2.0%)	0.04 (4.3%)
Total EPT Individuals to Total Chironomids.	5.06 (506%)	3.14 (314%)	4.60 (461%)	5.21 (521%)
EPT Index	12	13	15	12
Percent Contribution of Dominant Taxon	26.8%	23.3%	31.9%	29.5%

Physical Habitat Assessment – The proposed stream restoration area, as are both the upstream and downstream control segments of this SHA site, is a mixture of habitats, reflecting past land use, especially animal pasturing. On the south side of the site, an old farm lane borders the stream. Generally, the restoration and upstream control are pure multiflora rose hells. There are a number of large trees (sycamores, cherry, etc.) present; along with a fairly well-defined riparian buffer (exotic bamboo is also present along the stream). There are a few places with deep bank incisions.The MPHI for the proposed stream restoration area was 50.4 (fair) and for the control 38.3 (poor).

Summary: This is a new pre-restoration stream site, with the overall recommendation for benthic and physical assessment to continue until construction.

Long Draught Branch (LDB)

Site Description: Long Draught Branch is a small first-order stream located in a very highly urbanized area of Montgomery County that includes residential development, large and small office complexes, numerous shopping centers, apartment complexes and significant amounts of impervious surface due to parking lots, extensive road systems and numerous buildings (Figures LDB 1 and LDB 2). There is a small dam located in the upstream reach of Long Draught Branch. In lower Long Draught Branch, there is another small dam located along Rabbit Road that is slated for future removal to enhance downstream stream connectivity (Figure LDB 2).

A segment of Long Draught Run flows through a park area with a swimming pool and playground. Many of the parking areas adjacent to the numerous apartment units have direct flow pathways into the stream through riprapped drainage swales. In the spring, there is significant urban refuse found in the stream after winter. Often, this trash forms small blockage dams throughout the stream with significant pooling, especially in the area between the two restoration sites. The lower part of the restoration area is heavily wooded.

Throughout its stream course until it enters Clopper Lake, there are numerous storm drains discharging into the stream as well as overland drainage from parking lots and roads**.** There is also a major sewage line paralleling the stream throughout the proposed restoration area with a few surface seeps present at times, indicating leakage.

Long Draught Branch Site Coordinates:

Site coordinates for Long Draught Branch (Figure LDB 1 and LDB2).			
Station	Latitude (N)	Longitude (W)	Comments:
Middle	39.142313	-77.225865	Projected middle restoration site.
Lower	39.144377	-77.228521	Projected lower restoration site.
Alpha Control	39.143820	-77.222785	Upstream Control One.
Beta Control	39.143660	-77.222066	Upstream Control Two.
Rabbit Road - Upper	39.141142	-77.233141	Downstream Control One.
Rabbit Road - Lower	39.139629	-77.235279	Downstream Control Two.

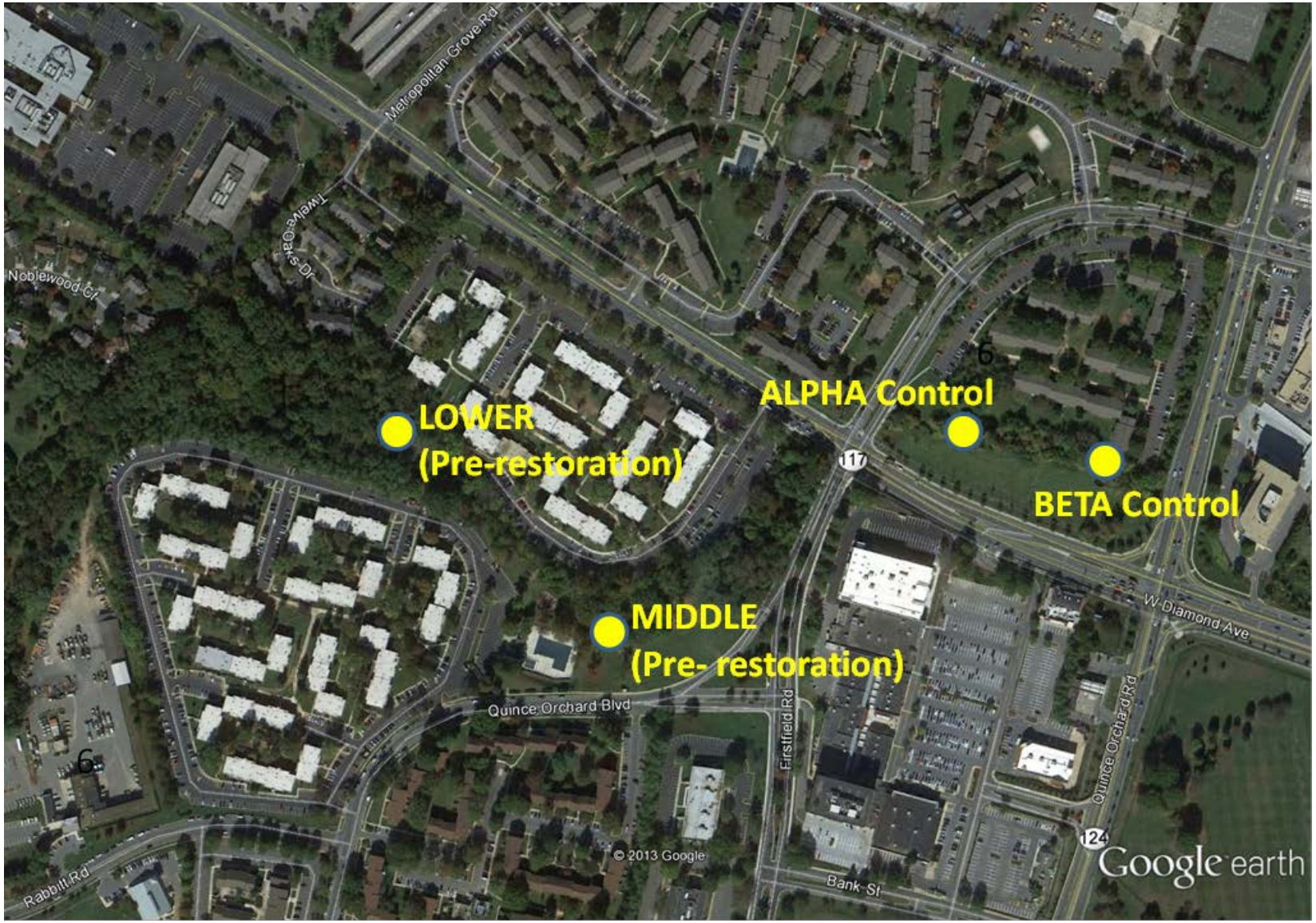

Figure LDB 1. Site locations for sampling of Long Draught Branch (LDB) in Montgomery County.

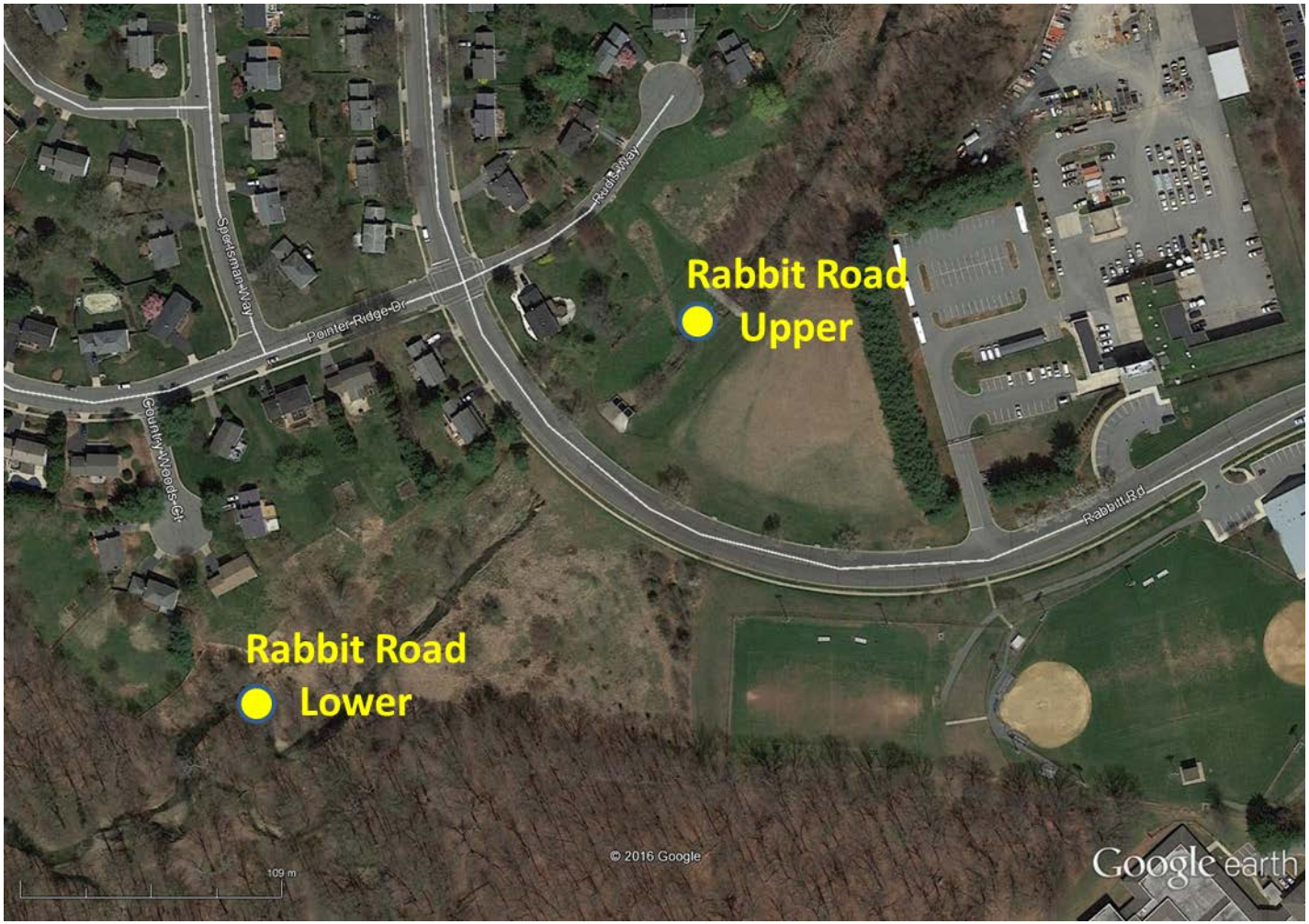

Figure LDB 2. Site locations for sampling of Long Draught Branch (LDB) along Rabbit Road in Montgomery County.

Fall 2016 Benthic Community (LDB) - For benthic subsamples with the MBSS 100 + macroinvertebrate count (Table LDB 1), taxa richness was low at Beta Control and the Lower Rabbit Road lower sites and moderate and low at the remaining stations. The number of EPT taxa was low at the two control stations and moderate at the remaining sites. *Cheumatopsyche* sp. was the dominant EPT taxon collected. The number of ephemeropteran taxa was low to non-existent at the sites. When present, baetid nymphs were the only mayfly taxon collected. The percent of chironomids collected was moderate at all stations. The percent of clingers was low at the two control stations, moderate at Upper Rabbit Road and Middle Restoration sites, and high at the remaining stations. Hydropsychid larvae were the most abundant clinger macroinvertebrate collected. BIBI values ranged from 1.3 at the Beta Control to 2.7 at the Lower Restoration site; these BIBI values were indicative of a stressed benthic community..

Table LDB 1. Data summary of benthic macroinvertebrates collected in D-frame samples on September 2016 at six stations in Long Draught Branch.

Piedmont Metrics	Riffle Community (MBSS 100 + subsample)					
	Alpha Control	Beta Control	Rabbit Rd. Lower	Rabbit Rd. Upper	Lower Restoration	Middle Restoration
Taxa Richness	15	14	14	16	16	18
Total EPT Taxa	1	1	5	5	5	6
Ephemeroptera taxa	0	0	1	1	1	1
% Intolerant Urban	0.0%	1.0%	6.7%	0.9%	5.5%	2.0%
% Chironomidae	21.6%	9.5%	14.3%	35.1%	12.8%	18.0%
% Clingers	10.8%	2.9%	85.7%	55.9%	80.7%	34.0%
BIBI	1.7	1.3	2.3	2.3	2.7	2.3

For benthic subsamples with the RBP III 300 + count, taxa richness ranged from 18 at the Rabbit Road Lower site to 25 at the Middle Restoration site. The Hilsenhoff Biotic Index was lowest (5.3) at Lower Rabbit Road and Lower Restoration sites and highest (8.4) at the Beta Control site. The ratio of scraper to filtering collector functional feeding group ranged from 0.00 at the Lower Rabbit Road site to 1.91 at the Beta Control station. Scraper taxa were in low numbers at most sites, but Planorbidae snails were the dominant scraper at the two control stations. Hydropsychid larvae were the dominant filtering collector macroinvertebrate at all stations. The

number of shredder macroinvertebrates was low at all sites, with *Polypedilum* sp. the most commonly collected shredder, when found. The ratio of total EPT individuals to chironomids ranged from 0.06 at the Beta Control site to 8.8 at the Lower Rabbit Road station. The number of EPT taxa was lowest (2) at the two controls and highest (6) at Upper Rabbit Road and Middle Restoration sites. *Cheumatopsyche* sp. and *Chimarra* sp. larvae dominated the EPT macroinvertebrates collected. The percent dominant taxon ranged from 16.3% (*Cheumatopsyche* sp.) at the Lower Rabbit Road site to 33.9% (Hoplonemertea oligochaetes) at the Beta Control.

Table LDB 2. Data summary of benthic macroinvertebrates collected in D-frame samples on September 2016 at stations in Long Draught Branch.

Metrics	Long Draught Branch Sampling Sites (RBP III 300 + Subsample)					
	Alpha Control	Beta Control	Lower Rabbit Rd.	Upper Rabbit Rd.	Lower Restoration	Middle Restoration
Taxa Richness	21	19	18	22	24	25
Hilsenhoff Biotic Index	7.5	8.4	5.3	5.8	5.3	6.3
Ratio Scrapers to Filtering Collectors	1.60 (160%)	1.91 (191%)	0.00 (0.0%)	0.02 (1.5%)	0.00 (0.4%)	0.10 (10.2%)
Ratio Shredders to Total Individuals.	0.00 (0.0%)	0.00 (0.0%)	0.01 (0.9%)	0.01 (0.9%)	0.01 (0.6%)	0.03 (2.8%)
Total EPT Individuals to Total Chironomids.	0.15 (15.0%)	0.06 (5.9%)	8.78 (878.1%)	1.05 (105%)	7.28 (728%)	1.45 (145%)
EPT Index	2	2	5	6	5	6
Percent Contribution of Dominant Taxon	27.9%	33.9%	16.3%	28.6%	20.8%	31.6%

Spring 2017 Benthic Community (LDB) - For subsamples with a MBSS 100 + macroinvertebrate count, taxa richness ranged from 9 (Alpha Control and Lower Rabbit Road) to 16 at the Upper Rabbit Road site. No ephemeropteran nymphs were collected at any of the sites and the number of EPT taxa was low or non-existent. *Cheumatopsyche* sp. was the dominant EPT taxon collected. The percent of chironomids collected was high at the Upper Rabbit Road and Lower Rabbit Road sites and moderate at the remaining stations. The percent of clingers was moderate at the Lower Restoration site and low at remaining stations. The BIBI ranged from 1.0 (Lower Rabbit Road) to 2.0 (Lower Restoration).

Table LDB 3. Data summary of benthic macroinvertebrates collected in D-frame samples in March 2017 at stations in Long Draught Branch.

Piedmont Metrics	Long Draught Branch Riffle Community (MBSS 100 + subsample)				
	Alpha Control	Rabbit Rd. Lower	Rabbit Rd. Upper	Lower Restoration	Middle Restoration
Taxa Richness	9	9	16	13	13
Total EPT Taxa	0	4	2	3	1
Ephemeroptera taxa	0	0	0	0	0
% Intolerant Urban	0.0%	0.0%	0.0%	0.0%	0.90%
% Chironomidae	61.4%	83.3%	83.7%	38.5%	55.0%
% Clingers	1.0%	13.7%	4.8%	35.6%	3.6%
BIBI	1.3	1.0	1.3	2.0	1.3

For subsamples with a RBP III 300+ count, taxa richness ranged from 10 at the Alpha Control site to 20 at the Lower Restoration site. The Hilsenhoff Biotic Index was lowest (6.1) at Lower Rabbit Road and highest (7.7) at the Alpha Control site. The ratio of scraper to filtering collector functional feeding group ranged from 0.03 at the Lower Restoration site to 1.5 at the Upper Rabbit Road station. Scraper taxa were in low numbers at all the sites. Hydropsychid larvae were the dominant macroinvertebrate filtering collector at all the stations. The number of shredder macroinvertebrates was low at all sites, with *Polypedilum* sp. the most commonly collected shredder. The ratio of total EPT individuals to Chironomids was low at all the stations. The number of EPT taxa was lowest (0) at Alpha Control and highest (4) at Lower Rabbit Road and Lower and Middle Restoration sites. *Cheumatopsyche* sp. larvae dominated the EPT macroinvertebrate collection. The percent dominant taxon ranged from 37.2% (*Orthocladius* sp.) at the Lower and Middle Restoration sites to 65.7 (Orthocladius sp. at the Lower Rabbit Road station.

Table LDB 4. Data summary of benthic macroinvertebrates collected in D-frame samples on March 2017 at stations in Long Draught Branch.

Metrics	Long Draught Branch Sampling Sites (RBP III 300 + Subsample)				
	Alpha Control	Lower Rabbit Rd.	Upper Rabbit Rd.	Lower Restoration	Middle Restoration
Taxa Richness	10	19	19	20	19
Hilsenhoff Biotic Index	7.7	6.1	6.7	6.6	7.1
Ratio Scrapers to Filtering Collectors	1.0 (100%)	0.07 (7.4%)	1.5 (150%)	0.03 (3.3%)	0.32 (32%)
Ratio Shredders to Total Individuals.	0.0 (0.0%)	0.01 (0.7%)	0.01 (0.9%)	0.003 (0.3%)	0.01 (1.2%)
Total EPT Individuals to Total Chironomids.	0.0 (0.0%)	0.01 (10.0%)	0.03 (3.4%)	0.7 (69%)	0.1 (11%)
EPT Index	0	4	2	4	4
Percent Contribution of Dominant Taxon	40.2%	65.7%	47.0%	37.2%	37.2%

Physical Habitat: For FY17, physical habitat in the control area remains good although there was a limited buffer width along the stream, as well as many signs of primate disturbance (it

should be noted that the local inhabitants preferred either Miller Lite or Heineken). Stream shading was good for most of the control area. However, there were three problems that we observed during all benthic sampling in the upper control region, and discussed in earlier reports on Long Draught Branch. Stream flows in Spring 2017 were too low to adequately collect benthic samples at the Beta Control site; however, there was enough flow present to collect at the Alpha Control site, as well as the four downstream sites.

First, there was a dam upstream of the control area that formed a small pond clogged with cattails (dam coordinates: 39.142686° N; -77.219645° W). During the summer, this shallow pond could create high temperature spikes downstream during storm events and may even create excessive stream temperatures during the summer without storm events. In addition, there were several outfalls from paved surfaces discharging into the stream that would generate significant temperature spikes during summer rain events.

Second, Long Draught Branch flows underground through large culverts for a significant distance (an estimate of ~ 0.18 km) from its spring sources near I-270. Third, the stream originated very close to I-270 and West Diamond Avenue from spring seeps in this area. Consequently, the upstream characteristics of Long Draught Branch affect the control and the potential stream restoration area, as well as the downstream area along Rabbit Road.

The stream area to be restored on Long Draught Branch remains an urban chaos, as observed throughout the long period of study on this proposed stream restoration area. There were numerous, large (~1 m high) undercut banks and large amounts of large urban debris, including shopping carts, bicycles, mattresses and springs as well as smaller refuse such as bottles and cans. More of this urban material was present than observed in earlier years – it appears that the local primates utilize the stream as a dumping ground. There was some shading along the stream restoration area, but the stream buffer was broken in most areas, with a fairly large expanse of grass in the park area. In past surveys, we observed some whitish-brown effluent draining from a culvert into the stream, as well as some surface drainage problems from a stream sewer system in the floodplain of Long Draught Branch. There are significant spring banks (generated by high flows) present on the park side of the stream.

The MPHI was 6.8 for the control area, 18.2 for the middle restoration area and 12.0 for the lower restoration area. For the two Rabbit Road sites, the MPHI was 24.3 for the lower site and 18.2 for the upper site. The lower Rabbit Road site was in a less disturbed area with better flows than found upstream, as well as more stable banks and adequate riparian vegetation. The upper Rabbit Road site had poor habitat, with little shading and lots of briars, and many exotic plant species. Basically, the control and restoration areas were classic examples of the effects of extreme urbanization on stream physical habitat structure.

Assessment Recommendation: Throughout the entire stream sampling program on Long Draught Branch, the benthic community was found to be in either poor or very poor condition, generally due to extreme urbanization stressors. There may be several factors

forcing the benthic response, including road salt, high flows (from impervious surfaces) during storm events and sewer leakage from the sewer line running next to the stream. It is recommended that water quality be sampled more intensively at this site on a more frequent basis (monthly) to determine the levels of chemical stressors. Monitoring of storm events is also recommended but this would require the installation of a stream gaging station to determine the stream hydrograph during events.

Long Draught Branch remains a contentious SHA pre-restoration site, and is one of the longest monitored sites for any current stream restoration activities. It should be revisited 2-4 years after the completion of all stream construction and riparian zone activities, and then placed on a ten-year revisit cycle.

Watkins Mill Road - Unnamed Tributary to Seneca Creek (UTSC)

Site Description: This SHA pre-restoration site is located in Montgomery County, and is adjacent to I-270 – the major high-traffic density road between Frederick, MD and I-495 – the Washington Beltway (Figure UTSC 1). Additionally, it is close to the interchange of I-270 and SR 124 (Quince Orchard Road), and also close to the SHA pre-restoration site on Long Draught Branch. The current construction plan is for the building of a bridge across I-270 that will link the current southern and northern extensions of Watkins Mill Road. During the bridge construction, stream restoration work will be done with the upper limit of work being close to where the stream crosses under I-270. The lower limit of stream work is the power line corridor that crosses I-270 to the west of SR 124. The UTSC flows into Seneca Creek just to the west of Game Preserve Road.

During the 2014-2015 work, we noted that this unnamed tributary flows under I-270 through a large culvert. During the Fall 2015 work, we assessed the feasibility of sampling UTSC to the north of I-270. However, there was very limited access to the stream since it was located next to the westbound on-ramp for I-270, creating multiple safety and security problems. In addition, a downstream UTSC site, serving as an indicator of downstream refugia, was added (Gamma Control) close to where the stream flows across the power line corridor. In the future, another site closer to Seneca Creek (or upper Seneca Creek itself, unless MBSS data are available) may be assessed to better determine the potential adequacy of downstream benthic refugia.

Unnamed Tributary to Seneca Creek Site Coordinates:

Site coordinates for the Unnamed Tributary to Seneca Creek (UTSC) site at Watkins Mill Road (Figure UTSC 1).

Station	Latitude	Longitude	Comments:
Middle	39.156352	-77.226806	Projected middle site.
Lower	39.158406	-77.229986	Projected lower site.
Alpha Control	39.152463	-77.221602	Upstream control I.
Beta Control	39.151496	-77.220157	Upstream control II.
Gamma Control	39.158529	-77.230156	Downstream Control
Potential Control Area	39.150461	-77.217267	Control area

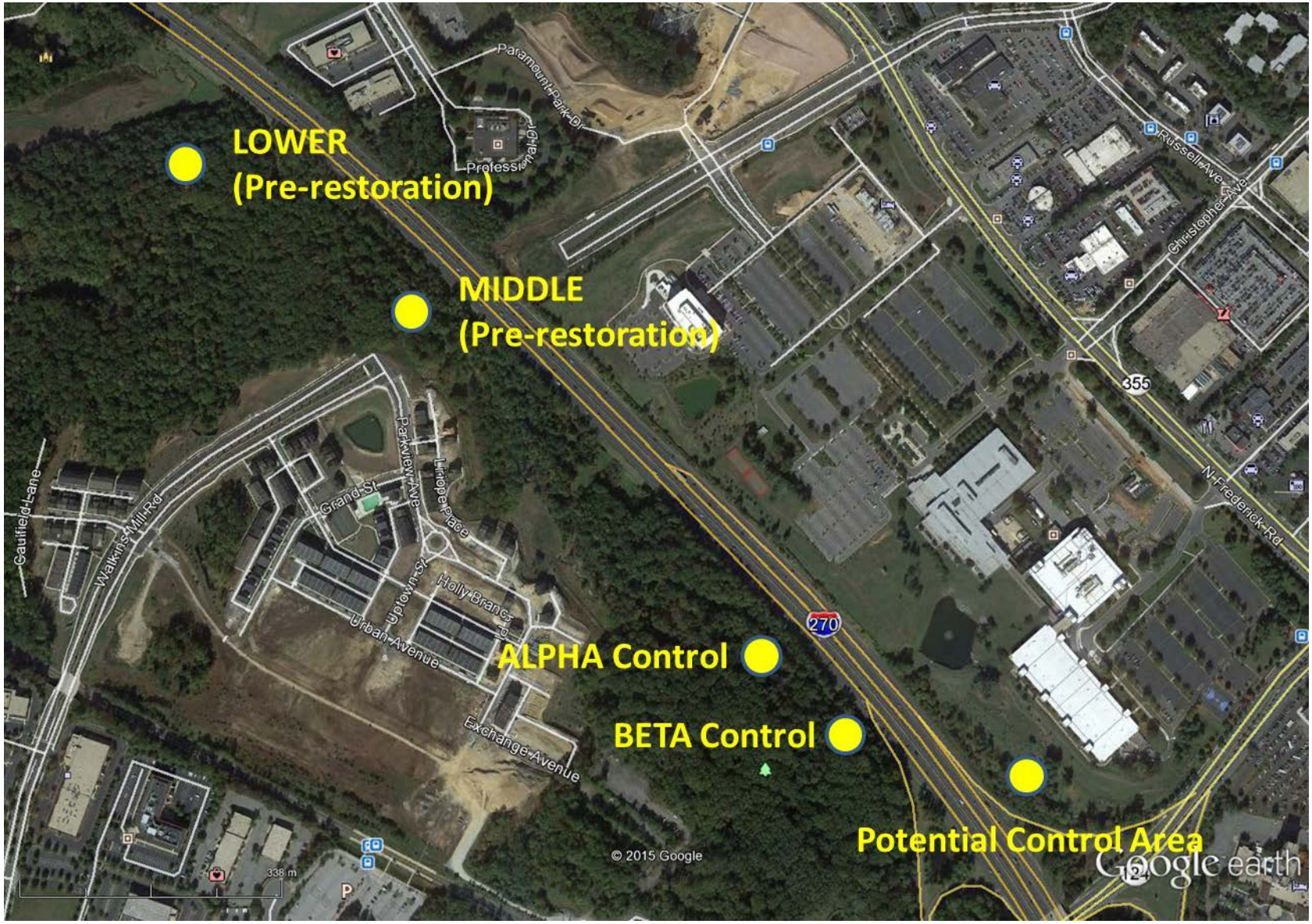

Figure UTSC 1. Site locations for sampling of unnamed tributary to Seneca Creek at Watkins Mill Road (Montgomery County). Downstream Gamma Control is not shown.

Fall 2016 UTSC Benthic Community – For the benthic subsamples with the MBSS 100 + macroinvertebrate count, taxa richness was low at the Middle Restoration site and moderate at all the remaining sites (Table UTSC 1). The total number of EPT taxa was moderate at the Middle Restoration site and low at the remaining sites. *Cheumatopsyche* sp. larvae were the dominant EPT taxon collected. The number of ephemeropteran taxa collected was low at all sites. Baetid nymphs, when present, were the only mayfly found. The percent of urban intolerant macroinvertebrates was low at all sites. The percent of chironomids was high at Alpha Control and moderate at the four remaining stations. The percent of clingers was high at Beta Control and moderate at the remaining stations. *Chimarra* sp. and *Polypedilum* sp., larvae were the dominant clingers collected. The BIBI ranged from 1.7 at Alpha Control and Middle Restoration to 2.3 at the Beta Control station - these values are in the poor to very poor range.

Table UTSC 1. Data summary of benthic macroinvertebrates collected in D-frame samples on September 2016 at stations in an unnamed tributary to Seneca Creek at Watkins Mill Rd.

Piedmont Metrics	Watkins Mill Riffle Community (MBSS 100 + subsample)				
	Alpha Control	Beta Control	Gamma Control	Lower Restoration	Middle Restoration
Taxa Richness	16	15	15	17	13
Total EPT Taxa	2	4	4	4	5
Ephemeroptera Taxa	0	0	1	1	1
% Intolerant Urban	0.02 (1.9%)	0.01 (1.0%)	0.04 (3.6%)	0.07 (6.9%)	0.05 (4.9%)
% Chironomidae	0.61 (61%)	0.29 (29%)	0.25 (26%)	0.38 (38%)	0.68 (68%)
% Clingers	0.51 (51%)	0.75 (75%)	0.68 (68%)	0.52 (53%)	0.46 (46%)
BIBI	1.7	2.3	2.0	2.0	1.7

For subsamples with a RBP III 300 + macroinvertebrate count, taxa richness ranged from 20 at Beta Control to 26 at the Lower Restoration site (Table UTSC 2). The Hilsenhoff Index ranged

from 5.0 at the Gamma Control station to 6.3 at Alpha Control. The ratio of scrapers to filtering collectors was lowest (0.00) at Beta Control and highest (0.11) at Alpha Control. *Stenelmis* sp. was the most common macroinvertebrate scraper collected. *Cheumatopsyche* sp. and *Chimarra* sp. larvae were the dominant filtering collectors collected. Shredders were low to non-existent at all the sites. The ratio of EPT macroinvertebrates to total Chironomids ranged from 2.76 at Gamma Control to 0.43 at Alpha Control. The number of EPT taxa ranged from 3 at Alpha Control to 6 at the Gamma Control and Middle Restoration sites. *Cheumatopsyche* sp. and *Chimarra* sp. larvae dominated the EPT macroinvertebrate collections. The percent contribution of the dominant taxon ranged from 13.6% (*Thienemanniella* sp.) at Middle Restoration to 33.3% (*Chimarra* sp.) at Gamma Control.

Table UTSC 2. Data summary of benthic macroinvertebrates collected in D-frame samples on September and December 2016 at stations in an unnamed tributary to Seneca Creek at Watkins Mill Rd.

Metrics	Watkins Mill Riffle Community (RBP III 300 + subsample)				
	Alpha Control	Beta Control*	Gamma Control	Lower Restoration	Middle Restoration
Taxa Richness	24	20*	24	26	21
Hilsenhoff Biotic Index	6.3	5.9*	5.0	5.9	5.9
Ratio Scrapers to Filtering Collectors	0.11 (11.0%)	0.00 (0.0%)*	0.10 (10.2%)	0.05 (5.2%)	0.02 (2.4%)
Ratio Shredders to Total Individuals.	0.00 (0.0%)	0.01 (1.3%)*	0.00 (0.3%)	0.00 (0.0%)	0.01 (0.7%)
Total EPT Individuals to Total Chironomids.	0.43 (43%)	1.89 (189%)*	2.76 (276%)	0.86 (86%)	0.51 (51%)
EPT Index	3	4*	6	5	6
Percent Contribution of Dominant Taxon	28.9%	20.3%*	33.3%	17.0%	13.6%

Spring 2017 UTSC Benthic Community - For benthic subsamples with a MBSS 100 + macroinvertebrate count, taxa richness, the number of EPT macroinvertebrates and the number of ephemeropteran taxa were low at all Watkins Mills sites (Table UTSC 3). C*heumatopsyche* sp. and *Chimarra* sp. larvae were the dominant EPT taxa collected. Ephemeropteran taxa were

low to non-existent at all of the sampled stations, with no urban intolerant macroinvertebrates present. The percent of chironomids was high at all stations while the percent of clingers was low at all five stations. The dipteran larva, *Polypedilum* sp., was the dominant clinger collected. The BIBI ranged from 1.7 at Beta Control to 1.0 at the remaining stations.

Table UTSC 3. Data summary of benthic macroinvertebrates collected in D-frame samples on March 2017 at stations in an unnamed tributary to Seneca Creek at Watkins Mill Rd.

Piedmont Metrics	Watkins Mill Riffle Community (MBSS 100 + subsample)				
	Alpha Control	Beta Control	Gamma Control	Lower Restoration	Middle Restoration
Taxa Richness	10	17	13	14	14
Total EPT Taxa	1	3	1	2	2
Ephemeroptera Taxa	0	1	0	0	0
% Intolerant Urban	0.0%	0.0%	0.0%	0.0%	0.0%
% Chironomidae	75.2%	59.6%	85.0%	84.5%	74.5%
% Clingers	15.8%	15.4%	10.0%	19.4%	15.7%
BIBI	1.0	1.7	1.0	1.0	1.0

For subsamples with a EPA RBP III 300 + count, taxa richness ranged from 16 at the Alpha Control to 24 at the Lower Restoration site, with the Hilsenhoff Index ranging from 5.9 at the Lower Restoration station to 6.8 at the Beta Control site. The ratio of scrapers to filtering collectors was lowest (0.47) at the Alpha Control and highest (4.33) at the Middle Restoration site. The chironomid larva, *Hydrobaenus* sp., was the most common macroinvertebrate scraper collected. *Cheumatopsyche* sp. and *Chimarra* sp. larvae were the dominant filtering collectors seen, with shredders low to non-existent at all the sites. The ratio of EPT macroinvertebrates to total chironomids ranged from 0.14 at the Lower Restoration site to 0.02 at the Gamma Control and the Middle Restoration site. *Cheumatopsyche* sp. and *Chimarra* sp. larvae were the dominant EPT macroinvertebrates collected, with the total number of EPT macroinvertebrates ranging from 2 to 3 taxa at all the sites. The percent contribution of the dominant taxon, *Orthocladius* sp. ranged from 43.5% (Beta Control) to 61.9% (Gamma Control).

Table UTSC 4. Data summary of benthic macroinvertebrates collected in D-frame samples on March 2017 at stations in an unnamed tributary to Seneca Creek at Watkins Mill Rd.

Metrics	Watkins Mill Riffle Community (RBP III 300 + subsample)				
	Alpha Control	Beta Control	Gamma Control	Lower Restoration	Middle Restoration
Taxa Richness	16	18	18	24	21
Hilsenhoff Biotic Index	6.3	6.8	6.2	5.9	6.5
Ratio Scrapers to Filtering Collectors	0.47 (47%)	0.60 (60%)	1.21 (121%)	0.71 (71%)	4.33 (433%)
Ratio Shredders to Total Individuals.	0.00 (0.0%)	0.00 (0.0%)	0.00 (0.0%)	0.01 (0.8%)	0.00 (0.0%)
Total EPT Individuals to Total Chironomids.	0.10 (10.0%)	0.13 (13.4%)	0.02 (2.5%)	0.14 (13.8%)	0.02 (2.3%)
EPT Index	2	3	3	3	2
Percent Contribution of Dominant Taxon	53.4%	43.5%	61.9%	49.3%	48.1%

Physical Habitat: The UTSC arises from a series of springs on the north side of I-270 adjacent to Quince Orchard Road, and then flows under I-270 through a long culvert. The stream is in very close proximity to the on-ramp for westbound I-270 traffic. There is some shading present in this area, but the stream bed is very constricted in this area.

After passing under I-270 through a long culvert, the stream is very well-shaded until it reaches the treeless power line corridor (~ 113 m in width at stream crossing of corridor). Throughout the proposed restoration reach, there are mature hardwood trees present of several species, as well as significant undergrowth and several exotic species. Numerous trees have fallen into the stream, creating a number of stable pools. In the upper part of the stream reach, there is strong evidence of impervious surface effects with erosion of bed material down to bedrock, as well as deep incisions into bed material throughout the entire restoration reach. There are abundant debris bars, consisting of small stones to moderate cobble, formed in the stream. Numerous pool-riffle zones are present, with many of the larger, deeper pools having fishes present.

Bank slumping was observed in the upper reaches, as well as numerous perched tree roots in many areas, indicating a severing of the riparian zone from the stream. Sections of the stream appeared to have had some past stabilization work, with several riprap areas present (presumably added during the I-270 construction). In addition, there was also a sewage line running through the stream reach. The MPHI in FY 2017 was 58.5 for the control area (fair) and 51.8 for the restoration area (fair).

During the first visit to UTSC on 3.16.17, stream flow was virtually non-existent and no sampling was performed, although pools were still present. The UTSC was resampled on 3.29.17 when there was adequate flow present for benthic sampling.

Assessment Recommendation: Throughout the entire sampling program on the UTSC, the benthic community, as based on the BIBI, was either in poor or very poor condition. There may be several factors forcing the benthic response, including road salt, high flows (from impervious surfaces in the watershed) during storm events and sewer leakage. It is recommended that water quality be sampled at this site on a more frequent basis (monthly) to determine the levels of chemical stressors. Monitoring of storm events is also recommended but this would require the installation of a stream gaging station to determine the stream hydrograph.

After the bridge over I-270 is finished and all stream construction and restoration work is completed on UTSC, the site should be re-evaluated. It should be revisited 2-4 years after the completion of all stream and riparian zone activities, and then placed on a ten-year revisit cycle. However, it may be necessary to wait at least two years after the completion of construction work before attempting any revisits.

UTSC Specific Conductance and Temperature Profiles – Stream specific **c**onductance at the Watkins Mill site ranged from 51.5 µS/cm on 6.16.16 to 49,004 µS/cm on 12.17.16 (Figure UTSC 2). Average monthly specific conductance values for 2016 were: 3245 µS/cm in February (23 days), 1661 µS/cm in March, 1234 µS/cm in April, 1119 µS/cm in May, 1246 µS/cm in June, 1209 µS/cm in July, 1274 µS/cm in August, 1344 µS/cm in September, 2604 µS/cm in October, 4192 µS/cm in November, and 3140 µS/cm in December. For 2017, mean monthly specific conductance values were: 1452 µS/cm in January, 1809 µS/cm in February, and 1728 µS/cm in March (6 days). The overall mean specific conductance for the length of record (N = 18,947) was 1940 µS/cm, median = 1619 µS/cm, lower quartile limit = 1233 µS/cm, upper quartile limit = 2117 µS/cm, and Winsorized mean = 1851 µS/cm.

Of major concern would be the stream specific conductance levels associated with any major winter storm event (Figure UTSC 2), as well as base flow levels. Two episodic events, occurring on 15-16 February 2016 and 17-18 December 2016, displayed stream specific conductance levels over 30,000 µS/cm (estimated 5.6 ppt chloride using equation from Morgan et al. 2012) and 49,000 µS/cm (estimated 9.2 ppt chloride). Respectively, these two peaks in stream chloride are equivalent to 29% and 47% of the chloride concentration in the oceans (assuming an average oceanic salinity of about 35 ppt).

From February 2016 to March 2017, mean monthly specific conductance (Figure UTSC 3) at Watkins Mill substantially exceeded the EPA regional specific conductivity criteria of 300 µS/cm for local streams (U. S. EPA 2011). The presence of high specific conductivity, a function of elevated sodium and chloride presumably from road salt, in the stream water could potentially affect biotic resources, especially important to consider in any present and future restoration activities (Morgan et al. 2012). With the potential for future regional conductivity criteria (based on ecoregion analyses) to be soon proposed by EPA, the high specific conductivity observed in the Seneca Creek watershed could be of concern for stream restoration and the overall maintenance of stream water quality (Cormier and Suter 2013, US EPA 2011).

Of particular importance to SHA would be those stream restoration sites (both completed and proposed) in very close proximity to major roadway systems, e.g. the Downes site, Little Paint Branch, Long Draught Branch, Minebank Run, Plumtree Run, Piney Creek, Upper Little Patuxent, Watkins Mill, and White Marsh Run. At these sites, it may be necessary to install temperature/conductivity probes to monitor water quality from October to May (perhaps even on an annual basis) to determine water quality from storm events as well as establishing baseline conductivity data.

Stream temperature over the study period ranged from 0.89 C (1.9.17) to 28.8 C (7.28.16). Stream temperature at Watkins Mill showed an ascending pattern from February through August (Figure UTSC 2 and 3) and then a decreasing pattern from September to January; typical of what

would be expected for the region and a function of local climatic conditions. Within the study period, there were some large fluctuations in daily stream temperature (Figures UTSC 2 and 3).

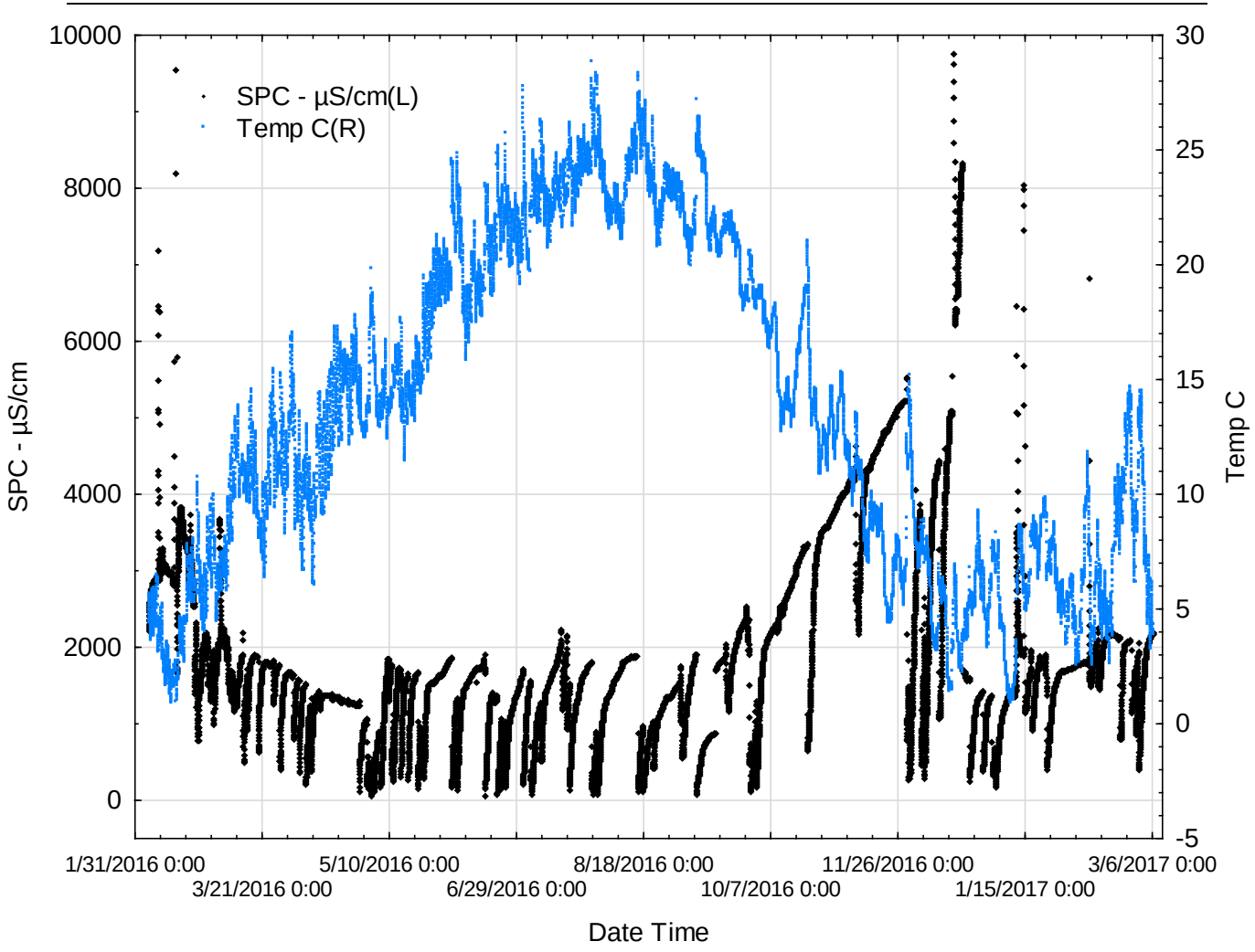

Figure UTSC 2. Temperature (C) and specific conductance (µS/cm) at the unnamed tributary to Seneca Creek from 2.5.16 to 6.16.16.

SHA Site Water Chemistry

Water Quality (WQ): All FY 17 sites were sampled for MBSS water quality parameters during the Fall (five sites in October) and Spring (five sites in March) SHA field work (Table WQ 1). All TP, TN and TSS values fell within the 10 - 90th percentile range in both the Fall and Spring sampling except for Fahrney Branch (Fall only), with a high TN value of 5.5 mg/L – assumed to be either a reflection of past or current agriculture activities in the upstream watershed or residual TN in groundwater from farming near the site. Seven observed conductivity and five ANC values for these SHA sites fell outside of the upper MBSS 90th percentile (Table WQ 1). For conductivity, these included Deep Run (Fall and Spring), Israel Creek in the Fall only, and Long Draught Run and Watkins Mill in Fall and Spring. For both Long Draught Run and Watkins Mill, the Fall and Spring conductivity levels were extremely high, reflecting road salt inputs during snow and ice events as well as residual soil saturation along the roads. ANC was elevated in Deep Run and Israel Creek (Fall and Spring) and Long Draught Run in the Spring. Closed pH was within the 10 - 90th percentile for most sites, both in the Fall and Spring water quality sampling, except for Deep Run and Israel Creek, where pH levels ranged from 7.92 to 8.2 (near saturation).

Stream conductivity exceeded the 25th percentile (145 µS/cm) for the Northern Piedmont (EPA Level III) ecoregion sites (four SHA sites except for Deep Run which falls into the EPA Level III Southeastern Plains) by a factor of 1.4 – 11.9 times (Morgan et al. 2012). Deep Run exceeded the Southeastern Plains 25th percentile (103 µS/cm) by a factor of approximately 17.8 – 18.9 times (Table WQ 1). These elevated stream conductivity values, and conceivably the high ANC levels, observed for the SHA stream restoration sites may potentially reflect the urban stream syndrome (Walsh et al. 2005) in which stream conductivity is high due to considerable inputs from road salt usage (primarily sodium chloride), and many other urban-related sources. In particular, many of these SHA sites are in very close proximity to several major metropolitan road systems (I-270, I-70, I-97, I-495, I-695, I-95, Route 40, Route 144, Route 355, Route 24 and many others) that are often excessively salted during icing and snow events in Maryland. Other potential sources of stream conductivity may be leaking sewage pipes, runoff from impervious surfaces and fertilizers, as well as legacy salt accumulation along roads and in shallow groundwater (Walsh et al. 2005).

Although all TN and TP values fell within the 10 - 90th MBSS percentile range (Table WQ I) except for Fahrney Branch (TN = 5.5 mg/L), several sites exceeded the TN 25th percentile estimates (Morgan et al. 2013) for the Northern Piedmont (1.6 mg/L) and Southeastern Plains (0.33 mg/L) ecoregions of Maryland for both the Fall and Spring sampling. In addition, a few sites also exceeded the TP 25th percentile estimates (Morgan et al. 2013) for the Northern Piedmont (0.010 mg/L) ecoregion of Maryland, again also for both the Fall and Spring sampling. Indeed, many SHA sites exceeded both the TN and TP values similarly derived using the EPA Y-intercept and 75th percentile estimations (Morgan et al. 2013). These exceedances of the derived TN and TP criteria, based on scientifically acceptable EPA methodology, may be a

major concern for any stream restoration project since eutrophic stream conditions would not be advantageous for functional stream recovery, benthic recolonization and re-establishment of fish and amphibian populations over time (Morgan et al. 2013, Ashton et al. 2014).

For DOC, (Table WQ 2), none of the values exceeded the calculated 90th MBSS percentile value for this analyte. However, low DOC levels below the 10th percentile were observed for Long Draught Run and Watkins Mill in the Fall and Little Gunpowder River (UT) and Long Draught Run in the Spring, potentially indicating a lack of allochthonous inputs to the stream. Ortho-phosphate was within the 10th-90th percentile range except for a low value observed for Deep Run in the Spring sampling. Watkins Mill (0.017 mg/L) exceeded the nitrite-N level in the Spring and Fahrney Branch (5.1 mg/L) exceeded the nitrate-N level in the Fall – all other values for ammonia-N, nitrite-N and nitrate-N were within the 10th-90th MBSS percentile for these analytes.

Chloride and bromide concentrations at Deep Run, Long Draught Run and Watkins Mill sites exceeded the MBSS 10 - 90th percentile ranges for all October and March sites (Table WQ 3). These chloride levels correlate to specific conductance measurements at these sites - expected since there is a strong relationship between chloride concentration and stream conductivity in Maryland non-tidal streams (Morgan et al 2012). For all Northern Piedmont SHA sites, chloride exceeded the derived 25th Cl percentile (17.8 mg/L) by factors ranging from 1.6 to 24.8. For Deep Run (Southeastern Plains SHA site), chloride exceeded the derived 25th Cl percentile (10.9 mg/L) by factors of 11.3 – 15.3. At any SHA stream restoration site, these elevated chloride levels illustrate latent salt effects observed in October and March, presumably from the over-salting of road systems and residual soil concentrations. Although reflecting conductivity, these elevated chloride levels could have a number of potential biological effects at SHA restoration sites.

For sulfate, there was only one exceedance of the 90th percentile at the Israel Creek site (Table WQ 3). This high sulfate level (168 mg/L) may be due to quarry activity just upstream of the sampling sites. Calcium and magnesium concentrations (from several potential urban and agricultural sources) exceeded the MBSS 90th percentile for many sites in both the Spring and Fall, with Long Draught Branch having the highest values for both calcium (108 mg/L) and magnesium (41.8 mg/L). Although elevated at several SHA sites, copper exceeded the MBSS 90th percentile at Deep Run (3.5 mg/L) in October and Watkins Mill (2.5 mg/L) in March (Table WQ 3), with only one exceedance of zinc (from many potential urban sources) observed in the Spring sampling at Watkins Mill (21.0 mg/L).

Water Quality Summary: Conductivity and ANC values for several SHA sites fell outside of the upper 90th percentile for MBSS random site data. Stream conductivity exceeded the 25th percentile (145 µS/cm) for the Northern Piedmont (EPA Level III) ecoregion sites by a factor of 1.4 - 11.9 times (Morgan et al. 2012). For the Northern Piedmont SHA sites, chloride exceeded

the derived 25th Cl percentile (17.8 mg/L) by factors ranging from 1.6 to 24.8. Elevated stream conductivity, ANC and chloride for the SHA restoration sites potentially reflect the urban stream syndrome (Walsh et al. 2005), and are of concern for all past, present and future SHA stream restoration projects due to the importance of water quality.

Several sites SHA exceeded the TN 25th percentile estimates (Morgan et al. 2013) for the Northern Piedmont and Southeastern Plains ecoregions of Maryland for both the Fall and Spring sampling. In addition, numerous sites also exceeded the TP 25th percentile estimates (Morgan et al. 2013) for the Northern Piedmont (0.010 mg/L) and Southeastern Plains (0.016 mg/L) ecoregions of Maryland. These TN and TP exceedances may be a major concern for any stream restoration project since eutrophic stream conditions would not be favorable for either stream recovery or biotic recolonization over time (Morgan et al. 2013, Ashton et al. 2014).

Water Quality Recommendations: It is recommended that the MBSS chemistry be continued at all scheduled FY 18 SHA sites for both Fall and Spring site efforts, with the potential to expand the chemical analyses of transportation-linked chemicals in the future, if funding allows. The success of stream restoration is dependent on a number of factors, including acceptable water quality.

Table WQ 1. Summary of total nitrogen (TN), total phosphorus (TP), total suspended solids (TSS), specific conductance (SPC), closed pH and acid neutralizing capacity (ANC) parameters for FY17 SHA stream restoration sites (Bold = outside of 10-90th percentile range; NA = not applicable).

Sample ID/Date	TP (mg/L)	TN (mg/L)	TSS (mg/L)	SPC (µS/cm)	Closed pH (STU)	ANC (µeq/L)
10-90th Percentile Range (MBSS)	*0.007-0.092*	*0.29-4.6*	*NA*	*62-416*	*6.07-7.85*	*71-1292*
Deep Run 10.10.16	0.011	0.86	0.0	**628**	**8.00**	**1946**
Fahrney Branch 10.06.16	0.012	**5.5**	1.3	202	7.24	496
Israel Creek 10.06.16	0.022	4.4	1.9	**886**	**7.92**	**2747**
Long Draught Run 10.06.16	0.021	1.7	0.6	**1094**	7.43	1270
Watkins Mill – UTSC 10.06.16	0.015	1.9	0.9	**1143**	7.44	1156
Deep Run 3.09.17	0.0074	0.47	0.7	**846**	**8.2**	**1829**
Israel Creek 3.09.17	0.017	1.9	3.3	316	**8.7**	**1666**
Little Gunpowder River - (UT) 3.09.17	0.0099	4.3	0.7	261	7.6	322
Long Draught Run 3.06.17	0.011	2.2	1.4	**1615**	7.7	**1347**
Watkins Mill – UTSC 3.17.17	0.018	1.4	4.2	**1732**	7.8	1151

Table WQ 2. Summary of dissolved organic carbon (DOC), orthophosphate (Ortho-PO_4), ammonia-N, nitrite-N and nitrate-N for SHA stream restoration sites in FY17 (Bold = outside of 10-90th percentile range; NA = not applicable). Note = bold high underlined low

Sample ID/Date	DOC (mg/L)	Ortho-PO_4 (mg/L)	Ammonia-N (mg/L)	Nitrite-N (mg/L)	Nitrate-N (mg/L)
10 - 90th Percentile Range (MBSS)	*1.0-9.0*	*0.0007-0.023*	*0.0033-0.085*	*0.0004-0.016*	*0.13-4.6*
Deep Run 10.10.16	2.0	0.0020	0.0077	0.0015	0.42
Fahrney Branch 10.06.16	1.1	0.0050	0.0079	0.0028	**5.1**
Israel Creek 10.06.16	1.2	0.0081	0.017	0.0094	4.1
Long Draught Run 10.06.16	**0.75**	0.010	0.0077	0.0040	1.6
Watkins Mill – UTSC 10.06.16	**0.67**	0.0080	0.0088	0.0029	1.8
Deep Run 3.09.17	1.4	**0.0005**	0.0067	0.0011	0.27
Israel Creek 3.09.17	1.9	0.0032	0.012	0.0083	1.7
Little Gunpowder River - (UT) 3.09.17	**0.78**	0.0023	0.0066	0.0048	4.1
Long Draught Run 3.06.17	**0.63**	0.0022	0.0060	0.0065	2.1
Watkins Mill – UTSC 3.17.17	1.1	0.0011	0.0063	**0.017**	1.1

Table WQ 3. Summary of chloride, bromide, sulfate, magnesium, calcium, copper and zinc levels for SHA stream restoration sites (Bold = outside of 10-90th percentile range; NA = not applicable).

Sample ID/Date	Chloride (mg/L)	Bromide (mg/L)	Sulfate (mg/L)	Mg (mg/L)	Ca (mg/L)	Cu (µg/L)	Zn (µg/L)
10 - 90th Percentile Range (MBSS)	*3.8-68*	*0.0032-0.062*	*5.5-28*	*1.1-13*	*2.6-40*	*0.40-2.4*	*0.8-19*
Deep Run 10.10.16	**123**	**0.074**	19.5	10.7	**44.0**	**3.5**	10.1
Fahrney Branch 10.06.16	28.3	0.026	2.9	6.0	14.3	1.2	13.0
Israel Creek 10.06.16	38.4	0.028	**168**	**20.5**	**101**	2.3	5.5
Long Draught Run 10.06.16	**250**	**0.12**	13.6	**27.8**	**74.8**	2.1	15.3
Watkins Mill – UTSC 10.06.16	**260**	**0.18**	15.9	**27.6**	**73.9**	1.1	10.5
Deep Run 3.09.17	**167**	**0.093**	24.0	**13.8**	**52.7**	1.4	6.9
Israel Creek 3.09.17	31.0	0.017	17.1	9.1	36.5	0.97	3.7
Little Gunpowder River - (UT) 3.09.17	53	0.026	5.3	8.2	13.0	0.48	10.6
Long Draught Run 3.06.17	**393**	**0.40**	17.2	**41.8**	**108**	1.9	13.2
Watkins Mill – UTSC 3.17.17	**442**	**0.18**	18.6	**29.9**	**73.8**	**2.5**	**21.0**

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APPENDIX F
RESEARCH ACTIVITY

MEETING LOCAL TMDLS FOR PCBS

2017 PROGRESS REPORT

February 2017 Progress Report

Project: *Meeting Local TMDLs for PCBs*

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Submitted to: Ryan Doran, Maryland State Highway Administration

Introduction and background

Background

Polychlorinated biphenyls (PCBs) are a group of organic chlorine compounds derived from biphenyl with some of the hydrogen atoms replaced by chloride (Figure 1). As a result, PCBs have 209 different congeners. PCBs were widely used in industrial processes to produce coolants, transformer oil and flame retardants (Kimbrough, 1995). They were commercially produced for the first time in 1929 and their manufacturing was banned in 1977 (Kimbrough, 1995). Because of their high stability and low aqueous solubility, PCBs are persistent in the environment and are classified as a group of persistent organic pollutants (POPs) (Jones and de Voogt, 1999). POPs are a group of intentionally or inadvertently produced chemicals, which are resistant to photolytic, biological and chemical degradation (Ritter, 2007). Due to their long-life and harmful effects, PCBs and other POPs were listed in the Stockholm Convention (Organization, 2015), which means that they are hazardous and persistent chemicals to be reduced or eliminated.

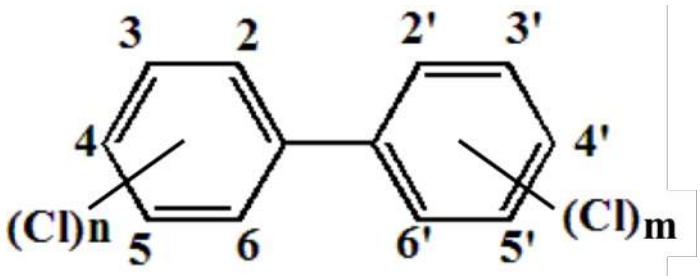

Figure 1. Structural formula of PCBs

Sources

Even though the production of PCBs was banned in the United States in 1979 (Kimbrough, 1995), there are still many products containing PCBs in use. In addition, a large amount of PCBs remain in the environment, especially in soils and sediments, due to their hydrophobic characteristics and very stable chemical structures (Kjellerup, et al., 2012, Kjellerup, et al., 2008). They are continuously released from old equipment and waste sites (Li, et al., 2010). About 1.3 million tons of PCBs were produced according to reported historical global production (Breivik, et al., 2002), among which about 440 to 92000 t is estimated to have been emitted into the environment (Breivik, et al., 2002, Breivik, et al., 2007). Breivik et al. (2002) classified emissions into three categories: usage, accidental release and disposal. Usage is estimated as the dominant emission pathway for less-chlorinated PCB congeners, while for more chlorinated PCB congeners, disposal is estimated as the predominant emission pathway.

The first major use of PCBs are electrical fluids, with sealants as the second (Herrick, et al., 2004, Kohler, et al., 2005). In the United States, the usage of PCBs was 70% in electrical equipment, 8% in plasticizers and 2% for miscellaneous applications during the period 1930 to 1975 (Scott and Snyder, 2015). It has been estimated that concentrations of PCBs in sealants and caulking were geographically higher in residential areas within buildings constructed during 1950 to 1970 (Diamond, et al., 2010). Among the 80 buildings constructed from 1945 to 1980 in Toronto, Canada, the geometric mean concentration of PCBs was 4630 mg kg^{-1}(of sealants) (Robson, et al., 2010). As a result, buildings constructed before the 1970s are important sources of PCBs. Utilization of construction and demolition waste (C&DW) is widely practiced, especially in many European countries. The crushed materials were reported to possess favorable geotechnical properties for construction of roads (Wahlström, et al., 2000). However, in Denmark, PCBs were detected in all C&DW samples (Butera, et al., 2014). As a result, the roads could also be a source of PCBs to the environment. What is more, public transportation corridors are locations containing in-use PCBs as well (Diamond, et al., 2010). High concentrations of PCBs were found in paint

(3520 mg kg^{-1}) and small capacitors (114000 mg kg^{-1}), which indicated that these two groups of items are among the main sources of PCBs. Since PCBs were widely used as a plasticizer, vehicle parts could also be a source of PCBs. Additionally, the wastes from the shredding of automobiles could also contain PCBs (Scott and Snyder, 2015). It has been hypothesized that elevated concentrations of PCBs in indoor air contributes to outdoor air concentrations via ventilation (Currado and Harrad, 2000, Jamshidi, et al., 2007). As a result, increased air concentrations and subsequent atmospheric deposition of PCBs also contribute to PCBs in stormwater and surface waters (Diamond and Hodge, 2007).

Runoff from building surfaces, such as roofs and walls could contain chemical contaminants (Bucheli, et al., 1998, Zobrist, et al., 2000). In addition, surface films, which are composed of biogenic compounds as the organic portion, accumulate on the surface of building materials (windows). The constituents of the surface films could be influenced by local sources. For example, the highest PCBs concentration was found in a building located very close to an electrical plant that housed electrical transformers containing PCBs (Diamond, et al., 2000). The total PCB concentration ranged from 900 to 62100 ng m^{-2} of window surface in downtown Toronto (Diamond, et al., 2000). Surface films also accumulated higher chlorinated PCB congeners. Once deposited, volatile organic compounds in surface films will volatilize. However, the less volatile contaminants can be washed away during rain events (Diamond, et al., 2000, Lerner, 2002). Figure 2 shows the sources of PCBs in urban areas, with bioretention cells, wastewater treatment plants and solid waste disposal areas as receptors of PCBs.

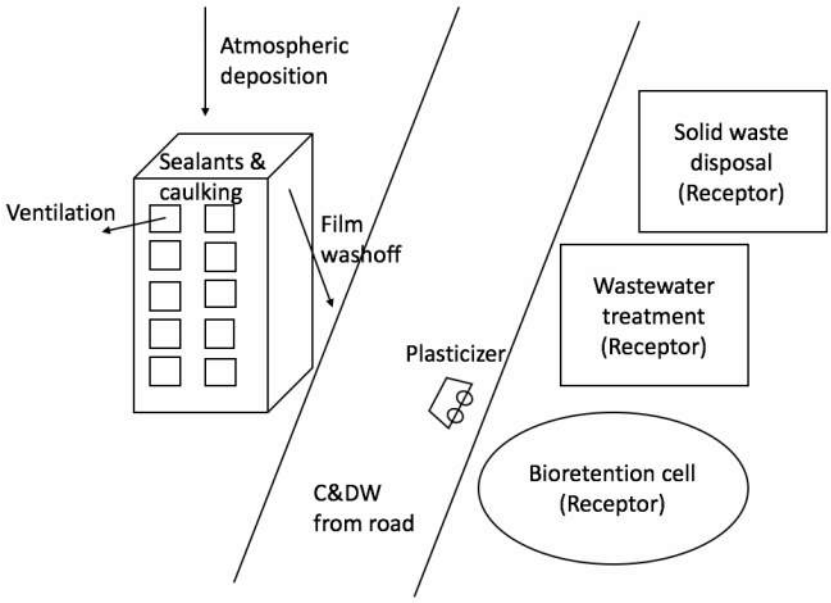

Figure 2. Sources of PCBs in urban areas

PCBs in stormwater

Since the 1960's, urban stormwater runoff has been identified as an important source of pollution (Granier, et al., 1990). Few studies have been completed on PCBs in stormwater runoff. (Cole, et al., 1984) found that the nationwide PCB concentration in the United States was 30 ng L^{-1}. Marsalek and Ng (1989) determined the concentration of PCBs in runoff at three sites in Canada, ranging from 27 ng L^{-1} to 179 ng L^{-1}. Granier, et al. (1990) measured the concentration of PCBs at the outfall of a stormwater drain during three rain events in 1988 and 1989 in France. In this study, the mean concentration of PCBs for each rain event were 130, 633 and 625 ng L^{-1}, with a range of 36 – 2600 ng L^{-1}. The mean concentration of PCBs in stormwater in Switzerland determined during the early 2000s ranged from values below the detection limit (Detection limit: 0.11 -0.24 ng L^{-1}) to 403 ng L^{-1} (Rossi, et al., 2004). Hwang and Foster (2008) studied PCBs in runoff entering the tidal Anacostia River, Washington, DC and found that stormwater runoff contained elevated levels of PCBs, which ranged from 9.82 to 211 ng L^{-1}. The median concentration of PCBs in three urban areas in Paris and its suburb were 211, 259 and 468 ng L^{-1}, respectively (Zgheib, et al., 2011). In a watershed in Hayward, California, PCBs concentrations in storm

flow ranged from 3.98 to 109 ng L^{-1} (Gilbreath and McKee, 2015). These data indicate that worldwide the concentration of PCBs in stormwater ranged from several ng L^{-1} to hundreds ng L^{-1} and some urban areas in Paris exhibited the highest concentrations of PCBs with 633 ng L^{-1} as the mean concentrations. Additionally, it is found that PCBs concentrations in stormwater did not change much with time for decades.

Schiff and Bay (2003) found the mean PCBs concentration in sediments offshore Ballona and Malibu Creeks in Southern California in the US following storm events between 1995 and 1997 were 21.5 and 3.0 ng dry g^{-1}, respectively. This indicated that sediments were important receiving areas for PCBs.

Additionally, some studies have related the atmospheric concentration of PCBs to water load. Atmospheric deposition of PCBs consists of two parts: local redistribution of contaminated soils and long-range transport of finer materials (Loganathan, et al., 1997). Loganathan, et al. (1997) studied samples from the Babcock Street sewer district, New York, and found that PCBs in atmospheric dry and wet deposition samples were close to the method detection limit, which were a few pg cm^{-2} day^{-1} and < 0.2 ng L^{-1}, respectively. Despite the low concentration, atmospheric dry deposition might still contribute to the stormwater load. In addition, a study in Norway suggested that stormwater carried 0.4 g of 7 selected PCBs into Lille Lungegårdsvannet lake in Bergen, Norway each year (Andersson, et al., 2015). This indicated that stormwater plays an important role in carrying PCBs from source to receiving areas. This also suggested that there are still active PCBs sources in the urban area today.

Removal pathway

Many microorganisms have been reported to utilize and metabolize PCBs as carbon and/or energy sources (Abraham, et al., 2002) under both aerobic and anaerobic conditions. As a result, bioremediation may ultimately be a solution for many PCB-contaminated sites. Under aerobic conditions, lower-chlorinated congeners (<4 chlorines per biphenyl) are good substrates and they act primarily as electron donors (Abraham, et al., 2002). *Burkholderia xenovorans* sp. LB400 and *Rhodococcus globerulus* strain

P6 are capable of transforming a broad range of low-chlorinated congeners (Kim and Picardal, 2001). Under anaerobic conditions, reductive dechlorination is the major transformation process using PCBs as the electron acceptor, during which highly chlorinated congeners experience dehalorespiration and the number of attached chlorines is reduced.

Phytoremediation can also be used to remove PCBs from soils. PCBs can be taken up from soil and accumulate in the stems and leaves of the plants (Whitfield Åslund, et al., 2007, Zeeb, et al., 2006). Two PCBs phytoremediation mechanisms are phytodegradation and rhizoremediation (Gomes, et al., 2013, Javorská, et al., 2009).

Chemical treatment, like activated metal treatment can be used to remove PCBs from various materials, including PCB-containing caulks and paints. Laboratory testing results showed that the removal rates were over 80% for PCBs from paint and primer (EPA, 2012). However, the removal efficiency decreased for thicker sources.

The hydrophobic nature of PCBs enables them to adsorb to particles and eventually sediments, especially sediments containing a high proportion of carbon (Choi and Al-Abed, 2009). In addition, the maximum adsorption capacities of PCBs correlate positively with the sorbent's specific surface area, which suggests that the sorption is surface sorption instead of pore sorption (Jantunen, et al., 2010). Because of the adsorption ability of PCBs, they are expected to be removed via particulate matter removal processes such as sedimentation and filtration in stormwater.

Project goals, Objectives, Hypotheses

Because PCBs are adsorbed to particulate matter in stormwater, they are expected to be removed in stormwater Best Management Practices (BMPs) via particulate matter removal processes such as sedimentation and filtration.

The goal for this project is to provide information and guidance to State Highway Administration (SHA) on PCBs in SHA watersheds and stormwater so that SHA can successfully meet the requirements of their most recent Municipal Separate Storm Sewer System (MS4) permit. Of particular interest are PCB concentrations, relationships to sediment concentrations and sediment grain sizes, and PCB removal with sediment removal. This information will assist in the establishment of benchmarks and timeframes for Total Maximum Daily Loads (TMDLs) program implementation. This will be done by determining the concentration of PCBs in deposited stormwater sediment and its relationship with different particle sizes.

Materials and Methods

Sampling site. Figure 3 shows a map of sampling points and bioretention sites at the University of Maryland. On Sep 30, 2016, sediment samples were collected after a rain event. During the collecting process, a scoop was used to collect the surface sediments of the bioretention cells. Sediment samples were collected from both the entrance and middle point of a bioretention cell in a parking lot (site 2, Figure 4A), the entrance of the bioretention cell (site 3, Figure 4B) across from site 2, and one near Reagent Drive (site 6, Figure 4C). In addition, sediment samples were also taken from a stormwater flume located below Route 1 in Mt. Rainer, Maryland. To minimize biological and chemical transformations, all samples were stored in glass containers at -20°C in the dark until analysis.

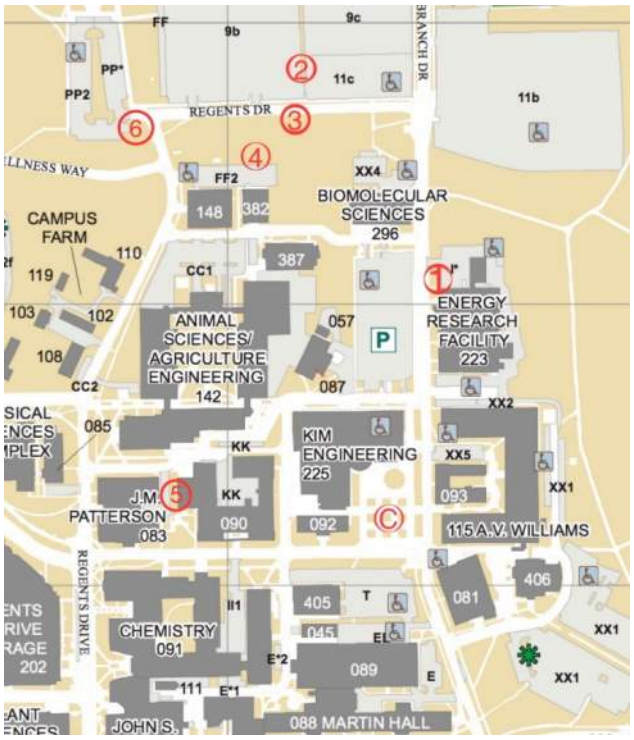

Figure 3. Map of sediment sampling points and bioretention cells at the University of Maryland.

Figure 4. Photos of different sample sites, A) Site 2, B) Site 3, C) Site 6. All are entrances to bioretention facilities.

Sediment fractionation. Sediment samples were separated into three fractions, as done by Sansalone and Kim (2008), with some modifications. Briefly, wet sieving (No. 200 sieve) was performed to separate the "sediment" fraction (>75 μm) from the other two parts. Then the filtrate was transferred to an Imhoff cone and settled for at least 1 h. The "settleable" fraction (~25 to 75 μm) was the part settled out in the Imhoff cone and the fraction remaining in Imhoff suspension was defined as the "suspended" fraction (<25 μm). Both the "sediment" fraction and the "settleable" fraction were air dried in the flume hood for further use.

Extraction of PCBs. Microwave-assisted extraction was used to extract PCBs from the sediment samples. The extraction method was based on that of Lopez-Avila, et al. (1995) with some modifications. Samples from the entrance of site 2 were used in this extraction experiment. Briefly, 5 grams of air dried sediment or settleable samples were transferred quantitatively to the extraction vessels. 5 grams of clean sea sand (Merck) were used as a blank control. Then 30 mL hexane-acetone (1:1) was added into the vessels. Prior to extraction, 15 μL of the mixed solution of surrogates (5 μg mL^{-1} 4-bromobiphenyl (4-BB) and 2,2',4,4',5,5'-hexabromobiphenyl (Hx-BB)) was added into the samples. Extractions were performed at 115°C for 10 min at 1000 W. After extraction, the vessels were allowed to cool to room temperature before they were opened. Then the extracts were centrifuged (3000 rpm, 30 min) and the supernatants were collected. The residues were washed with hexane, hexane-acetone (1:1), acetone separately and centrifuged (3000 rpm, 30 min). The supernatants were combined and then concentrated under nitrogen to 200 μL and hexane was added to dissolve the extracts again. Extracts were stored at -20 °C until cleanup.

Cleanup of PCBs extracts. The cleanup method was based on EPA method 3620c with some modifications. Briefly, florisil was heated at 450°C for at least 4 h and cooled to room temperature in a desiccator. Deionized water was added (125 μL to 4 g florisil) to deactivate it to 3.2%. Glass wool was used to fill the bottom of a Pasteur pipette and prepared florisil was added into the pipette. After these, a

layer of sodium sulfate was added to remove water from the extracts. First hexane was added to wash the column. Then both the extract and the rinse was transferred into the pipette and the effluent was collected for further analysis.

GC analysis. Samples were analyzed by gas chromatography/ECD (Agilent). The temperature program was 100 °C to 280 °C at 2 °C/min, to 300°C at 10 °C/min (10 min). The injection volume was 2 µL.

Results

During the fractionation experiment, for all the sediment samples, the sediment fraction and the settleable fraction accounted for more than 99% of the total sediments. As a result, the sediment fraction and the settleable fraction were acquired successfully. PCBs were extracted from the both the sediment fraction and the sediment fraction.

Figure 5 shows the composition of different particle size fractions collected at the different sites. Except for site 2-mid, the sediments from other sites mainly consisted of the sediment fraction. The suspended fractions were small, almost negligible (< 0.5%) for all the five sites on a total sediment mass basis.

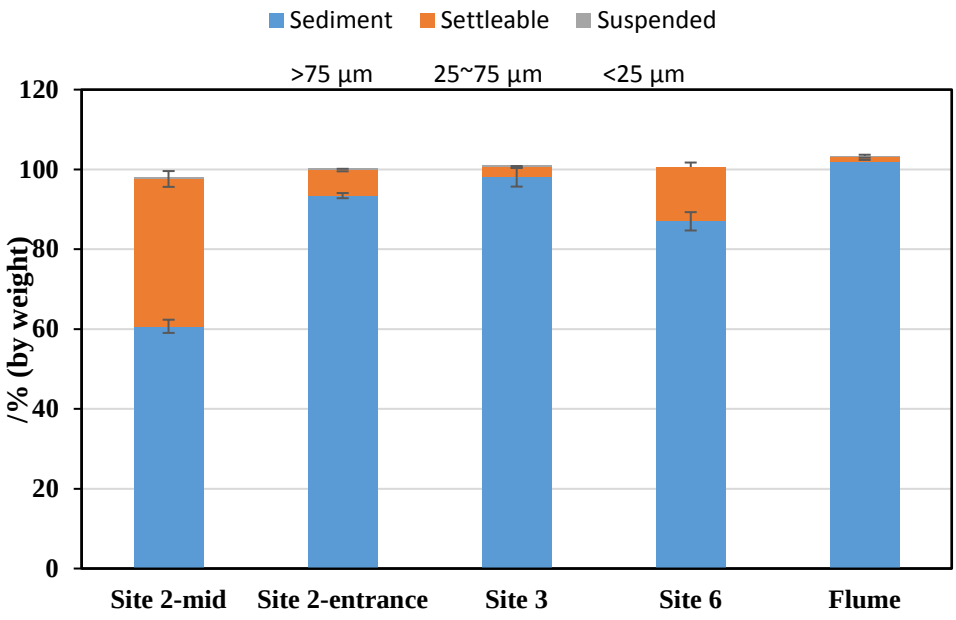

Figure 5. Composition of different size fractions in stormwater sediment from different sites.

Figure 6 shows the chromatograms of the extracts from the sea sand, sediment and settleable fraction of site 2-entrance. Higher peaks were found in the settleable fraction. This indicates that smaller particles absorb more PCBs than larger particles. This result is in accordance with other results that showed that the maximum adsorption capacities of PCBs correlate positively with the sorbent's specific surface area (Jantunen, et al., 2010). However, the sediment fraction accounts for 93.4 $\pm$ 0.65% of the total sediment. As a result, the removal of the sediment fraction can still remove potentially a large portion of PCBs from the stormwater. Hwang and Foster (2008) also assumed that particles are primary vector for transporting PCBs because more than 90% of the total PCBs are enriched in particles.

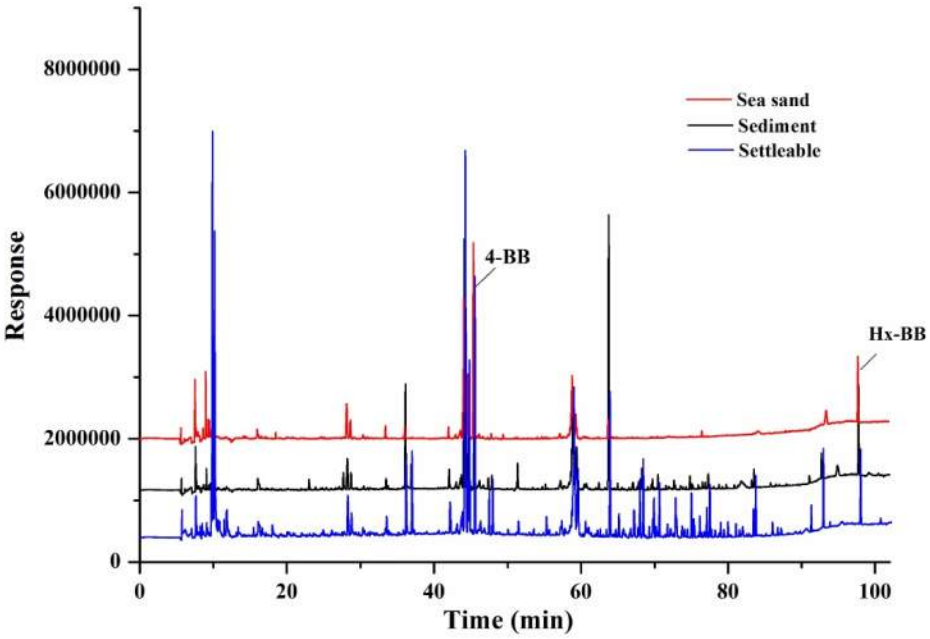

Figure 6. Chromatograms of sediment and settleable fractions from site 2-entrance, with sea sand as lab control

Figure 6 shows the chromatograms of sediment and settleable fractions compared with Aroclor 1242 (A1242), A1254 and A1260. Aroclor is the trade name of PCB mixtures being manufactured in the US. The second two numbers in Aroclors indicate the percentage of chlorine by mass in the mixture. For example, Aroclor 1260 contains 60% chlorine by mass. As a result, Aroclor 1260 has more chlorines per biphenyl than A1254 and A1242. A1260 mainly consists of hex-PCBs (39.28%), hepta-PCBs (36.38%) and penta-PCBs (11.96%). However, A1254 mainly consists of penta-PCBs (45.33), hex-PCBs(31.38%) and tetra-PCBs (19.67%) (Mayes, et al., 1998). When comparing the peaks of the two fractions and the Aroclors, it can be found that some of the peaks from the two sediment fractions were identified in A1254 and A1260, which means some of the congeners found in the fractions could also be found in these two Aroclors. Figure 6 indicates that PCBs extracted from the two sediment fractions were mainly higher chlorinated PCBs. This is in accordance with the findings of Hwang and Foster (2008) in which stormwater runoff in all sites (except Lower Beaverdam Creek) were enriched with high-chlorinated PCBs. This is explained with the fact that less-chlorinated PCBs are more volatile and easy to be biodegraded or photolyzed. As a result, less-chlorinated PCBs can either volatilize or transform in the environment, or volatilize during the experiment, which needs to be further studied. The difference in PCB congener pattern could also indicate the source of PCBs; it is possible that the source of PCBs to the parking lot is enriched in heavier PCBS.

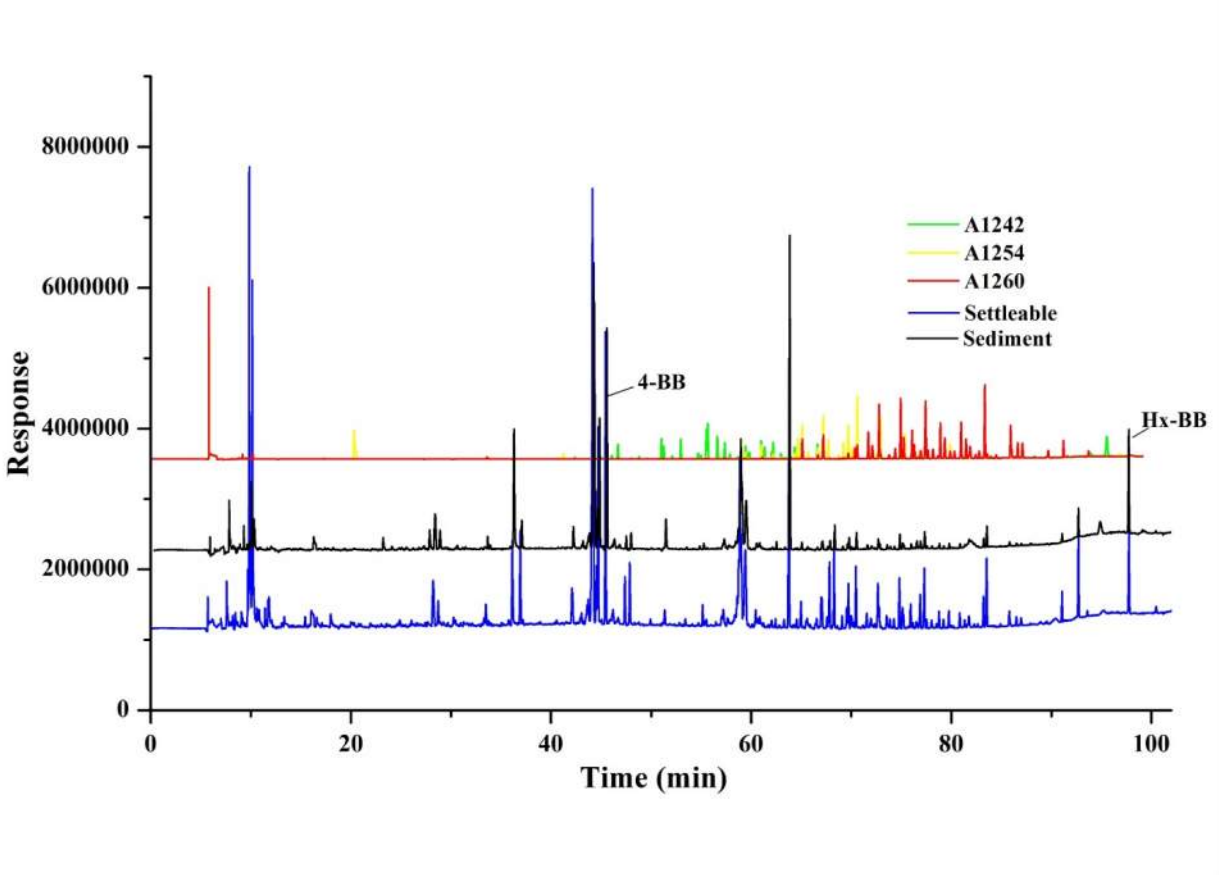

Figure 7. Chromatograms of sediment and settleable fractions from site 2-entrance compared with A1242, A1254, A1260

Summary

A literature survey has indicated that the reuse of C&DW can have a direct effect on the amount of PCBs that can be found in roads. More information is needed about this practice in the US and whether this constitutes a significant source for PCBs in stormwater run-off from highways.

Smaller stormwater particles have an increased tendency to absorb highly chlorinated PCBs than larger particles.

The sediment fraction (>75 µm) accounted for more than 90% of the total amount of sediment. This fraction is easier to remove and may be a viable treatment for stormwater PCBs.

Future work

Internal standards will be added into the GC samples to quantify the results and calculate the recovery of the extraction and cleaning processes.

Removal rate of PCBs by bioretention sediments will be determined.

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APPENDIX F
RESEARCH ACTIVITY

INLET CLEANING POLLUTANT CHARACTERIZATION STUDY

2017 QUARTERLY PROGRESS REPORT

MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

MDOT SHA
SPR Research Projects
Quarterly Progress Report

MDOT SHA Task Number (i.e, SHA/UM/4-18)	**Report Period**
SHA/MSU/4-11	☑ Quarter 1 (January 1 - March 31) ☑ Quarter 2 (April 1 - June 30) ☐ Quarter 3 (July 1 - September 30) ☐ Quarter 4 (October 1 - December 31)

Project Title:
Inlet Cleaning Pollutant Characterization Study for TMDL Compliance

Project Start Date: March 4, 2016
Original Project End Date: March 31, 2018
Current Project End Date: March 31, 2018
% of Work Completed to Date: 50%

Project Schedule Status:

☐ On Schedule ☑ On Revised Schedule ☐ Ahead of Schedule ☑ Behind Schedule

	Name	Agency	Phone	Email
Principal Investigator / PM	James Hunter	MSU	443-885-4733	*James.hunter@morgan.edu*
Project Manager	Neely Law	CWP	410.461.8323	*nll@cwp.org*
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Researcher	Bill Stack	CWP	410-461-8323	*bps@cwp.org*

Project Description

Schedule of Tasks

Quarters	Description	Year 1				Year 2			
		1	2	3	4	1	2	3	4
Task1	**Project Meetings and Coordination**	**Technical meetings, progress meetings, and conference calls**							
Task2	**Programmatic & Literature Review**								
Task 3	**Monitoring Study Design and QAPP**								
Task 4	**Sample Collection & Analysis**								
Task 5	**Related Tasks "as assigned"**								
Task 6	**Final report**								

	% Complete	Notes
Task 1: Project Management & Coordination	65%	Ongoing meetings and calls until project end
Task 2: Programmatic & Literature Review	83%	SHA Programmatic review – survey to be completed, literature review - redraft version
Task 3: Study Design & QAPP	95%	Study design/QAPP completed. Task requires limited additions / revisions following field/lab experience
Task 4: Sample Collection & Analysis	25%	Sampling – delayed, started March '17
Task 5: Related Tasks – "As Assigned"	---	
Task 6: Final Report	0%	

Project Deliverables

At project's end, SHA will be provided with a final report. Deliverables for the project:

- Draft and Final survey of District/Regional inlet cleaning practices
- Programmatic & Literature Review
- Quality Assurance Project Plan and study design
- Electronic copy of databases (study inlet locations, field/laboratory analysis, literature review papers, etc.)

Progress this previous Quarter (includes meetings, work plan status, significant progress, etc.)

The project team (MSU and CWP) has completed on-site visits with SHA Maintenance crews on 6/15/16 & 6/24/16 and to review current practices for cleanout and disposal.

CWP reviewed the SHA geodatabases relevant to the study. This information informed development of a programmatic survey to SHA District and Maintenance Shops, planned for distribution in September 2016.

CWP and MSU submitted the QAPP and Monitoring Plan on 9/21/17 – this plan describes the methods and sampling design to quantify material removed from inlets using SHA-owned Vactor trucks. The selection of inlets will be based on a representative set of inlets and samples to provide assurance that results will characterize statewide practices. Additional monitoring activities will include measurements from selected inlets to estimate accumulation rates of materials within the inlets on a seasonal and annual basis. The QAPP will follow EPA guidance and approved methods for materials analysis. MSU CBEIS Environmental laboratory setup and stocked to support project activity prior to first sampling period.

Dry run and monitoring of the inlets was planned to begin in October 2016, subsequently pushed to March 2017.

January 4th - Karen Coffman before the holidays requesting we delay implementation of the survey

October 14th – Conference Call with CWP/MSU

January 13th CWP/MSU Conference call – coordination for followup and feedback from SHA, meeting requested for February

Feb 17, 2017 - Progress Meeting (w/SHA):

- CWP/MSU provided SHA with specifications for dry run
- MSU coordination with weighing Vactor truck at nearby weigh station
- MSU and CWP review sampling frequency with Maintenance Crew and shops
- CWP provided SHA with background on 'equivalent impervious acres' credit in MDE MS4 guidance
- MSU method adjustment, unable to purchase equipment with grant funds
- Current project end date March 31, 2018. Possible to extend to June 30, 2018. This is the end date of MD SHA Master Agreement and no further extensions are allowable. CWP and MSU to evaluate extension Dec 2017

February 23rd – Conference call CWP/MSU. Sampling coordination and updates to SHA. Information for Maintenance Crews for Inlet Cleaning Monitoring (weighing, sampling, tank water level, and disposal)

March 1St DRY RUN – Sample data logging, form edits, pictures, and assessment

March 3rd – MSU/CWP followup after dry run in field – email exchange, revised field data sheets, review of Inlet

Data Viewer (online GIS)

March 22 – The inlet cleaning was on Liberty RD area. Morgan team directly collected two samples at the inlet. 5 inlets were cleaned without water refill. Vactor truck visited the weighing station again to weigh the truck with gross solid (64,800 lbs). Three gross solid and three water samples were collected at Owings Mill dumping site.

March 23- Total 6 inlets were cleaned and three field samples were collected. No water refilled.
Vactor truck visited the weighing state to weigh the truck with gross solid after finished inlet cleaning work, (66,960 lbs). Three gross solid and three water samples were collected at Owings Mill dumping site.

March 29 - SHA inlet cleaning team was cleaning at Security BLVD area. Morgan team directly collected one sample at the inlet. Vactor truck visited the weighing state to weigh the truck with gross solid after done their job. Three gross solid and three water samples were collected at Owings Mill dumping site.

March 30 – 11 inlets were cleaned along Security BLVD. The Vactor truck visited the weighing state to weigh the truck with gross solid after finished inlet cleaning work (51,580 lbs). Three gross solid and three water samples were collected at Owings Mill dumping site.

April/May - During beginning of this project period, the MSU research team wrapped up laboratory analysis on the first-run on sampling that occurred during the last two weeks of March. Laboratory analysis included the sorting, gravitational measures, and chemical analysis of field samples. Data reformatted. MSU working to provide an improved and more comprehensive final draft of literature review.

CWP worked on GIS data provide by KCI to generate map of all MD SHA inlets. Additional information was provided by SHA about KCI's inlet inspection inventory. From this data, CWP has identified the inlets for accumulation monitoring. CWP and MSU in review of laboratory methods and data to determine revisions based on laboratory methods to separate and analyze materials.

Progress meeting held May 16th meeting with Travis Vance of SHA, Dr. Law of CWP, and Drs. Hunter, Dr. Kang, Saliha Khan from MSU.

May 30 – MSU and CWP data review, updates from progress meeting.

The proposed July field sampling and accumulation monitoring schedule was sent to SHA.

Anticipated Work for next Quarter

During the next quarter, we will include next round of field sampling and laboratory analysis from District 4 Owings Mill shop location and associated routes. Accumulation monitoring will continue. With additional feedback from SHA, CWP will look to complete survey. Review and possible revisions to and monitoring plan QAPP based on MSU/CWP review of field and laboratory experience.

Significant Results

An initial (empty) weight of the Vactor truck is taken at the Barrick Quarry-Finksburg Terminal in Finksburg, MD. The weight of the truck was 47,660 lbs (empty) and 58,780 lbs (w/ water).

Summary of Field Sampling Analysis

	Sampling date	3/22/2017	3/23/2017	3/29/2017	3/30/2017	Average
Collected Gross solid weight (Kg)	Sediment 84%	2765.6	1008.6	581.1	315.4	1167.7
	Organic 13%	323.9	239.8	78.1	58.0	174.9
	Trash 3%	91.1	43.6	17.7	21.4	43.5
	Total	3180.7	1291.9	676.8	394.9	1386.1
Cleaned inlet		5	6	9	11	7.8
Collected gross soil weight per inlet (Kg)		636.1	215.3	75.2	35.9	240.6
Total Phosphorus concentration	Water (mg/L)	166.2	29.3	80.7	21.3	74.4
	Sediment (mg/Kg)	347.3	935.8	1302.1	1354.3	984.9
	Organic (mg/Kg)	1653.5	1011.9	1103.9	1580.3	1337.4
Total Nitrogen (TKN)	Water (mg/L)	708.3	258.8	286.6	197.4	362.8
	Sediment (mg/Kg)	1178.4	1062.7	2255.3	556.2	1263.1
	Organic (mg/Kg)	24316.0	23680.9	12892.7	13879.2	18692.2
Collected Phosphorus Weight (Kg)	Water	0.754	0.222	0.428	0.081	0.371
	Sediment	0.961	0.944	0.757	0.427	0.772
	Organic	0.536	0.243	0.086	0.092	0.239
Collected Total Phosphorus (Kg)		2.251	1.408	1.270	0.599	1.382
Collected Total Phosphorus per inlet (Kg)		0.450	0.235	0.141	0.054	0.220
Average Total Phosphorus per inlet (Kg)		0.220				
Collected Nitrogen Weight (Kg)	Water	3.215	1.958	1.518	0.747	1.860
	Sediment	3.259	1.072	1.311	0.175	1.454
	Organic	7.876	5.678	1.006	0.805	3.841
Collected Total Nitrogen(Kg)		14.351	8.708	3.835	1.727	7.155
Collected Total Nitrogen per inlet (Kg)		2.870	1.451	0.426	0.157	1.226
Average Total Nitrogen per inlet (Kg)		1.226				

Table1: Review of Nutrient Characteristics of Gross Solids

	Type of study	Land Use	Total Nitrogen	Total Phosphorus	TKN	NO2-3	Total Volume of Gross Solids	Notes
Catch basins / Inlet Studies								
Allison et al (1998)	catch basins	residential streets	0.11 mg/L	0.01 mg/L	-	-		TP & TN for organic material only
Guo & Kim (2010)	catch basins	highways	-	28.9 mg/kg	992.5 mg/kg	-	29.83 ft3	
Hunt, Anderson, Waichowski (2015)	catch basins	varying land use	0.98 lb/acre/year	0.093 lb/acre/year	-			High density residential, low-density residential, urban/downtown
Stack, Neely, & Drescher	catch basins		9,592 mg/kg	799 mg/kg	-	-		TN and TP from organic leaf matter only
Waickowski and Hunt	catch basins	residenital streets	1.125 kg/ha/yr	0.1045 kg/ha/yr	-	-		Residential: high-. medium-, and low-density residential
Walch, Cole, & Polasko	catch basins	varying land use	-	4.13 mg/L	59.3 mg/L	1.53 mg/L		Residential, commercial parking, and gas station and vehicular
Winston et al (2016)	catch basins	varying land use	0.6225 kg/ha/yea	0.08 kg/ha/year	-	-		Roadway classes represented the four major types present in NC:
Winston & Hunt (2013)	catch basins	varying land use	12,334 mg/kg	1,207 mg/kg	-	-		The sites had varying characteristics, with different road classes,
Leaf litter studies								
Cowen & Lee (1973)	leaf study	Lake shore	-	oak = 1000 µg/g, poplar = 675 µg/g	-	-		Only studied P in leaves, units are: µg of TP /g of leaves
Gaebler & Selbig (2015)	street sweeping for leaf litter	residential streets	-	0.0155 lb/acre	-	-		Data from two study basins: control site: TP = 0.0579 lb/acre and test site with TP given in chart. Study is ongoing
Hobbie et al. (2013)	leaf litter study	residential streets	0.5 hours: 0.284 mg/g, 24 hours: 0.851 mg/g	0.5 hours: 0.221 mg/g, 24 hours: 0.635 mg/g	-	-		Data averaged from 5 species of leaves. Measured total mass of dissolved nutrients leached from litter after 0.5 and 24 hours. Units are Total Dissolved N Leached (mg/g litter), and Total Dissolved P
Strynchuk, Royal, & England (2003)	leaf and grass clippings study	residenital streets		Avg for solid and liquid phase: 1000 mg/kg	Avg for solid: 2 g/kg Avg for liq: 22 g/kg			Samples contained grass clippings with 31-66% coming from oak tree litter by weight. Liquid phase: N & P that leached from grass and leaves into water. Solid phase: N & P found in the grass and leaves. After 130 days, TKN in liquid increased but solid phase remained
Street Sweeping Study								
Kalinosky (2015)	street sweeping	residential streets	Coarse Organic Material = 179 g/kg, Fine organic material = 13.2 g/kg, Total sweeper waste =	Coarse Organic Material = 20.43 g/kg: Fine organic material = 7.82 g/kg, Total sweeper waste	-	-		

Circumstance affecting project or budget.

Due to project logistics, the research team works exclusively with District 4 Shop in Owings Mills. The Vactor truck is only available for the month it is assigned to this location, so the sampling activities are obligated to that window of time. This will require our project team to sample every week during the assigned month, up to 2 times per week to get the required number of samples. Some challenges have been encountered pertaining to the research team's ability to complete field sampling activities due to some uncontrollable circumstances. These issues include sampling cancellations due to weather events and mechanical issues with the assigned Vactor truck used for inlet cleaning. These challenges are anticipated and we will continue to work with SHA to find solutions to stay on schedule as the project progresses. The project team also provides additional days/periods for sampling when Vactor truck is not available. Travis Vance has worked extensively with the project team to coordinate field activities with SHA District 4 shop and crew during the project period.

No-cost extension may likely be needed if additional time for sampling is required.

Potential Implementation

The purpose of this study is to determine the appropriate crediting of inlet cleaning practices by SHA for TMDL compliance and to provide information to enhance the existing credit allowed by MDE for NPDES and TMDL compliance as an alternative BMP. The Chesapeake Bay Program provides a protocol to credit inlet cleaning practices and this method relies upon direct measurement of material removed from inlets and literature-based nutrient enrichment factors. This data is used to determine the nitrogen and phosphorus pollutant load reduction credits. SHA can utilize the results of this study to more accurately determine the anticipated nutrient and sediment loads physically removed annually from the storm drains. Additional guidance will be provided to optimize this maintenance operation.

APPENDIX F
RESEARCH ACTIVITY

ASSESSMENT OF BIOSWALE PERFORMANCE

2016 REPORT

Assessment of Bioswale Performance: 2016 Report

Prepared for:

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December 2016

1.0 INTRODUCTION

The State Highway Administration (SHA) of the Maryland Department of Transportation is required to consider Total Maximum Daily Loads (TMDL) in their operational plans, with a special emphasis on improving water quality associated with the Maryland state road complex as part of the entire Chesapeake Bay watershed restoration effort. One aspect of the SHA TMDL program is to provide supporting data for the design and maintenance of both bioswale and bioretention facilities that are associated with the SHA TMDL 'Legacy Pavement' program. Although bioswale and bioretention facilities (and many other stormwater management techniques) are now rather common practices in Maryland to treat roadway runoff, there is a critical need to understand their overall efficiency (both in the short-term and in the long-term) and their lifetime expectancy, especially under real-life and real-time field conditions.

2.0 PROJECT OBJECTIVES

There are four distinct project objectives for the SHA bioswale study.

1. The first objective is to determine if there are reductions in base pollutant levels (primarily focusing on TSS, TN and TP) as roadway stormwater runoff passes through SHA bioswale design facilities (both lined and unlined), with a corollary objective to examine selected heavy metal concentrations or other roadway pollutants associated with roads in both runoff and bioswale soil samples.
2. The second objective is to develop the field procedures employed in this study to monitor the ability of the designed bioswale facilities to infiltrate stormwater flowing into the facilities over an extended period of time, as well as to characterize the bioswale filter soil to determine its long-term efficiency.
3. The third objective is to understand the dynamics of water movement through the bioswales in order to determine whether these systems have been optimally designed.
4. The fourth objective is to examine the potential recharge capacity of unlined bioswales at the interface of the bioswale and the underlying soil.

3.0 BIOSWALES

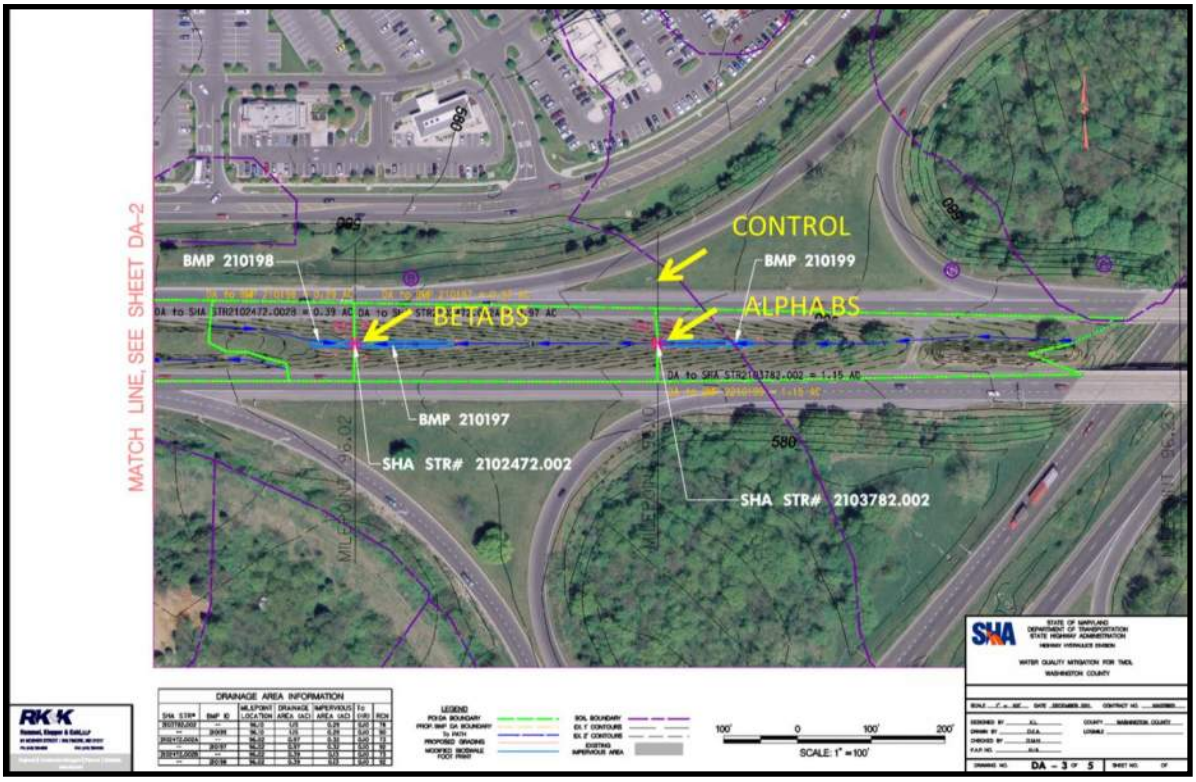

Figure 1. Location of two study bioswales and the original control along Dual Highway near the intersection of I-81 and Maryland Route 40 (Dual Highway). The two bioswales (Alpha and Beta) and present control are sited in the median and the original control in the off-ramp median.

3.1 Bioswale Sites: For the initial phase of the project, one bioswale complex was selected for assessment in consultation with Mr. Parley Hess and Mr. Patrick Zinkan of SHA. The two bioswales are located in the Great Valley/western Piedmont region, and were constructed in the median of the Dual Highway (Maryland Route 40) in western Hagerstown, MD (Figure 1). These include one bioswale with a checkdam (not completed) and one without a checkdam. In addition, a control (lacking bioswales) in the nearby vicinity of the selected bioswale sites was established directly across from the bioswales. During the second phase of the project, the control was relocated into the median area approximately one mile west to better reflect the conditions found at the two bioswales. At the same time, an additional bioswale site was selected in consultation with Mr. Armand de Rosset of SHA. The bioswale is located in the eastern Piedmont region west of Ellicott City in the US 40 median (Figure 2).

Figure 2. Location of the Ellicott City bioswale near the intersection of Marriottsville Road and US Route 40. The bioswale (Delta) is located in the median of US route 40.

3.2 Bioswale Instrumentation: Each of the three Hagerstown sites (Alpha, Beta, and Gamma) was similarly instrumented in order to monitor the stormwater runoff and pollutant responses to rainfall events. The two responses to be monitored consisted of *overland flow* (discharge and pollutant concentrations/loads) at the outlets of all sites and *subsurface flow* (discharge and pollutant concentrations/loads) from perforated 6" pipe underdrains at Alpha and Beta (Gamma is not underdrained). The common monitoring equipment consisted of: 1) a prefabricated, fiberglass truncated Parshall flume (6" throat width; max. capacity = 3.91 cfs at H = 1.5 ft.; Tracom Inc.) installed at the outlet of each catchment (flume outlet located over a stormwater inlet box to maintain critical flow conditions through the flume by reducing the probability of submergence/backwater effects); 2) wingwalls (1.0 ft. high) constructed from pressure-treated timbers to channel surface runoff from the catchment into the flume (flume discharge = 2.06 cfs at H = 1.0 ft.); 3) an ultrasonic water level sensor and module (Teledyne ISCO no. 2110) to monitor and record water level/discharge in the flume; 4) a tipping bucket rain gage (Teledyne ISCO No. 674); 5) a portable sequential water sampler (Teledyne ISCO no. 3700) capable of

collecting 24 discrete 1L stormwater samples; 6) an interface module/data logger (Teledyne ISCO no. 2105) used to store rainfall and a sequential sampler data and trigger the sampler using inputs from either the rain gauge or a water level sensor; 7) a solar panel/battery charging apparatus to maintain continuous 12V DC power to the equipment; and 8) a prefabricated instrument shelter housing samplers, batteries, and interface modules (Figure 3).

Figure 3. Fully instrumented bioswale site (i.e., "Alpha", with flume, wingwalls, ultrasonic sensor, instrument shelter, and solar panel clearly shown) within the median on MD Route 40 west of Hagerstown.

In addition, the underdrain pipe outlets at Alpha and Beta were each equipped with a covered plastic sump housing a second ultrasonic water level sensor and an inlet line leading to a second portable sequential sampler housed in the instrument shelter. Flume and underdrain water level readings were recorded over two different rates depending upon the level within a flume or sump box; every 4 hours when the level reading was < 0.5 in and every 5 minutes when ≥ 0.5 in. The ultrasonic modules use the water level readings and geometry of the flume/sump box outlet to simultaneously calculate and record the flow rate and total flow. Rainfall data were recorded as a total over each 15-minute interval.

All sequential samplers (Figure 4) were programmed using the STORM routine designed to capture the *first flush* from stormwater runoff. The overland flow samplers were programmed to trigger sampling when the water level within a given flume was ≥ 0.5 inches. The program allows the first sample to be collected immediately upon activation, with the next three collected at 5-minute intervals. Remaining samples (a maximum of 20) are collected every 1000 gallons of discharge or until the flow rate was less than 10 gal/hr as calculated by the level modules. The subsurface flow samplers deployed at Alpha and Beta include triggers using level actuators which activate the sampler whenever the water level within a sump box was high enough to reach the outlet. The first four samples are collected in an identical manner to the overland flow samples. Remaining samples are collected every 30 minutes or until the water level has dropped below the sump box outlet. As of the date of this report, no flow has been measured in any of the flumes or underdrains at any of the Hagerstown sites, thus no stormwater samples have yet been collected.

Figure 4. Instrument shelter at "Alpha" housing two portable sequential water samplers, two ultrasonic water level sensor modules, an interface module/data logger, and 12V battery.

3.3 Subsurface Monitoring: One piezometer was installed in the bioswale portion of both Alpha and Beta to monitor transient saturation and groundwater levels in response to rainfall events; each piezometer was constructed of a section of 2" dia. PVC pipe coupled to a 12" length

of well screen (0.02 mm slots) and end cap, and installed into the aggregate material underlying the biosoil. Piezometer installations were completed by backfilling the well screen section of the annular space with coarse sand, then backfilling with silica flour slurry, and capping with biosoil materials removed during installation. Each piezometer was equipped with a continuously-recording, pre-calibrated pressure transducer (Onset Inc. no. U20L-01) programmed to monitor at a 15-minute frequency.

In addition, one zero-tension lysimeter was installed in each of the two Hagerstown bioswales, the Gamma control area, and the Ellicott City Delta bioswale. Each lysimeter was constructed of a 6" dia. PVC culvert pipe coupled to a 6" dia. perforated cap and 6" dia. conical PVC base and was installed within the sand/gravel layer of the bioswale (or similar depth in the case of the control). Any water samples were retrieved via a portable peristaltic pump (Masterflex E/S/ Portable Sampler).

4.0 BIOSWALE SOIL ASSESSMENT METHODOLOGY

Figure 5. Double ring infiltrometer setup with air entry and outflow valves/ports and plastic level measurement tube clearly shown. Plastic carboys were used to manually maintain a constant water level in the outer ring to minimize lateral flow.

4.1 Infiltration Rate: Soil infiltration capacity measurements were repeated at the Hagerstown location on 06 November 2015 based on the standard method recommended by Bouwer (1986); three measurements were made at each of the two bioswales (Alpha and Beta), one in the native fill material located within the highway median between the two bioswales, and three at the original Gamma (control) site (Figure 5). Infiltration measurements were also taken at the Ellicott City location on 21 September 2016; three measurements in the bioswale (Delta) and three at a proposed control site (Kappa) two miles to the east. For each measurement, two cylindrical steel rings (i.d. of outer ring = 2.00 ft, i.d. of inner ring = 1.00 ft., height of rings = 1.0 ft.) were driven about halfway (~6") into the soil with the smaller ring nested inside the larger. A Mariotte bottle (constructed from a 4 ft. section of 4" dia. schedule 40 PVC pipe and cemented endcaps) filled with sufficient water for the measurement was suspended from a surveyor's tripod directly over the inner ring—about 2-4 inches above the soil surface (Figure 5).

Water was quickly poured into both rings simultaneously to pond the water to the height of the air intake valve at which time both the outflow valve and air intake valves were simultaneously opened; the ponded water level in the inner ring was maintained at a constant level by air entry into the Mariotte bottle, while the ponded water in the outer ring was maintained at the same level by manually pouring water from a carboy throughout the experiment.

Measurements of the water level inside the Mariotte bottle were taken at fixed time intervals (15-60 s) using the clear plastic tube and measuring tape as a reference. The cumulative infiltration capacity (mm/min) was plotted after correcting the Mariotte readings using the ratio of the cross-sectional areas (πr^2) of the Mariotte bottle and inner ring, and the steady-rate infiltration capacity (slope of the cumulative infiltration capacity curve) was computed using linear regression (omitting measurements showing clear evidence of a non-linear response presumably due to soil capillarity during initial wetting).

4.2 Bioswale Soil Collections: Soil samples were collected from the top 25 cm soil layer at the Hagerstown location on 15 November 2015 and at the Ellicott City location on 21 September 2016 (Figure 6). At Hagerstown, longitudinal transects of 15 m were selected for each bioswale (Alpha, Beta) and then divided into three segments of five m each (Ingvertsen et al. 2012). In each segment, ten core samples were randomly obtained with a soil corer (~2 cm i.d.). For the control (Gamma), three points were selected 15 meters out from the inlet box: one along the 81 ramp, one along U.S. 40 West, and one halfway between. Ten samples were randomly collected in a 1 meter radius of each point. At Ellicott City, the bioswale (Delta) was divided into three segments of five meters. Ten random cores were obtained from each segment and along the median buffer material above and below the bioswale (the median buffer was not segmented). For the proposed control location (Kappa) three sets of ten random cores were collected along cross-sectional transects ten, 15 and 25 meters out from the inlet box. Following collection, all cores were subdivided into three sections – 0 to 5 cm, 5 to 15 cm, and 15 to 25 cm, with the ten subsamples from each depth combined into three bulk samples. Each bulk soil sample was air-dried (nominally 20°C) and sieved through a 2 mm Teflon sieve, followed by thorough mixing to make certain of soil sample homogeneity. Images of the bioswale soil profiles were recorded in the field with a digital camera.

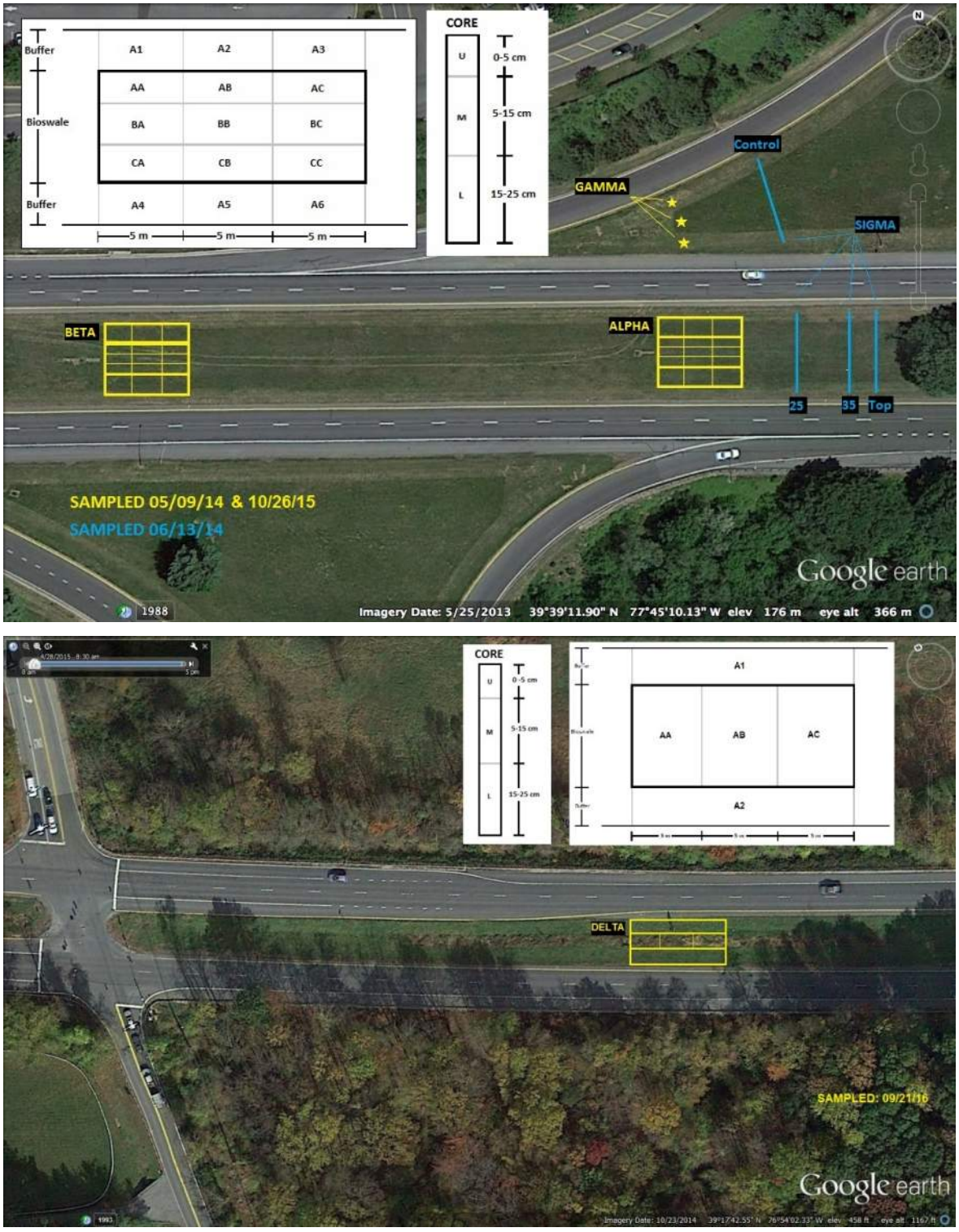

Figure 6. Soil sampling design for the two Hagerstown bioswales (Alpha and Beta) and control (Gamma) and the Ellicott City bioswale (Delta).

4.3 Bioswale Soil Analyses: Soil pH was measured on each sample using a combined glass electrode in a soil solution (1:2.5 soil: deionized water) after a 1-h equilibration period. Soil Total Organic Carbon (TOC) was determined using a dichromate oxidation with external heat followed by titration with ferrous ammonium sulfate. Soil Total Nitrogen (TN) was done by combustion analysis with an elemental analyzer (Carlo Erba C,H,N,S,O Combustion Elemental Analyzer) on a dried sieved sample. Soil Total Phosphorus (TP) was analyzed via a Mehlich III extraction followed by automated flow injection colorimetry (Lachat QuikChem 8000). Selected heavy metal concentrations (Cd, Cr, Cu, Pb and Zn) in the bioswale soil samples were determined by microwave assisted acid digestion (CEM Mars 5) followed by atomic absorption spectroscopy (Agilent 7900 ICP-MS).

4.4 Bioswale Soil Statistics: Analyses of variance on multiple comparisons of soil elements, sites and depths (and associated interaction factors) were performed using either STATISTICA (StatSoft, Tulsa, Oklahoma) or STATA 10 (StataCorp LP, College Station, Texas) with statistical significance set at $\rho \leq 0.05$. Prior to any statistical analyses, each analyte was log transformed if needed (Sokal and Rohlf 1995), with homogeneity for each set of variables examined. If required, non-parametric tests were also employed (STATISTICA or STATA 10). For pH, values were converted to H+ concentrations for analyses, and then converted back to pH (note that it is generally inappropriate to estimate either standard deviations or errors for pH).

During the statistical work on the 2015 soil metals, we observed an unusually high copper content (234 mg/kg) in one of the composited soil replicates (Alpha-CA- Middle), with the value analytically double-checked. Although there could be a localized, exogenous source of copper at this site and depth that may be the reason for the high value, it was deleted as an extreme outlier. The remaining eight replicates were averaged for copper content and the mean value of 21.7 mg/kg was substituted for statistical analysis (Sokal and Rohlf 1995).

5.0 BIOSWALE ASSESSMENT RESULTS

5.1 Soil Infiltration Capacity Measurements: Cumulative infiltration capacity curves were largely identical to those established in the first phase of the bioswale study. Curves constructed for the two Hagerstown and one Ellicott City bioswale sites indicate a nearly constant rate of infiltration under ponded conditions throughout the experiments (Fig. 7 - A and C). Such a behavior is indicative of domination by gravity drainage through relatively coarse, highly permeable soils. In contrast, most of the curves constructed for the areas comprised of native soil or fills show clear evidence of a sorptive phase attributable to capillarity under relatively dry conditions (Fig. 7 - B and D). The cumulative infiltration capacity curves for the native soils/fills generally straightened out after about 2 – 5 min or less as the soils wetted up and sorptivity was greatly reduced or eliminated, however.

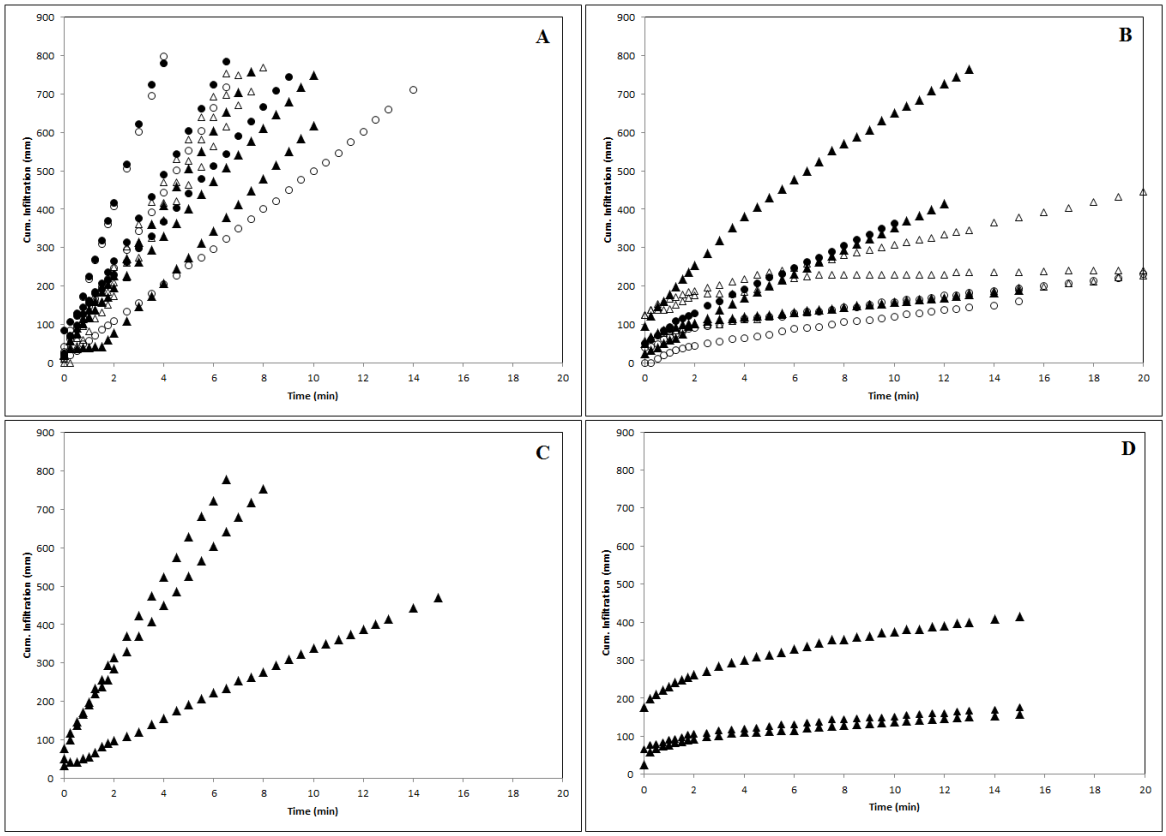

Figure 7. Cumulative soil infiltration capacity: A: Alpha (▲ 2015, Δ 2014) & Beta (● 2015, ○ 2014); B: median (● 2015, ○ 2014) and Gamma (▲ 2015, Δ 2014); C: Delta (2016); and D: proposed Kappa (2016).

Steady-state infiltration capacities for the Hagerstown bioswale soils in 2015 averaged 21.3 mm/min (range of 17.3 – 28.8 mm/min) at Alpha and 33.0 mm/min (range of 18.5 – 51.3 mm/min) at Beta. Rates for the native median soil and Gamma averaged 7.4 mm/min and 6.7 mm/min (range of 1.6 – 10.6 mm/min), respectively. For Ellicott City, bioswale soil at Delta averaged 17.9 mm/min (range of 7.2 – 26.47 mm/min) while the native soil at Kappa averaged 1.7 mm/min (range of 1.2 – 2.8 mm/min).

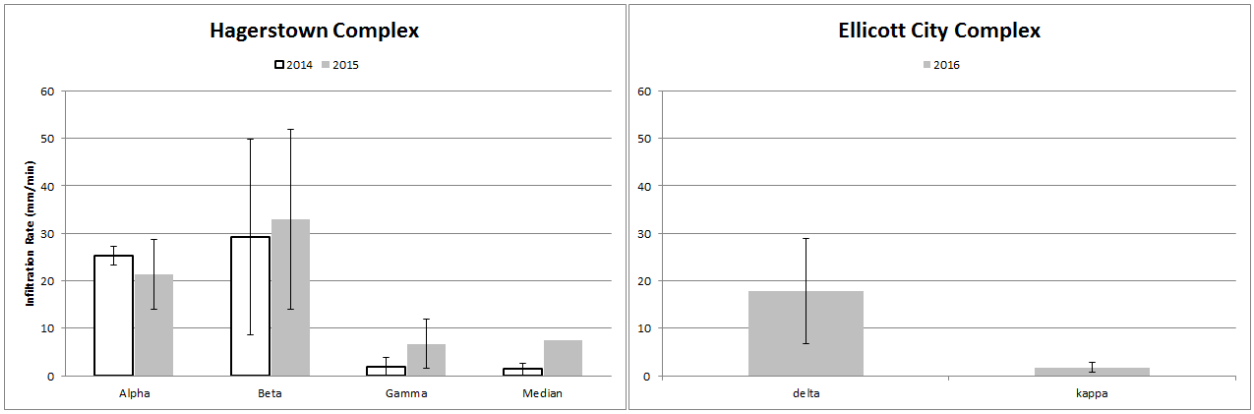

Figure 8. Average infiltration capacities for Hagerstown (left) and Ellicott City (right) complexes with 95% confidence intervals shown.

When averaged together, the results indicate that the mean steady-state infiltration capacity of bioswale soils was roughly four times greater than that of the native soils at the Hagerstown location in fall of 2015 compared to 17 times greater in spring of 2014 (Figure 8). A statistical test (t-test) found no statistically-significant difference ($\rho < 0.001$) between the mean infiltration capacities of the two bioswale soils (i.e., Alpha and Beta), the two native soils (i.e., median and Gamma), or the bioswale soils and native soils during the fall of 2015, while the spring measurements of 2014 did find a statistically significant different between the bioswale soils and native soils. Although temporal statistical analysis suggests no significant difference between Gamma in 2014 and 2015 ($P = 0.09$), the 350% increase in infiltration capacity for Gamma soil is likely responsible for both the observed decrease in bioswale performance relative to native soils, and the lack of statistical difference between soil types in 2015. This observed increase in infiltration capacity for the Gamma soils is believed to be due to the drier conditions preceding the measurements in 2015. Conversely, the lack of difference in infiltration rate for bioswale

soils between 2014 and 2015 (27.2 vs 27.3 mm/min respectively) suggests that bioswale systems are far less impacted by climatic variability than native Hagerstown soils (Figure 8). In Ellicott City, despite the mean steady-state infiltration capacity of bioswale soils being roughly ten times greater than that of native soils (Figure 8), there was no statistically significant difference between the two soil types ($P \geq 0.05$).

5.2 Steady-State Modeling of Bioswale Runoff: We used a simple steady-state model of bioswale runoff to assess how the measured infiltration capacities may affect the performance of these systems to a variety of design storms with short duration (30 min). One meter elevation DEMs, satellite imagery and on-site measurements were used with ESRI®ArcGIS to calculate watershed, bioswale and impervious surface areas. Design storm intensity and frequency were based on data provided in Hershfield (1961). Unlike in the Phase I model which was based on theoretical values of performance, we used our mean steady-state soil infiltration data. We made the normal assumptions of constant intensity and, uniform rainfall over the sites, and assumed that the time of concentration would be sufficiently short (< 5-10 min) so we could assume that the entire watershed was contributing runoff at some point during each storm event. We computed steady-state peak surface runoff rates for the Hagerstown Alpha (for both 2014 and 2015) and the Ellicott City Delta bioswale systems, as well as for the two systems before the bioswales were constructed (i.e., "with" and "without" bioswales) so we could perform a comparative analysis.

Table 1. Results from steady-state model of bioswale runoff (using mean steady-state soil infiltration capacity data) to assess Delta bioswale performance.

Storm No.	Storm depth, (in)	Storm duration, (hr)	Storm frequency, (yr)	Storm intensity, in/hr	Est. steady-state infiltration (Buff), cfs	Est. steady-state infiltration (BS), cfs	Est. maximum surface runoff (no BS), cfs	Est. maximum surface runoff (w/BS), cfs	Reduction in surface runoff, %
1	0.10	0.5	<1	0.20	2.05	1.66	0.00	0.00	NA
2	0.25	0.5	<1	0.50	2.05	1.66	0.00	0.00	NA
3	0.50	0.5	<1	1.00	2.05	1.66	0.00	0.00	NA
4	0.75	0.5	<1	1.50	2.05	1.66	0.00	0.00	NA
5	1.00	0.5	1	2.40	2.05	1.66	0.06	0.00	100
6	1.10	0.5	1.5	2.60	2.05	1.66	0.24	0.00	100
7	1.20	0.5	2	2.80	2.05	1.66	0.41	0.00	100
8	1.60	0.5	5	3.60	2.05	1.66	1.12	0.00	100
9	1.80	0.5	10	4.00	2.05	1.66	1.47	0.00	100
10	2.00	0.5	25	4.40	2.05	1.66	1.82	0.16	91

Table 2. 2014 results from steady-state model of bioswale runoff (using mean steady-state soil infiltration capacity data) to assess Alpha bioswale performance.

Storm No.	Storm depth, (in)	Storm duration, (hr)	Storm frequency, (yr)	Storm intensity, in/hr	Est. steady-state infiltration (Buff), cfs	Est. steady-state infiltration (BS), cfs	Est. maximum surface runoff (no BS), cfs	Est. maximum surface runoff (w/BS), cfs	Reduction in surface runoff, %
1	0.10	0.5	<1	0.20	3.13	1.51	0.00	0.00	NA
2	0.25	0.5	<1	0.50	3.13	1.51	0.00	0.00	NA
3	0.50	0.5	<1	1.00	3.13	1.51	0.00	0.00	NA
4	0.75	0.5	<1	1.50	3.13	1.51	0.00	0.00	NA
5	1.00	0.5	1	2.00	3.13	1.51	0.00	0.00	NA
6	1.10	0.5	1.5	2.20	3.13	1.51	0.00	0.00	NA
7	1.20	0.5	2	2.40	3.13	1.51	0.00	0.00	NA
8	1.60	0.5	5	3.20	3.13	1.51	0.16	0.00	100
9	1.80	0.5	10	3.60	3.13	1.51	0.57	0.00	100
10	2.00	0.5	25	4.00	3.13	1.51	0.98	0.00	100

The model predicts that the Delta bioswale will completely eliminate surface water runoff for design storms with intensities ranging from 2.4 to 4.0 in/hr while reducing 91% of runoff for a 25 – year storm with an intensity of 4.4 in/hr (Table 1). For 2014, the model predicts that the Alpha bioswale will completely attenuate surface water runoff (100%) for design 30-min storms with intensities ranging from 3.2 to 4.0 in/hr, corresponding to storms with a recurrence interval of five to 25 years (Table 2). For storms with a recurrence interval more frequent than five years, the model predicts that the infiltration capacity for the native median soil is sufficient to prevent the formation of any runoff. In 2015, the significant increase in infiltration capacity for native soils resulted in the model predicting the lack of any runoff for all designed storms (Table 3), highlighting the impact of climatic conditions on infiltration capacity, and by extension the ability – or necessity – of bioswales to reduce runoff.

Table 3. 2015 results from steady-state model of bioswale runoff (using mean steady-state soil infiltration capacity data) to assess Alpha bioswale performance.

Storm No.	Storm depth, (in)	Storm duration, (hr)	Storm frequency, (yr)	Storm intensity, in/hr	Est. steady-state infiltration (Buff), cfs	Est. steady-state infiltration (BS), cfs	Est. maximum surface runoff (no BS), cfs	Est. maximum surface runoff (w/BS), cfs	Reduction in surface runoff, %
1	0.10	0.5	<1	0.20	11.48	1.48	0.00	0.00	NA
2	0.25	0.5	<1	0.50	11.48	1.48	0.00	0.00	NA
3	0.50	0.5	<1	1.00	11.48	1.48	0.00	0.00	NA
4	0.75	0.5	<1	1.50	11.48	1.48	0.00	0.00	NA
5	1.00	0.5	1	2.00	11.48	1.48	0.00	0.00	NA
6	1.10	0.5	1.5	2.20	11.48	1.48	0.00	0.00	NA
7	1.20	0.5	2	2.40	11.48	1.48	0.00	0.00	NA
8	1.60	0.5	5	3.20	11.48	1.48	0.00	0.00	NA
9	1.80	0.5	10	3.60	11.48	1.48	0.00	0.00	NA
10	2.00	0.5	25	4.00	11.48	1.48	0.00	0.00	NA

5.3 Bioswale Soil Chemistry

5.3.1 2015 Soil Sampling - There were significant differences in five common soil parameters among the two bioswales sites, the adjoining median to each bioswale, and the control site for three soil depths (Table 4) for the September 2015 soil chemistry sampling. This soil sampling was an extension of the work completed in May 2014 and June 2014, with the September sampling duplicating the sampling protocol employed in May 2014, and occurring approximately 15 months apart.

Total Phosphorus (TP) – As observed previously in 2014, the most striking observation centered on the TP levels at the two bioswale sites, at all three sampling depths, in comparison to the adjoining road median for each bioswale and the control (Table 5, Figure 9). Mean TP ranged from 46.1 to 85.5 mg/kg at all depths in the bioswales, with TP ranging from 3.4 - 13.5 mg/kg (all depths) in the road median samples, and 3.9 – 10.0 mg/kg (all depths) at the control site (Table 5). TP levels throughout the Alpha and Beta bioswales were substantially higher than observed for either median samples or the control site.

The upper layers of soil TP at the Alpha site (85.5 mg/kg) and the Beta site (84.2 mg/kg) were elevated versus the upper, middle and lower soil profiles from both medians (3.4 – 13.5 mg/kg) and the control (3.9 – 10.0 mg/kg), as well as being higher than the TP levels in the middle and lower depth strata (46.1 – 54.2 mg/kg) of both bioswales. The source of the high TP in the upper profile of the bioswale is unknown; however, it appears that any TP present in the upper depth profile is potentially leaching into the middle and lower soil profiles of the bioswales through time (Figure 9). Basically, the TP profiles for the median sites and the control are similar, as are the TP profiles for the two bioswales.

There were highly significant differences between SOILSITE and DEPTH for TP with a significant interaction term of SOILSITE*DEPTH, denoting that the independent parameters of SOILSITE and DEPTH showed a difference in the magnitude of the response, or else a difference in the direction of the response (Table 5). Inspection of the SOILSITE*DEPTH interaction plots indicate that the TP levels, over the three soil depths, in the bioswales do not follow a linear decrease with depth. Both bioswale sites had TP levels greater than 45 mg/kg for all three soil depths, whereas the median sites and the control site were below 15 mg/kg TP, with a trend towards decreasing TP with increasing depth. The deepest soil profiles for the median

and control samples were all lower than 11 mg/kg TP. The soil TP patterns, although varying slightly in concentration levels, were similar between 2014 and 2015 (Figure 9 and Figure A1), except that the control site in 2015 contained less soil TP.

Total Nitrogen (TN) – For the two bioswale sites, soil TN (%) ranged from 0.064 – 0.088% along with the medians from 0.039 - 0.27%, and the control from 0.15 – 0.36% (Table 6). Although analyzed as % TN, these TN values were not that low given 0.1% TN is equivalent to 1 g/kg or 1000 mg/kg TN (agricultural soils are typically around 0.075% to 0.15% TN). The general trend was a decreasing TN with increasing depth, with median and control TN values below 0.10% (Figure 10).

There were highly significant differences between sites and soil depths for TN as well as a significant interaction of SOILSITE*DEPTH (Table 6). In part, the analysis of this interaction determined that TN values at the Alpha bioswale, although relatively constant, demonstrated a slight increase in the middle profile. Soil TN patterns, though varying slightly in concentration levels, were correspondingly similar between 2014 and 2015, with a large degree of variation in TN at the control site for both sampling periods (Figure 10 and Figure A2).

Total Organic Carbon (TOC) – TOC analyses from the two bioswales showed a consistent pattern of relatively identical levels (Figure 11), with bioswale TOC concentrations around 1.9 – 2.2% at all depths, indicating a uniformity of the parent material present in the bioswale. For the control and the two medians, the general trend was decreasing TOC with increasing depth, with the median and control TOC values ranging from 1.4 – 5.0%. For the control site, there was a large variation (as denoted by ± 1.96 SE) in the TOC in the upper and middle profile samples that was not reflected at any of the other sites (Figure 11).

There was a highly significant difference between soil depths for TOC with a significant interaction of SOILSITE*DEPTH present for TOC (Figure 11), with no significance among sites (Table 7). The soil TOC patterns, though varying slightly in concentration levels, were correspondingly similar between 2014 and 2015 (Figure 11 and Figure A3).

Total Carbon (TC) – In contrast to the 2014 sampling, there were significant differences among soil site and depth for TC, with TC ranging from 1.6 – 2.0% in the bioswale material, 1.0 – 3.4% in the median material, and 1.6 – 3.3% in the control (Table 8). TC analyses for the two bioswales showed a pattern of relatively constant TC levels at each depth (Figure 12), with

bioswale TC concentrations around 1.6 – 2.0% at all three depths, indicating a uniformity of soil structure and not unexpectedly mimicking the soil TOC concentrations (Figure 12). For the control and the two medians, the general trend was decreasing TC with increasing depth, with the median and control TC values below 0.10 mg/L. For the control site, there was large variation in TC at all three depths not reflected at any of the other sites.

Also, there was a significant interaction of SOILSITE*DEPTH present for TC (Table 8). In part, the analysis of this interaction determined that TC values (similar to TOC levels) at the Alpha and Beta bioswales, although relatively constant, showed either a slight increase in the middle profile or a level response. The soil TC patterns, although also varying slightly in concentration levels among the different sites, were correspondingly similar between 2014 and 2015 (Figure 12 and Figure A3).

pH - Soil pH analyses for the two bioswales (Alpha and Beta) showed a pattern of relatively constant levels, with bioswale pH values varying from 7.18 to 7.56 (pH 7.56 - 8.00 in 2014) at all three soil depths. This again indicates the overall uniformity of bioswale soil structure as observed in other soil analytes (Figure 13). In addition, the error bars around the mean H^+ (µM) concentration for the bioswales were generally small in comparison to the error bars for the two median sites (in association with the two bioswales) and the control (where the error bars were the largest for mean H^+ values in the upper profile). For the control and two medians near the bioswales, pH ranged from 7.05 to 8.12 (Figure 13). There were no general trends observed with pH and soil profile depth.

There were no significant differences among all soil sites for H^+, but there were significant differences among soil depths for H^+ (Table 9). Also, there was no significant interaction of SOILSITE*DEPTH present for H^+. Part of the reason for non-significance may be related to the high variation present in the control, as well as the fact that there were only three replicates per soil depth (three composite samples times three composite depths for an N = 9).

Table 4. Results (mean plus standard error – SE) for soil total phosphorus (TP - mg/kg), total organic carbon (TOC - %), total carbon (TC – %), total nitrogen (TN – %) and H^+ (µM) for September 2015 field work. (BS = bioswale – Alpha or Beta, M = median, and C = Control - Gamma. U = upper soil profile, M = middle soil profile and L = lower soil profile).

SITE	DEPTH	TP MEAN	TP SE	TOC MEAN	TOC SE	TC MEAN	TC SE	TN MEAN	TN SE	H^+ MEAN pH
BS-Alpha	U	85.5	6.1	2.07	0.058	1.93	0.17	0.088	0.0067	0.0494 7.31
BS-Alpha	M	54.2	2.4	2.02	0.065	1.87	0.075	0.082	0.0066	0.0350 7.46
BS-Alpha	L	52.8	3.0	2.13	0.077	1.96	0.092	0.082	0.0077	0.0273 7.56
BS-Beta	U	84.2	5.1	2.19	0.083	1.81	0.089	0.088	0.010	0.0654 7.18
BS-Beta	M	47.3	1.8	1.91	0.081	1.59	0.053	0.064	0.0079	0.0353 7.45
BS-Beta	L	46.1	1.0	2.02	0.057	1.67	0.099	0.077	0.0077	0.0286 7.54
M-Alpha	U	13.5	2.8	3.37	0.32	2. 97	0.28	0.24	0.032	0.0811 7.09
M-Alpha	M	6.0	1.6	2.35	0.11	2.12	0.039	0.15	0.0076	0.0477 7.32
M-Alpha	L	3.4	0.80	1.43	0.10	1.23	0.065	0.088	0.0057	0.0380 7.42
M-Beta	U	10.7	2.0	4.10	0.25	3.41	0.18	0.27	0.020	0.0718 7.14
M-Beta	M	5.0	0.90	2.21	0.17	2.04	0.11	0.12	0.014	0.0195 7.71
M-Beta	L	5.7	0.96	1.06	0.028	1.03	0.15	0.039	0.00045	0.00759 8.12
C-Gamma	U	10.0	2.4	5.03	1.31	3.33	0.22	0.36	0.066	0.0885 7.05
C-Gamma	M	3.8	0.66	2.85	1.25	1.98	0.30	0.15	0.043	0.0309 7.51
C-Gamma	L	3.9	0.13	-	-	1.58	0.21	-	-	0.0427 7.37

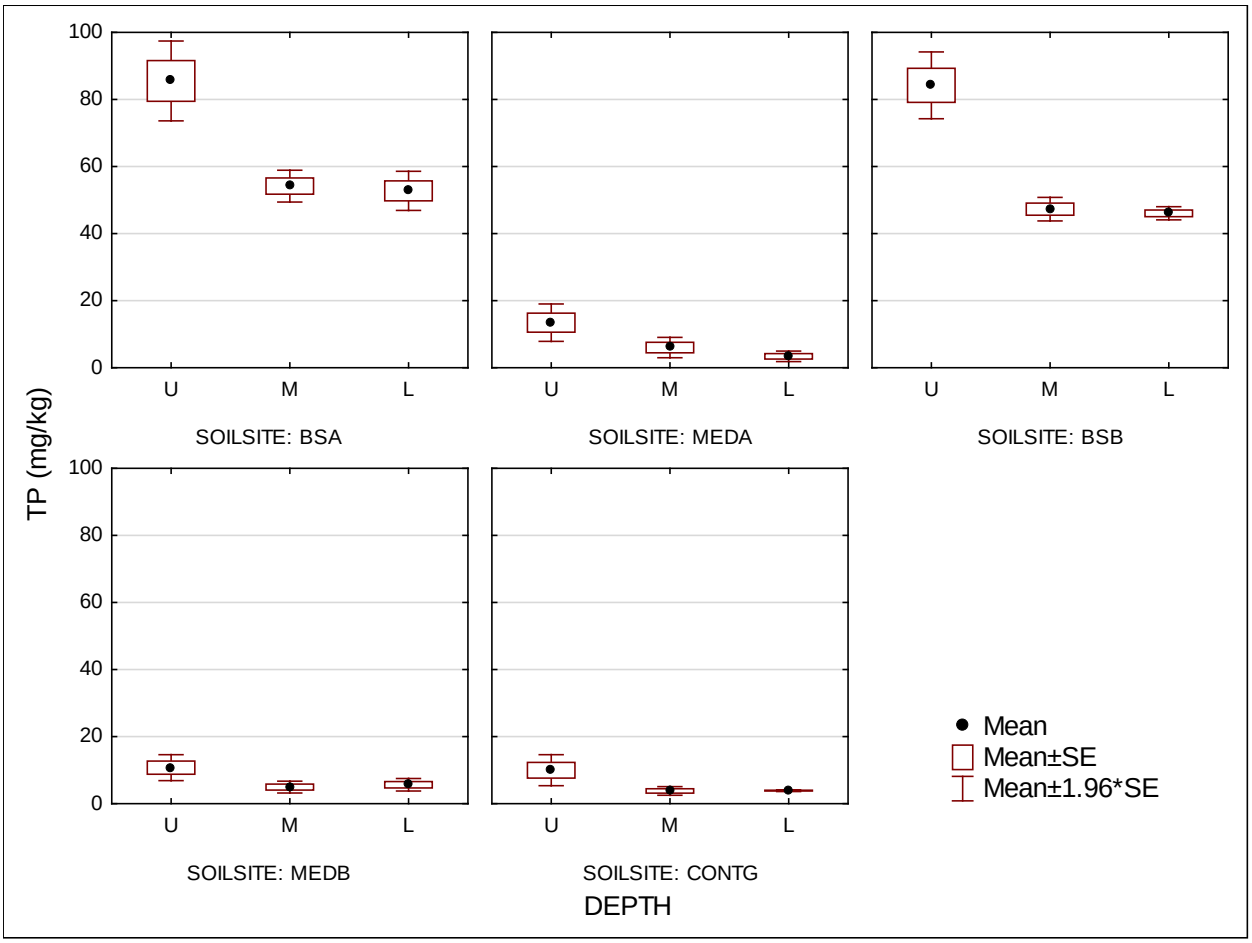

Figure 9. Mean TP (mg/kg) for bioswale sites Alpha (BSA) and Beta (BSB), median sites adjoining Alpha (MEDA) and Beta (MEDB) and the control site (CONTG) as a function of three soil depths.

Table 5. Summary of ANOVA for TP at three sites and three soil profiles (Figure 9).

Effect	SS	df	MS	F	p
SOILSITE	65526	4	16381	203	0.000000
DEPTH	5697	2	2849	35	0.000000
SOILSITE*DEPTH	4123	8	515	6.4	0.000002
Error	6388	79	81		

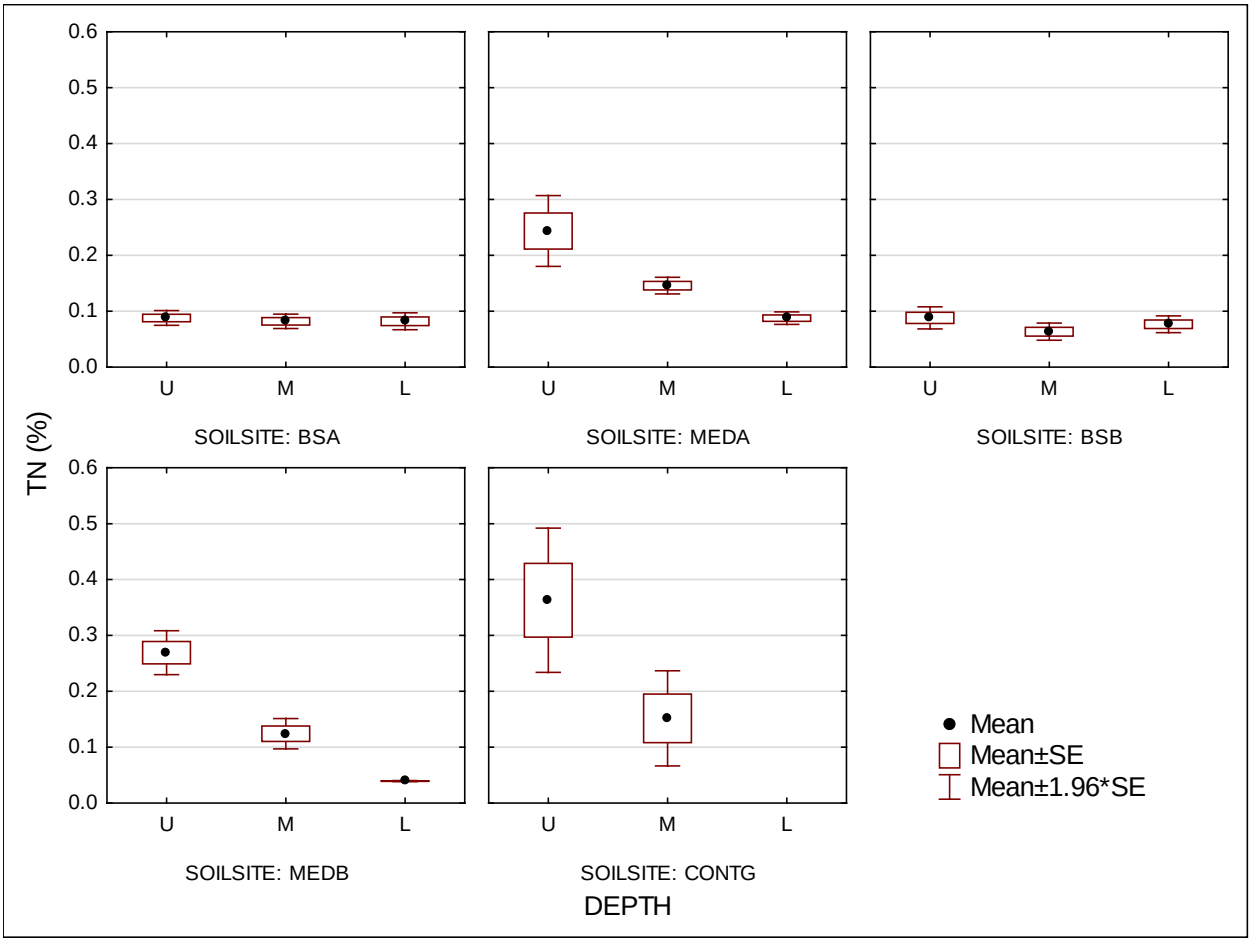

Figure 10. Mean TN (%) for bioswale sites Alpha (BSA) and Beta (BSB), median sites adjoining Alpha (MEDA) and Beta (MEDB) and the control site (CONTG) as a function of three soil depths.

Table 6. Summary of ANOVA for TN at three sites and three soil profiles (Figure 10).

Effect	SS	df	MS	F	p
SOILSITE	0.103	3	0.0345	23.2	0.000000
DEPTH	0.132	1	0.132	88.9	0.000000
SOILSITE*DEPTH	0.137	7	0.0195	13.1	0.000000
Error	0.116	78	0.00149		

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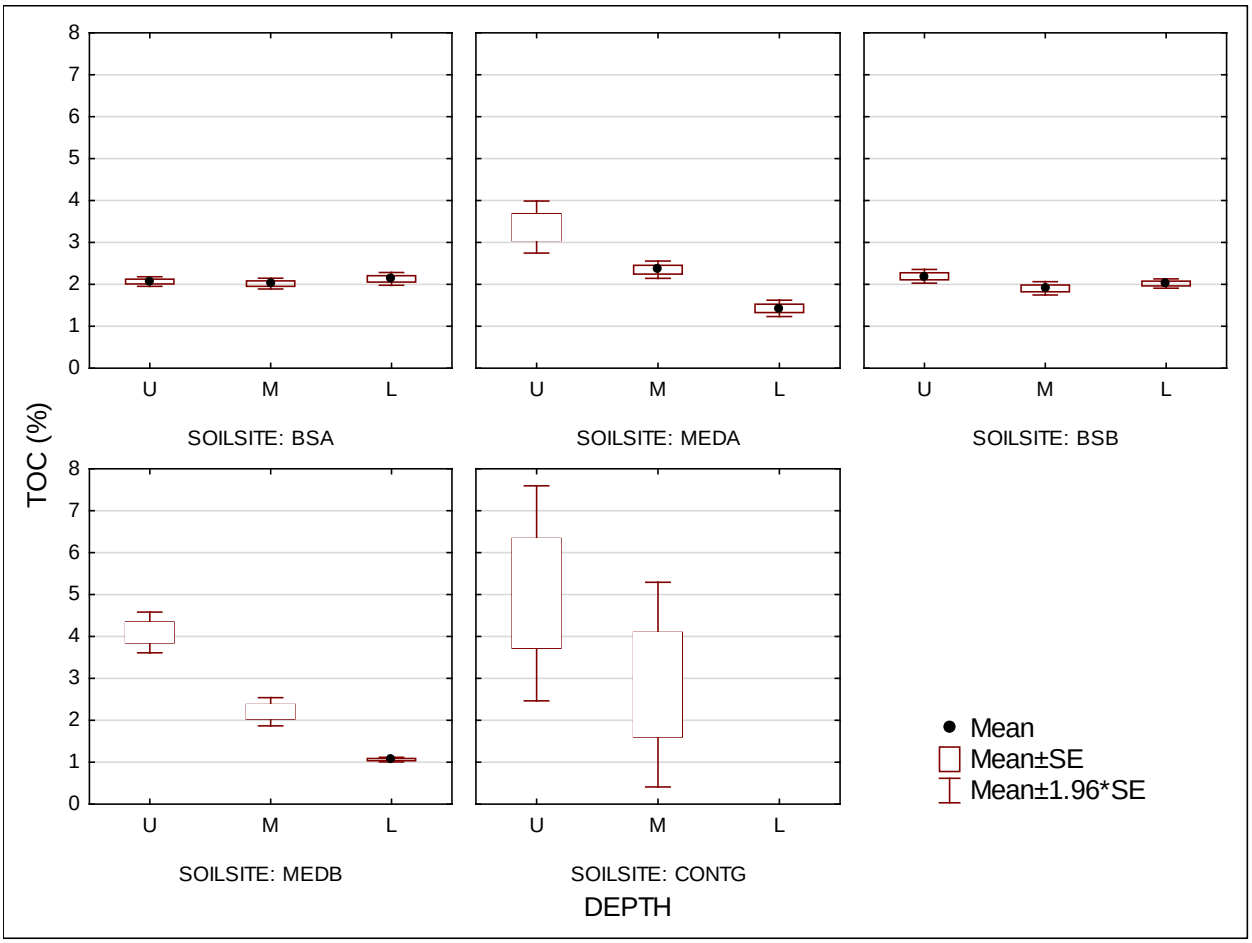

Figure 11. Mean TOC (%) for bioswale sites Alpha (BSA) and Beta (BSB), median sites adjoining Alpha (MEDA) and Beta (MEDB) and the control site (CONTG) as a function of three soil depths

Table 7. Summary of ANOVA for TOC at three sites and three soil profiles (Figure 11).

Effect	SS	df	MS	F	p
SOILSITE	2.39	3	0.80	2.2	0.093
DEPTH	16.6	1	16.6	45.9	0.000000
SOILSITE*DEPTH	21.4	7	3.1	8.5	0.000000
Error	28.1	78	0.36		

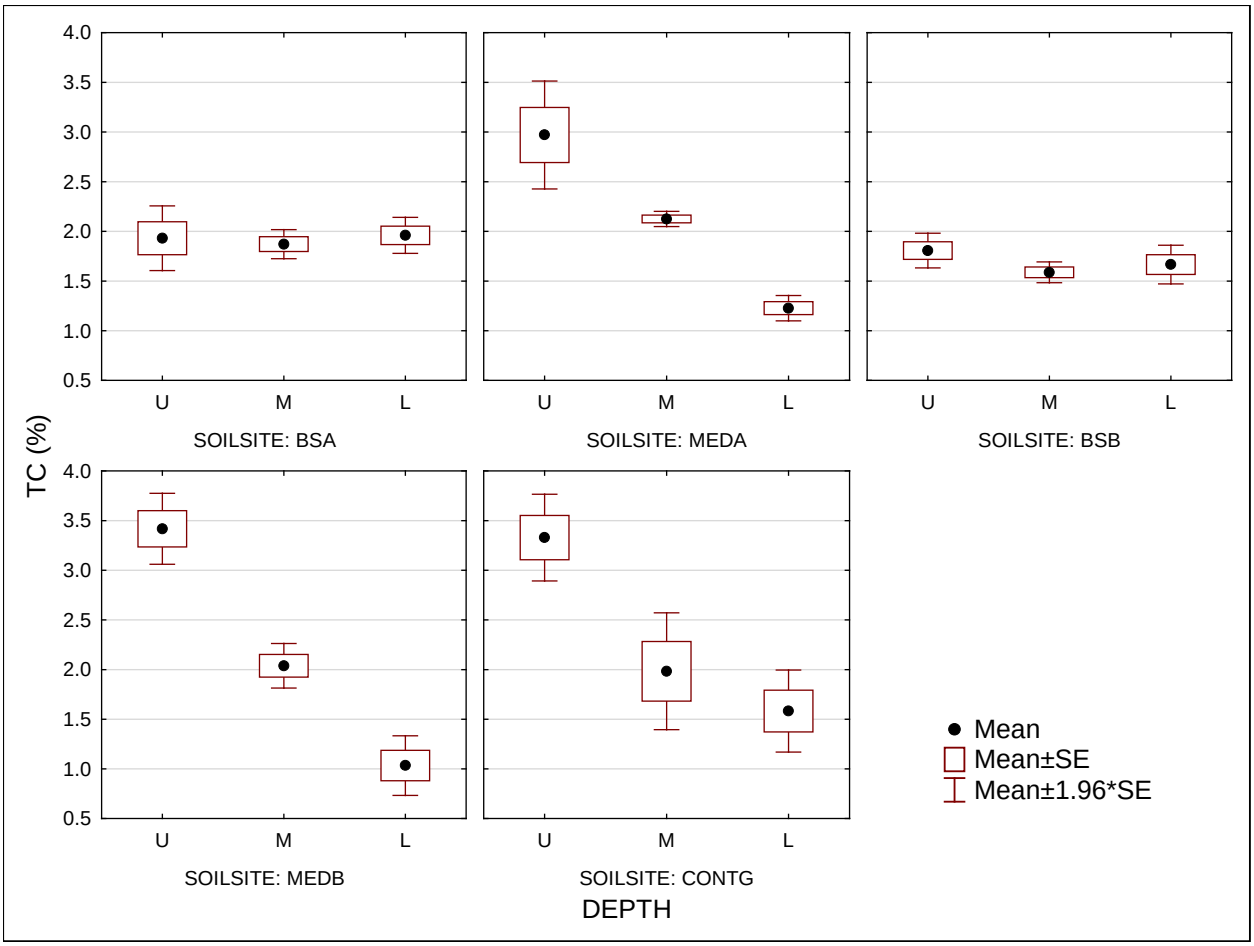

Figure 12. Mean TC (%) for bioswale sites Alpha (BSA) and Beta (BSB), median sites adjoining Alpha (MEDA) and Beta (MEDB) and the control site (CONTG) as a function of three soil depths.

Table 8. Summary of ANOVA for TC at three sites and three soil profiles (Figure 12).

Effect	SS	df	MS	F	p
SOILSITE	4.0	4	1.0	8.4	0.000011
DEPTH	19.0	2	9.5	79.9	0.000000
SOILSITE*DEPTH	14.4	8	1.8	15.1	0.000000
Error	9.56	80	0.12		

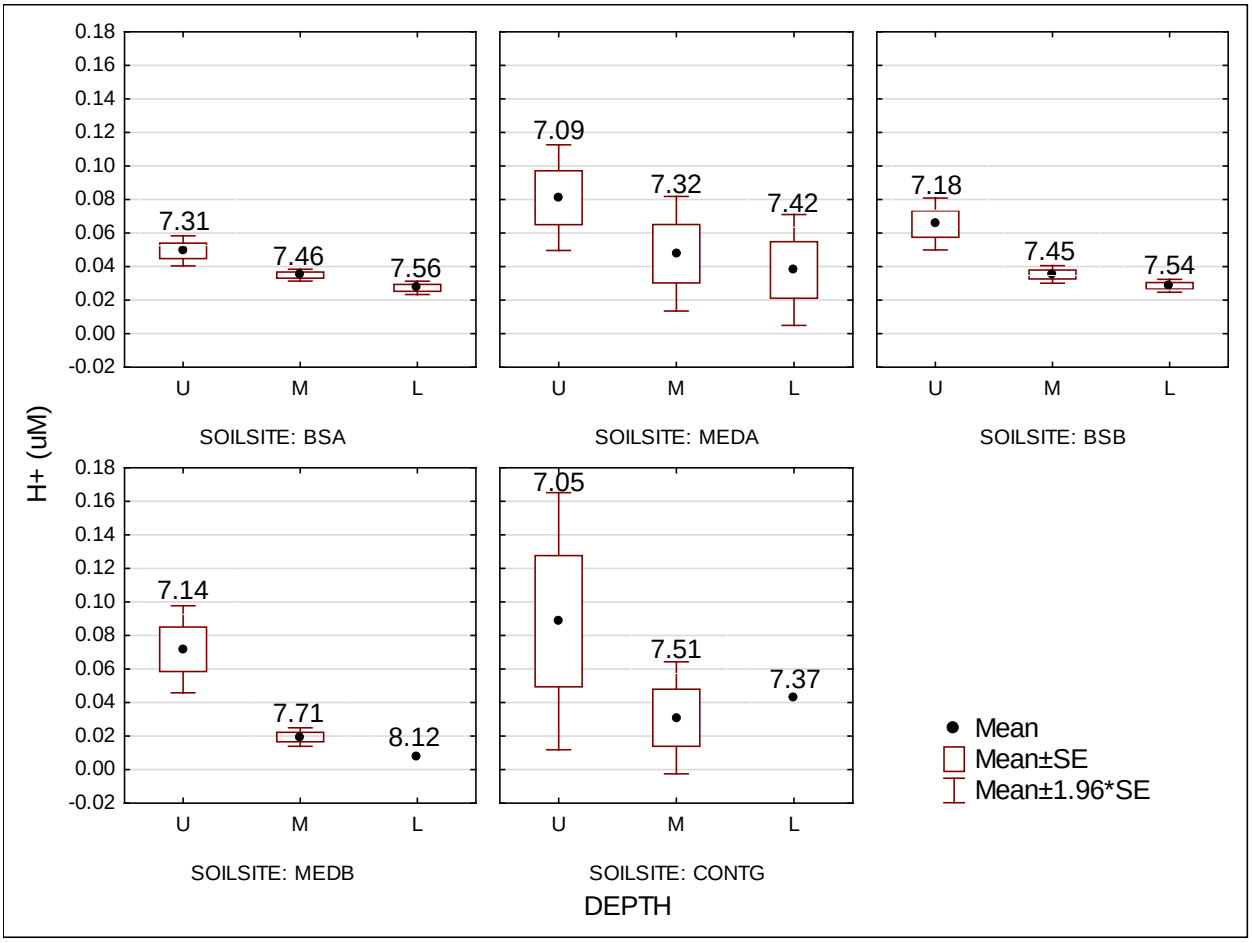

Figure 13. Mean H^+ (µM) for bioswale sites Alpha (BSA) and Beta (BSB), median sites adjoining Alpha (MEDA) and Beta (MEDB), and the control site (CONTG) as a function of three soil depth profiles. The pH value for each site-depth combination is above the box-whisker plot.

Table 9. Summary of ANOVA for H^+ (µM) at three sites and three soil profiles (Figure 13).

Effect	SS	df	MS	F	p
SOILSITE	0.0049	4	0.0012	2.0	0.102
DEPTH	0.025	2	0.012	20.3	0.000000
SOILSITE*DEPTH	0.0042	8	0.00053	0.87	0.55
Error	0.046	76	0.00061		

5.3.2 Soil Metals - Bioswales (Alpha and Beta), medians (adjacent to each bioswale), and control sites were sampled and analyzed for chromium (Cr), copper (Cu), zinc (Zn), cadmium (Cd), and lead (Pb) in September 2015 (Table 10). Composite cores for metal analyses were collected at three depths for each site as described in the methods. These five metals are all commonly associated with transportation activities.

Chromium (Cr) – There were significant differences in Cr levels among the two bioswales, two medians and the one control site (Tables 10 and 11, Figure 14). Both the Alpha and Beta bioswales had low concentrations of Cr, with concentrations ranging from 16.4 – 20.7 mg/kg (similar to the 2014 soil values). In contrast, the median material adjacent to the two bioswales had Cr levels ranging from 36.8 – 54.4 mg/kg, roughly twice the Cr concentrations seen in the bioswale material and potentially reflecting the young age of the bioswale material placed within each swale site (Table 9). Cr levels at the control site ranged from 46.3 – 53.3 mg/kg - very similar to the Cr levels observed in the Alpha and Beta median samples (Table 10).

There were significant soilsite, depth and soilsite*depth interaction effects observed for Cr in September (Table 11). Although the soilsite effect is quite pronounced (Table 11 and Figure 14), especially with the large differences in Cr among bioswales, medians, and the control, it is difficult to tease out a depth effect, although highly significant (Table 11). One observation on Cr by depth is that the middle composites were equal or slightly higher than either the upper or lower composites for both the medians and the control (same as for 2014). The Alpha bioswale was higher for Cr levels by depth than the Beta bioswale, indicating a potential difference due to runoff. Also, more variation was observed in the two medians and the control versus the two bioswales as reflected in the standard errors around the mean (Figure 14). Ingvertsen *et al.* (2012) suggested that chromium is converted to chromate in bioswale material allowing for greater movement within the soil profile, which could account for the relatively small amount of variation with depth at all sites.

Copper – In stark contrast to the May 2014 soil analyses (Table A10), there were no significant differences in Cu levels for the two bioswales, the two medians, and the one control site among site, depth, or soilsite*depth (Tables 10 and 12, Figure 15). Cu levels in the two ranged from 19.1 to 23.4 mg/kg in the bioswales, from 22.3 to 36.6 mg/kg in the medians, and from 21.6 to 36.0 mg/L in the control (Table 10). Cu levels in the two bioswales and the Alpha median site

were very similar; however, more variation in the Cu level was observed for the Beta median site and the control (Figure 15). Cu levels did not show any discrete patterns with depth; however, there was a large amount of variation in the Cu levels found in the upper and middle soil profiles of the control (Figure 15).

Zinc - There were significant differences in Zn levels for the two bioswales, the two medians, and the control site (Tables 10 and 13, Figure 16). Zn concentrations in the two bioswales were generally equivalent, ranging from 35.0 to 54.4 mg/kg (Table 10, Figure 16). Levels of Zn in the two medians varied from 75.5 – 101.7 mg/L over three depths, with the control ranging from 75.5 to 190.5 mg/kg. There was a high level of Zn (190.5 mg/kg) present in the uppermost soil profile in the control; a Zn level of 123.9 mg/kg was observed in this same profile in May 2014.

The presence of Zn in the two bioswales was significantly lower than in the medians and control (soilsite), with a significant depth and soilsite*depth component (Table 13). The depth component was evident in the Alpha and Beta median and the control, with decreasing levels of Zn with depth; however, this pattern was not observed in the two bioswales, although Zn levels present in the bioswales may reflect their recent construction. The significant soilsite*depth interaction term is a reflection of the rather stable soil Zn in the two bioswales and the consistent Zn levels in the Alpha and Beta medians, with decreasing levels of zinc with depth in the control site.

Cadmium - There were significant differences in Cd levels among the two bioswales, the two medians, and the one control site (Tables 10 and 14, Figure 17). Cd levels in both bioswales ranged from 0.35 to 0.86 mg/kg, from 0.32 to 1.4 mg/kg in the two medians, and from 0.31 to 1.2 mg/kg in the one control – very similar to the soil Cd results obtained in 2014 (Table 10). As in 2014, there were large standard errors (SE) for many of the Cd soilsite/depth combinations observed in 2015 (Table 10 and Figure 17).

There were significant soilsite and soilsite*depth factors for Cd, but not for soil depth (Table 14). The significant interaction term of soilsite*depth may be due in part to the varied responses of the soil material. For example, the Beta bioswale showed an increase in soil Cd with depth, while the levels were higher in the upper and middle soil profiles for the Alpha bioswale. The median adjacent to the Alpha site was higher in the middle profile, with greater variation. Soil Cd decreased with depth in the control (Figure 17).

Lead - There were significant differences in Pb levels for the two bioswales, two medians and one control site (Tables 10 and 15, Figure 18). Pb levels in the bioswales ranged from 13.3 to 21.1 mg/kg, from 39.5 to 94.0 mg/kg in the two medians, and from 7.8 to 214.5 mg/kg in the control (Table 10). The Alpha and Beta bioswales had low Pb levels (< 22 mg/kg) and were very consistent among all depths (with a small SE). In contrast, the two medians were higher in Pb than the bioswales, with Pb levels exceeding 50 mg/kg (slightly higher than 2014).

The control site was interesting in that it contained the highest level of Pb observed in the September sampling with Pb levels in the upper and middle soil profiles exceeding 150 mg/kg (perhaps a reflection of dry conditions). It is unknown at this time if this is legacy lead from the past usage of leaded fuels, lead present in diesel fuels, or lead from local point sources since, at one time, there were several active industries in the Hagerstown area that may have contributed atmospheric metals.

There were significant soilsite and depth effects for Pb, with a non-significant soilsite*depth factor (Table 15). Basically, the two bioswales differed from the two median sites and the control (Figure 18), with the control site differing from both bioswales and medians.

Table 10. Results (mean plus standard error – SE) for soil chromium (Cr - mg/kg), copper (Cu - mg/L), zinc (Zn – mg/L), cadmium (Cd – mg/kg) and lead (Pb – mg/kg) for September 2015 field work. (BS = bioswale – Alpha or Beta, M = median, and C = Control - Gamma. U = upper soil profile, M = middle soil profile and L = lower soil profile).

SITE – DEPTH	Cr Mean	Cr SE	Cu Mean	Cu SE	Zn Mean	Zn SE	Cd Mean	Cd SE	Pb Mean	Pb SE
BS-Alpha – U	20.0	0.61	21.5	0.48	54.4	4.4	0.73	0.14	21.1	1.6
BS-Alpha – M	20.5	0.54	21.7	0.71	50.6	2.2	0.86	0.22	17.8	0.73
BS-Alpha - L	20.7	0.87	23.4	0.59	50.9	1.8	0.40	0.027	18.6	0.59
BS-Beta - U	15.8	0.54	20.8	1.7	37.6	1.4	0.35	0.049	13.4	0.54
BS-Beta - M	17.3	0.60	20.5	1.0	36.2	1.7	0.41	0.073	13.6	0.44
BS-Beta – L	16.4	0.57	19.1	0.58	35.0	1.0	0.65	0.15	13.3	0.39
M-Alpha – U	36.8	3.4	22.3	1.2	91.3	9.4	0.71	0.19	86.3	12.2
M-Alpha - M	54.4	3.6	22.8	0.82	88.5	2.8	1.4	0.39	82.1	5.1
M-Alpha – L	53.8	3.4	25.3	2.8	75.5	4.9	0.77	0.15	54.8	5.7
M-Beta – U	42.0	2.8	27.0	1.7	101.7	6.1	0.54	0.060	94.0	5.3
M-Beta – M	51.7	4.4	28.3	2.3	91.9	3.9	0.55	0.065	73.3	6.9
M-Beta – L	40.6	2.6	36.6	8.2	88.4	8.9	0.32	0.069	39.5	6.0
C-Gamma – U	48.8	4.2	36.0	13.2	190.5	83.2	1.2	0.37	214.5	126.9
C-Gamma – M	53.3	2.1	30.4	9.4	121.3	54.7	0.67	0.33	157.0	101.5
C-Gamma – L	46.3	9.1	21.6	2.6	75.5	11.3	0.31	0.11	70.8	26.0

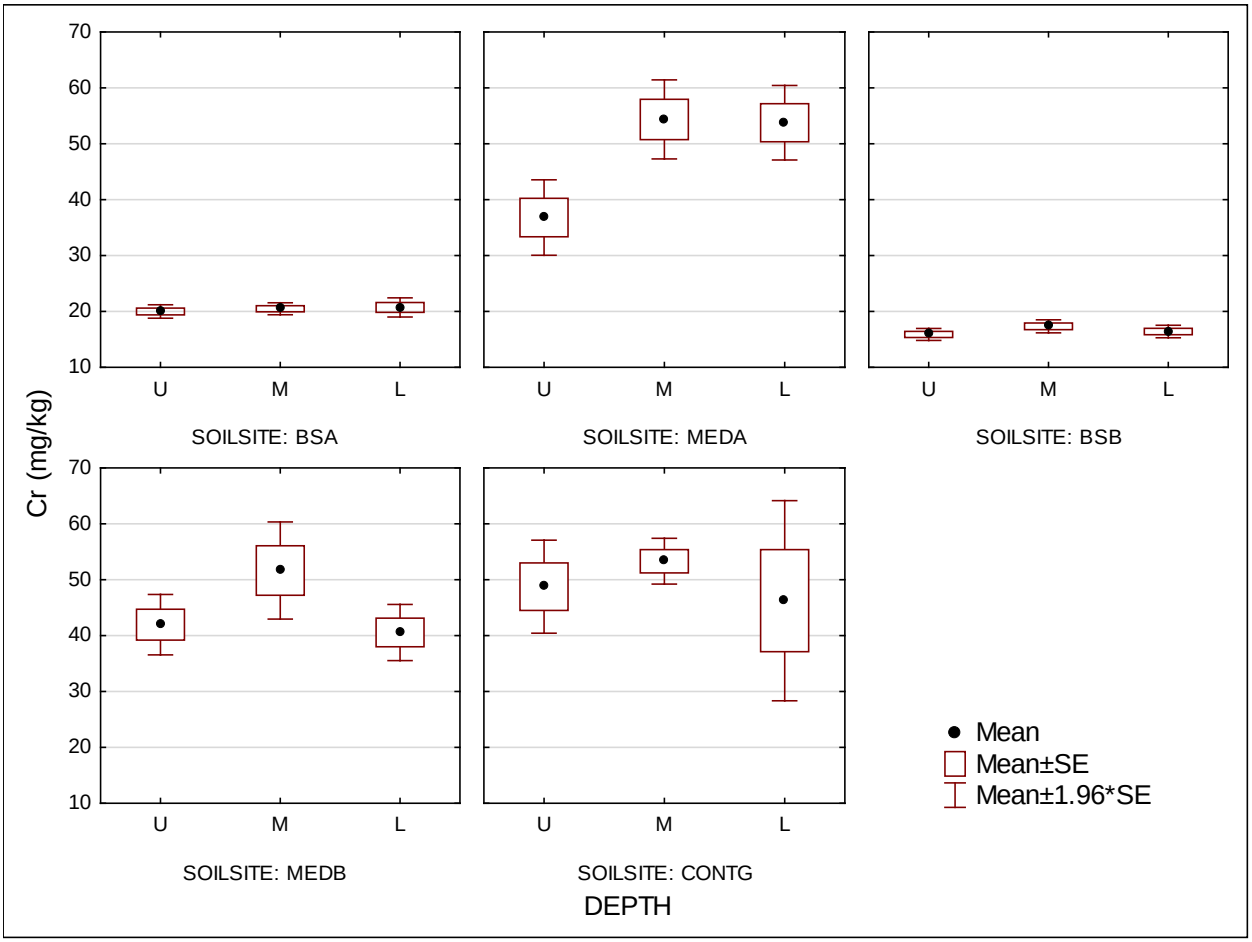

Figure 14. Mean Cr (mg/kg) for bioswale sites Alpha (BSA) and Beta (BSB), median sites adjoining Alpha (MEDA) and Beta (MEDB), and the control site (CONTG) as a function of three soil depth profiles.

Table 11. Summary of ANOVA for Cr (mg/kg) at three sites and three soil profiles (Figure 14).

Effect	SS	Df	MS	F	p
Intercept	102288	1	102288	3003	0.000000
SOILSITE	19671	4	4918	144	0.000000
DEPTH	644	2	322	9.5	0.00020
SOILSITE*DEPTH	1078	8	135	4.0	0.00054
Error	2759	81	34		

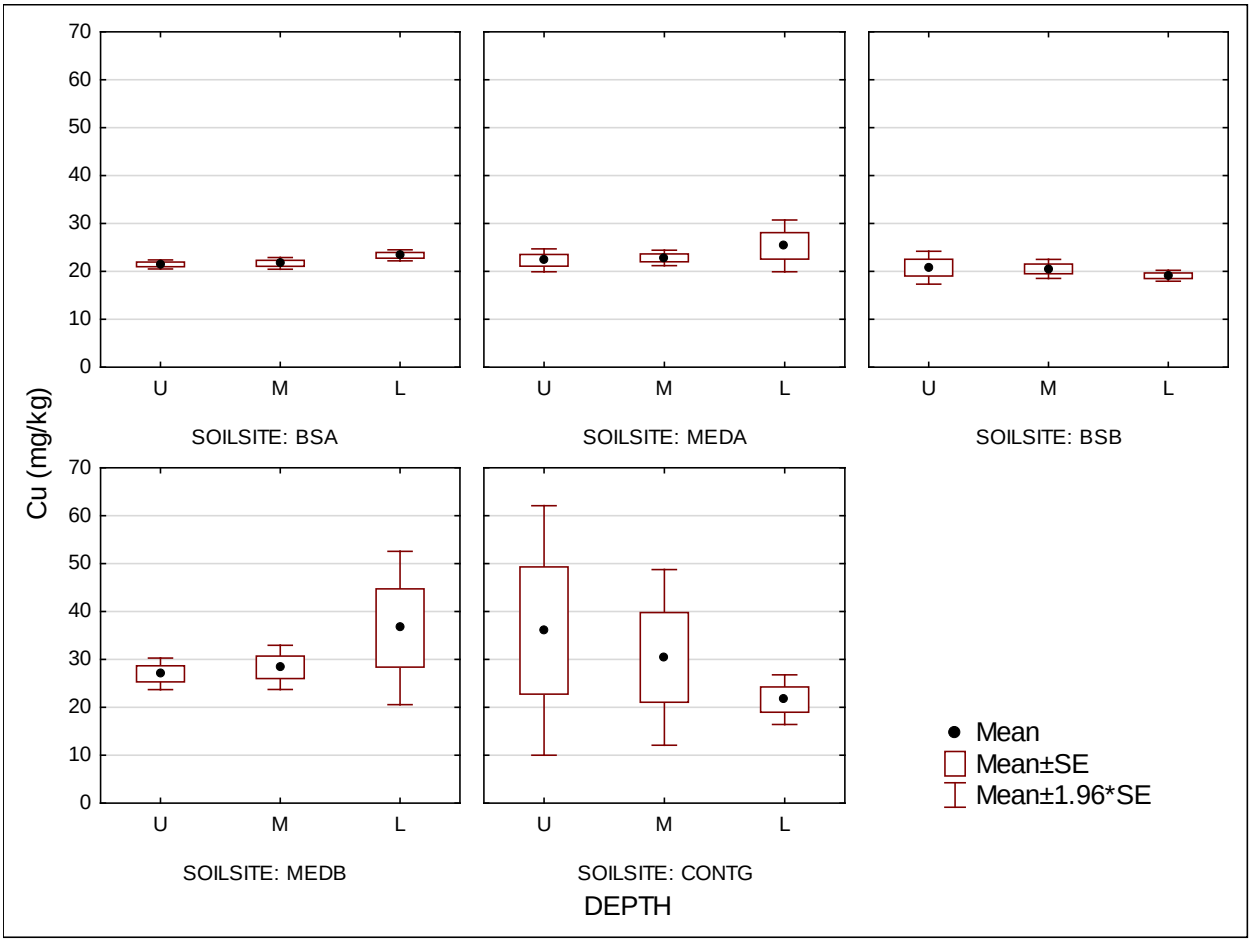

Figure 15. Mean Cu (mg/kg) for bioswale sites Alpha (BSA) and Beta (BSB), median sites adjoining Alpha (MEDA) and Beta (MEDB), and the control site (CONTG) as a function of three soil depth profiles.

Table 12. Summary of ANOVA for Cu (mg/kg) at three sites and three soil profiles (Figure 15).

Effect	SS	Df	MS	F	p
Intercept	56741	1	56741	107	0.000000
SOILSITE	1872	4	468	0.88	0.48
DEPTH	308	2	154	0.29	0.75
SOILSITE*DEPTH	2882	8	360	0.68	0.71
Error	42902	81	530		

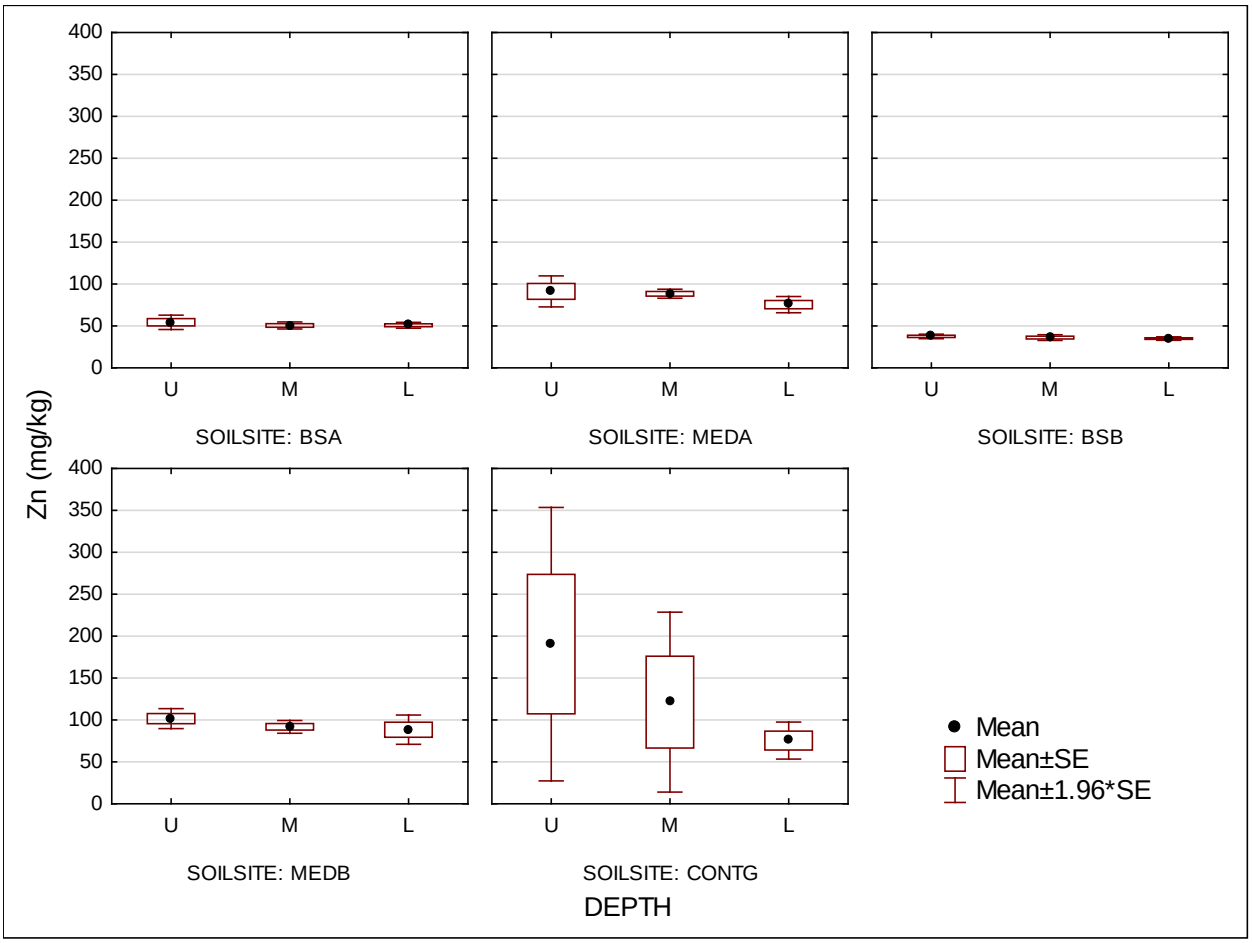

Figure 16. Mean Zn (mg/kg) for bioswale sites Alpha (BSA) and Beta (BSB), median sites adjoining Alpha (MEDA) and Beta (MEDB), and the control site (CONTG) as a function of three soil depth profiles.

Table 13. Summary of ANOVA for Zn (mg/kg) at three sites and three soil profiles (Figure 16).

Effect	SS	Df	MS	F	p
Intercept	499109	1	499109	592	0.000000
SOILSITE	82036	4	20509	24	0.000000
DEPTH	11859	2	5930	7.0	0.0015
SOILSITE*DEPTH	16591	8	2074	2.5	0.019
Error	68334	81	844		

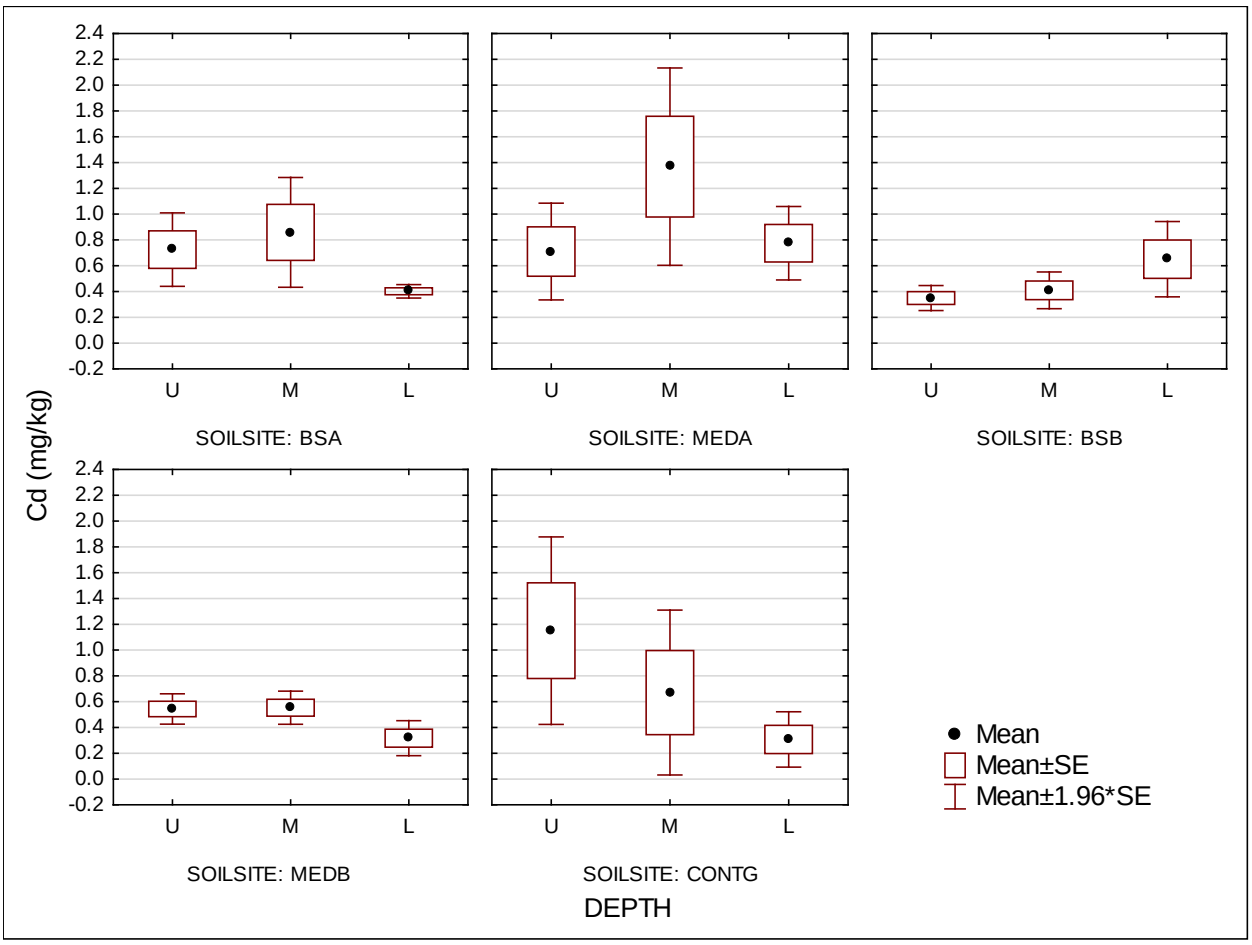

Figure 17. Mean Cd (mg/kg) for bioswale sites Alpha (BSA) and Beta (BSB), median sites adjoining Alpha (MEDA) and Beta (MEDB), and the control site (CONTG) as a function of three soil depth profiles.

Table 14. Summary of ANOVA for Cd (mg/kg) at three sites and three soil profiles (Figure 17).

	SS	Df	MS	F	p
Intercept	33.8	1	33.8	180	0.000000
SOILSITE	3.0	4	0.74	3.9	0.0056
DEPTH	1.1	2	0.54	2.9	0.064
SOILSITE*DEPTH	3.3	8	0.42	2.2	0.034
Error	15.2	81	0.19		

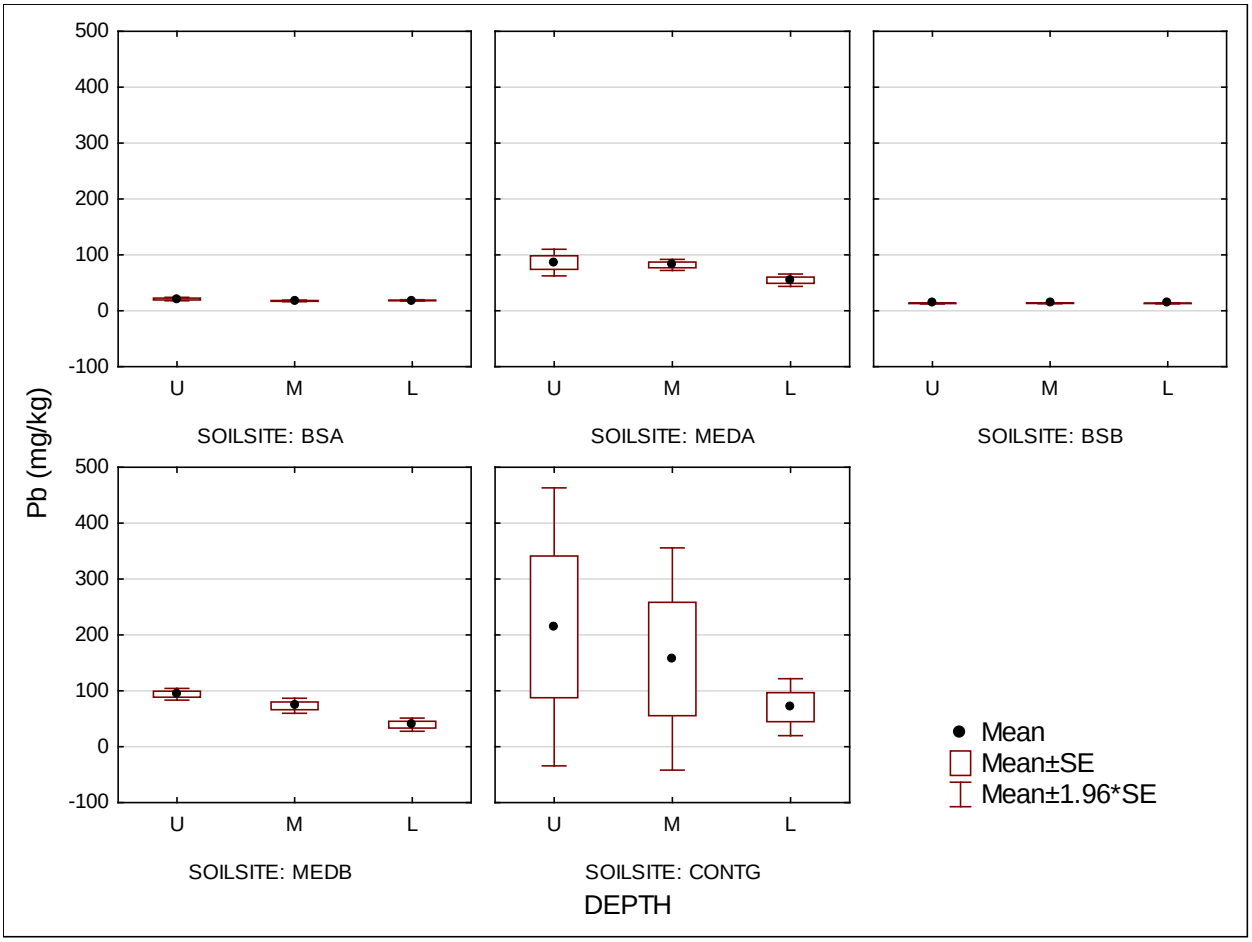

Figure 18. Mean Pb (mg/kg) for bioswale sites Alpha (BSA) and Beta (BSB), median sites adjoining Alpha (MEDA) and Beta (MEDB), and the control site (CONTG) as a function of three soil depth profiles.

Table 15. Summary of ANOVA for Pb (mg/kg) at three sites and three soil profiles (Figure 18).

Effect	SS	Df	MS	F	p
Intercept	332188	1	332188	157	0.000000
SOILSITE	162187	4	40547	19	0.000000
DEPTH	28069	2	14035	6.6	0.0022
SOILSITE*DEPTH	28725	8	3591	1.7	0.11
Error	171419	81	2116		

5.4 Time Series Analyses for Bioswale Soil Parameters

Alpha Bioswale – Of all analyte comparisons by year (2014 versus 2015), there were four soil parameters, TN, TOC, TC and Cu, that significantly decreased at the Alpha bioswale between years, with H+, Cr and Zn increasing between 2014 and 2015 (Table 16). There were two soil parameters (TP and H+) that decreased with depth. In addition, there were two significant year*depth interaction factors for TP and H+, with the TP interaction plot showing a slight decrease between years in the middle and lower soil levels but with an increase in TP in the upper layer (Figure 19). The H+ interaction plot shows increases at all soil depths but the rate of increase is higher in the upper soil horizon (Figure 20).

Table 16. Analyses (F values presented from factorial ANOVA) of soil analytes for **Alpha** B**ioswale** soil by year, (2014 versus 2015), depth (U, M and L profiles) and year*depth (interaction factor). Analytes are total phosphorus (TP), total nitrogen (TN), total organic carbon (TOC), total carbon (TC), H^+, chromium (Cr), copper (Cu), zinc (Zn), cadmium (Cd) and lead (Pb). Probability levels are: ns = non-significant at $p \geq 0.05$; * = significant at $\rho \leq 0.05$, ** = significant at $\rho \leq 0.01$, and *** = highly significant ($\rho \leq 0.001$ or lower). Arrows indicate: (↓) = observed significant decrease; (↑) = observed significant increase. The year*depth factor is excluded from the use of the two symbols since there may be variable responses observed by year and depth combinations for an analyte.

Analyte	Year	Depth	Year*Depth
TP (mg/kg)	0.48 ns	20.0*** (↓)	4.3*
TN (%)	7.8***(↓)	0.14 ns	0.68 ns
TOC (%)	75.9***(↓)	0.32 ns	0.50 ns
TC (%)	39.5***(↓)	0.57 ns	1.1 ns
H+ (µM)	159.4***(↑)	20.8***(↓)	5.1***
Cr (mg/kg)	4.2*(↑)	0.71 ns	1.3 ns
Cu (mg/kg)	7.3***(↓)	0.16 ns	0.49 ns
Zn (mg/kg)	20.5***(↑)	0.69 ns	0.17 ns
Cd (mg/kg)	0.0023 ns	2.8 ns	1.2 ns
Pb (mg/kg)	0.049 ns	0.80 ns	0.92 ns

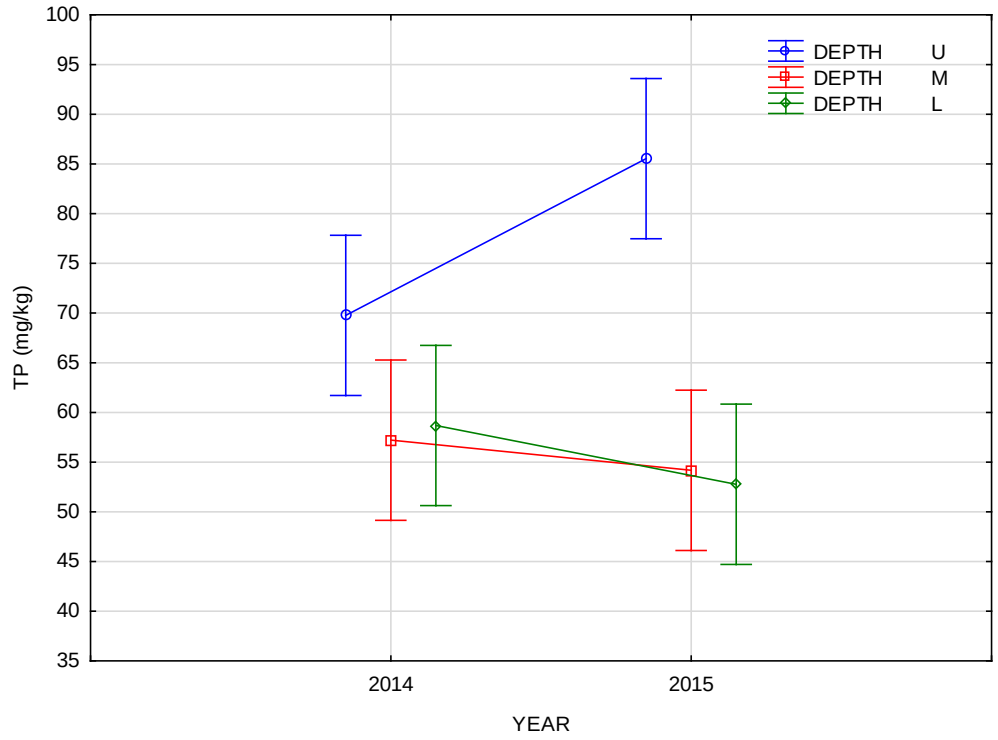

Figure 19. Interaction plot for year*depth for TP at the Alpha bioswale (error bars = 95% CI).

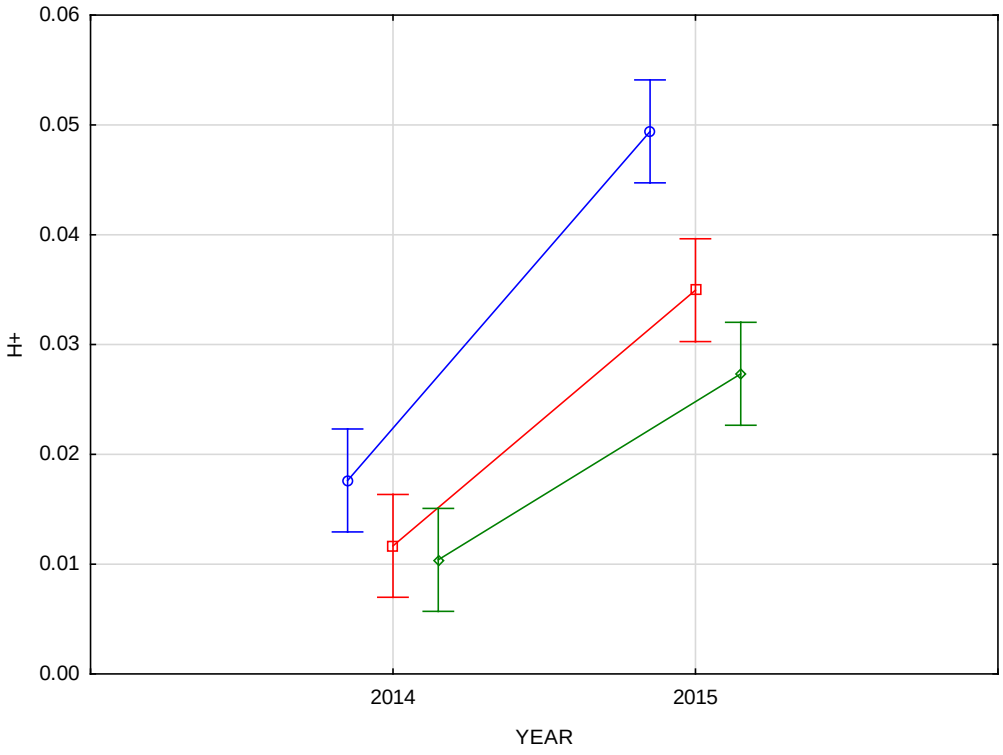

Figure 20. Interaction plot for year*depth for H+ at the Alpha bioswale (error bars = 95% CI).

Beta Bioswale – Of all analyte comparisons by year (2014 versus 2015), there were four soil parameters, TN, TOC, TC and Cr, that significantly decreased at the Beta bioswale between years, with both Zn and H+ increasing between 2014 and 2015 (Table 17). Moreover, there were two soil parameters (TP and H+) that decreased with depth at the Beta bioswale, with Cr increasing by depth (levels equivalent between the middle and lower profile). Both TP and H+ generally displayed a decreasing linear response with soil depth, with Cr increasing with depth. There were two significant year*depth interaction factors for TP and H+, with the TP interaction plot showing a slight decrease between years in the middle and lower soil levels but with an increase in TP in the upper layer (Figure 21). The H+ interaction plot shows increases at all soil depths but the rate of increase is higher in the upper soil horizon (Figure 22).

Table 17. Analyses (F values presented from factorial ANOVA) of soil analytes for **Beta** B**ioswale** soil by year (2014 versus 2015), depth (U, M and L profiles), and year*depth (interaction factor). Analytes are total phosphorus (TP), total nitrogen (TN), total organic carbon (TOC), total carbon (TC), H^+, chromium (Cr), copper (Cu), zinc (Zn), cadmium (Cd) and lead (Pb). Probability levels are: ns = non-significant at $p \geq 0.05$; * = significant at $\rho \leq 0.05$, ** = significant at $\rho \leq 0.01$, and *** = highly significant ($\rho \leq 0.001$ or lower). Arrows indicate: (↓) = observed significant decrease; (↑) = observed significant increase. The year*depth factor is excluded from the use of the two symbols since there may be variable responses observed by year and depth combinations for an analyte.

Analyte	Year	Depth	Year*Depth
TP (mg/kg)	3.1 ns	57.9*** (↓)	19.3***
TN (%)	5.6* (↓)	1.4 ns	0.33 ns
TOC (%)	45.8*** (↓)	2.6 ns	1.3 ns
TC (%)	96.5*** (↓)	0.81 ns	0.96 ns
H+ (µM)	64.8*** (↑)	26.0*** (↓)	7.1***
Cr (mg/kg)	27.8*** (↓)	3.7* (↑)	1.7 ns
Cu (mg/kg)	0.18 ns	0.36 ns	0.55 ns
Zn (mg/kg)	15.1*** (↑)	0.11 ns	0.53 ns
Cd (mg/kg)	1.4 ns	1.4 ns	1.3 ns
Pb (mg/kg)	0.52 ns	0.22 ns	0.057 ns

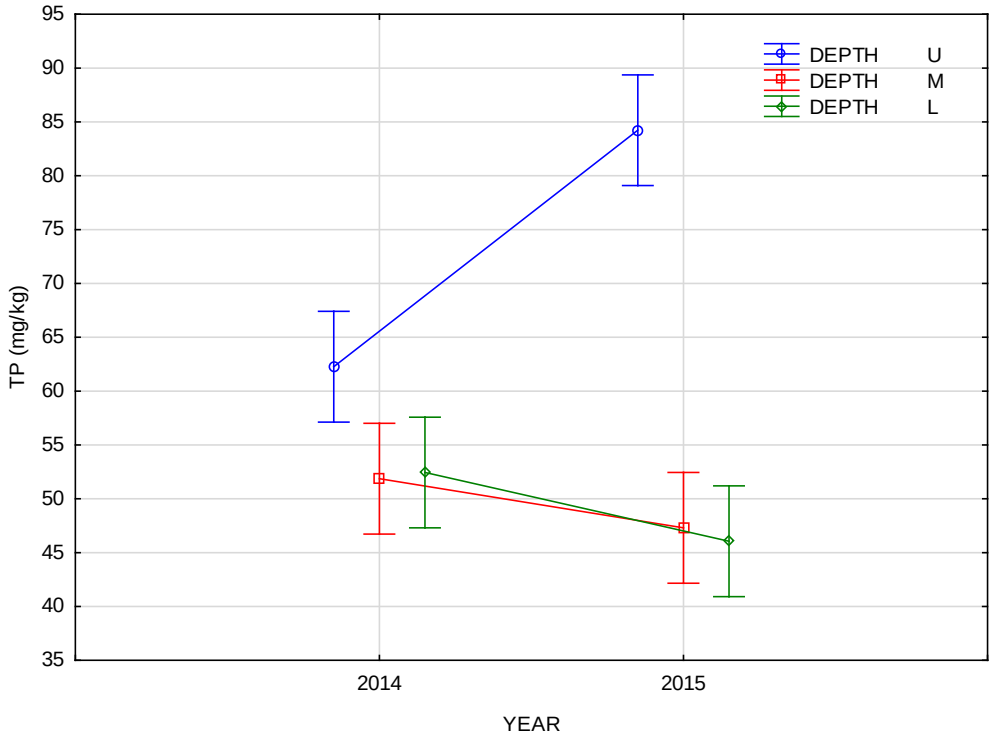

Figure 21. Interaction plot for year*depth for TP at the Beta bioswale (error bars = 95% CI).

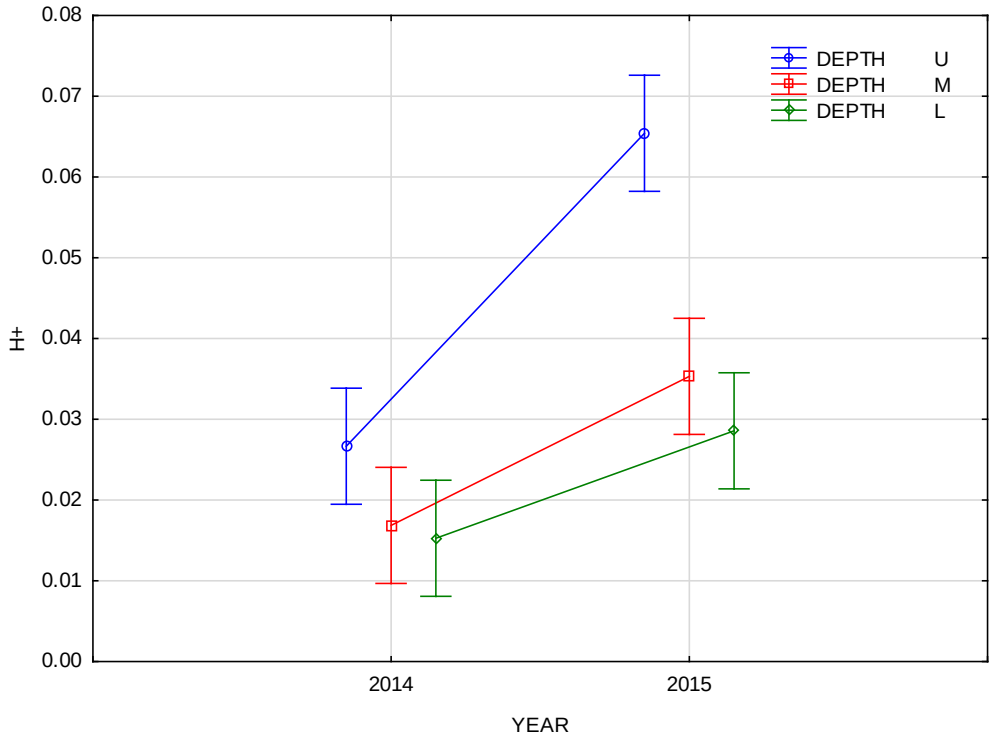

Figure 22. Interaction plot for year*depth for H+ at the Beta bioswale (error bars = 95% CI).

Alpha Median – Of all analyte comparisons by year (2014 versus 2015), there were three soil parameters, TOC, H+ and Cu, that were significant for the Alpha Median site adjacent to the Alpha bioswale, with TOC and H+ increasing, and Cu decreasing between 2014 and 2015 (Table 18). Moreover, there were five soil parameters (TP, TN, TOC, TC and Pb) that decreased with depth at the Alpha Median site, with both Cr and Cu increasing by depth level. There was only one significant year*depth interaction factor for Cu. The five soil parameters generally displayed a decreasing linear response with soil depth, with Cr and Cu increasing with depth. The single year*depth interaction plot for Cu illustrated an interaction factor where the upper and middle soil profiles showed consistent Cu levels between years, but with a decrease in Cu in the upper soil profile between years.

Table 18. Analyses (F values presented from factorial ANOVA) of soil analytes for **Alpha Median** soil by year, (2014 versus 2015), depth (U, M and L profiles) and year*depth (interaction factor). Analytes are total phosphorus (TP), total nitrogen (TN), total organic carbon (TOC), total carbon (TC), H^+, chromium (Cr), copper (Cu), zinc (Zn), cadmium (Cd) and lead (Pb). Probability levels are: ns = non-significant at $p \geq 0.05$; * = significant at $\rho \leq 0.05$, ** = significant at $\rho \leq 0.01$, and *** = highly significant ($\rho \leq 0.001$ or lower). Arrows indicate: (↓) = observed significant decrease; (↑) = observed significant increase. The year*depth factor is excluded from the use of the two symbols since there may be variable responses observed by year and depth combinations for an analyte.

Analyte	Year	Depth	Year*Depth
TP (mg/kg)	0.027 ns	17.6*** ↓)	0.12 ns
TN (%)	3.6 ns	32.2***(↓)	0.13 ns
TOC (%)	8.1*** (↑)	37.9*** (↓)	0.55 ns
TC (%)	1.1 ns	52.2*** (↓)	0.56 ns
H+ (µM)	10.7*** (↑)	1.1 ns	2.1 ns
Cr (mg/kg)	2.2 ns	5.3** (↑)	0.88 ns
Cu (mg/kg)	6.4* (↓)	8.7** (↑)	3.5*
Zn (mg/kg)	0.22 ns	1.3 ns	0.25 ns
Cd (mg/kg)	1.9 ns	3.0 ns	0.20 ns
Pb (mg/kg)	0.28 ns	7.8** (↓)	0.098 ns

Beta Median – Of all analyte comparisons by year (2014 versus 2015), there were three soil parameters, TN, Zn and Cd, that were significant, with TN and Cd decreasing and Zn increasing between years at the Beta Median site adjacent to the Beta bioswale (Table 19). However, there were seven soil parameters (TP, TN, TOC, TC, pH, Zn and Pb) that decreased with soil depth at the Beta Median site, along with two significant year*depth interaction factors (TOC and pH). All seven soil parameters generally displayed a decreasing linear response with soil depth. The two year*depth interaction plots for TOC and H+ illustrated the interaction factor where the upper soil profile showed an increase in either TOC or H+, with the middle soil profile increasing for TOC between years and decreasing at the lower soil profile (Figures 23 and 24). Both the middle and lower soil profiles decreased for H+.

Table 19. Analyses (F values presented from factorial ANOVA) of soil analytes for the **Beta Median** soil by year (2014 versus 2015), depth (U, M and L profiles) and year*depth (interaction factor). Analytes are total phosphorus (TP), total nitrogen (TN), total organic carbon (TOC), total carbon (TC), H^+, chromium (Cr), copper (Cu), zinc (Zn), cadmium (Cd) and lead (Pb). Probability levels are: ns = non-significant at $p \geq 0.05$; * = significant at $\rho \leq 0.05$, ** = significant at $\rho \leq 0.01$, and *** = highly significant ($\rho \leq 0.001$ or lower). Arrows indicate: (↓) = observed significant decrease; (↑) = observed significant increase. The year*depth factor is excluded from the use of the two symbols since there may be variable responses observed by year and depth combinations for an analyte.

Analyte	Year	Depth	Year*Depth
TP (mg/kg)	3.7 ns	17.4*** (↓)	3.4 ns
TN (%)	4.5* (↓)	102.1*** (↓)	1.2 ns
TOC (%)	2.2 ns	78.4*** (↓)	5.2*
TC (%)	3.4 ns	92.8*** (↓)	3.8*
H+ (µM)	0.42 ns	10.3*** (↓)	4.6*
Cr (mg/kg)	3.5 ns	1.9 ns	0.35 ns
Cu (mg/kg)	0.75 ns	1.6 ns	1.3 ns
Zn (mg/kg)	13.8** (↑)	8.1** (↓)	0.94 ns
Cd (mg/kg)	7.4* (↓)	0.064 ns	0.17 ns
Pb (mg/kg)	1.1 ns	21.4*** (↓)	2.9 ns

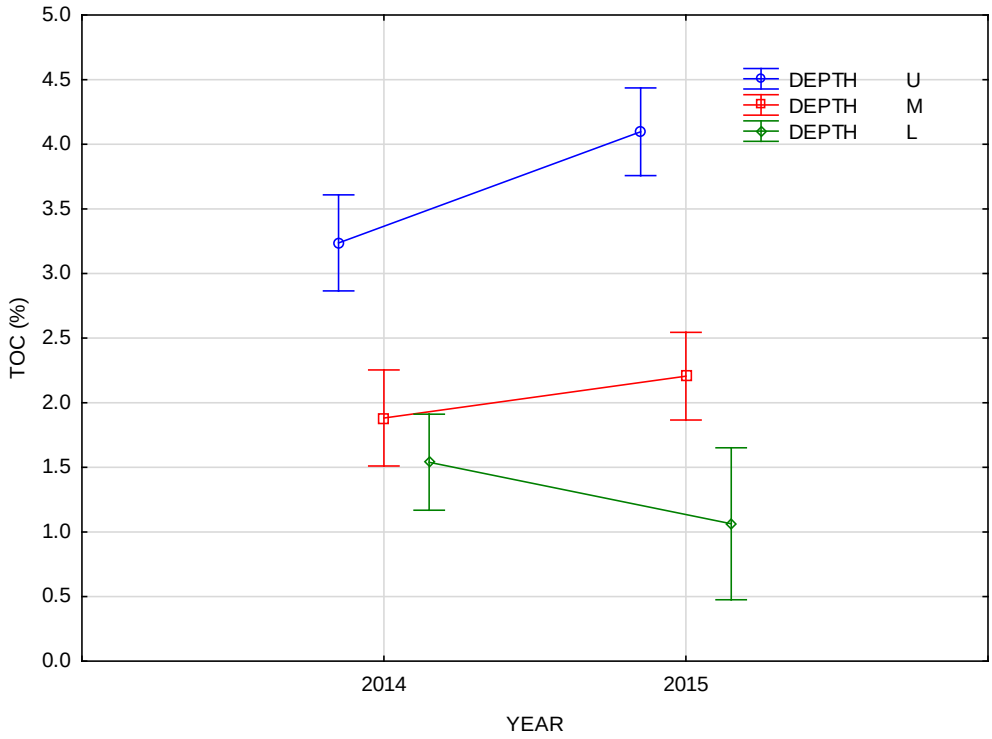

Figure 23. Interaction plot for year*depth for TOC at the Beta Median site (error bars = 95% CI).

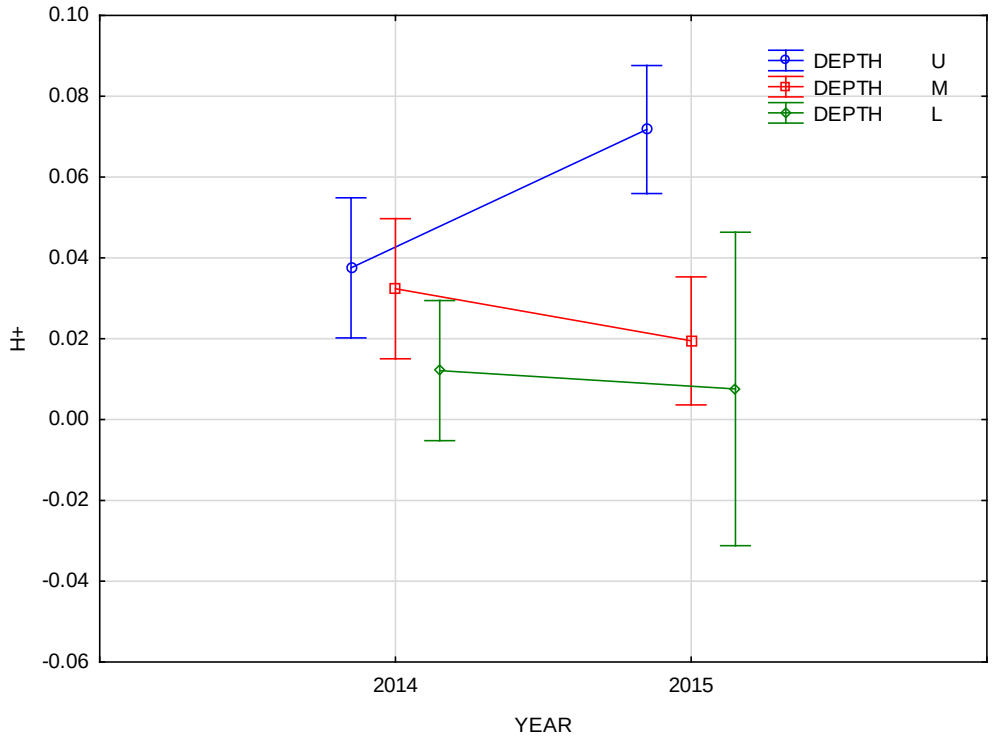

Figure 24. Interaction plot for year*depth for H+ at the Beta Median site (error bars = 95% CI).

Gamma Control – The Gamma Control site showed no significant differences between the year factor and the year*depth (interaction) factor for any soil analyte (Table 20). The only two significant soil parameters, displaying decreasing concentrations with soil depth, were TN and TC at the Gamma Control.

Table 20. Analyses (F values presented from factorial ANOVA) of soil analytes for **Gamma Control** soil by year (2014 versus 2015), depth (U, M and L profiles) and year*depth (interaction factor). Analytes are total phosphorus (TP), total nitrogen (TN), total organic carbon (TOC), total carbon (TC), H^+, chromium (Cr), copper (Cu), zinc (Zn), cadmium (Cd) and lead (Pb). Probability levels are: ns = non-significant at $p \geq 0.05$; * = significant at $\rho \leq 0.05$, ** = significant at $\rho \leq 0.01$, and *** = highly significant ($\rho \leq 0.001$ or lower). Arrows indicate: (↓) = observed significant decrease; (↑) = observed significant increase. The year*depth factor is excluded from the use of the two symbols since there may be variable responses observed by year and depth combinations for an analyte.

Analyte	Year	Depth	Year*Depth
TP (mg/kg)	2.9 ns	2.9 ns	0.75 ns
TN (%)	0.41 ns	14.2** (↓)	0.054 ns
TOC (%)	1.7 ns	3.3 ns	0.16 ns
TC (%)	1.5 ns	9.9** (↓)	0.61 ns
H+ (µM)	1.5 ns	0.76 ns	1.0 ns
Cr (mg/kg)	0.020 ns	0.67 ns	0.60 ns
Cu (mg/kg)	0.097 ns	0.86 ns	0.29 ns
Zn (mg/kg)	1.2 ns	2.0 ns	0.17 ns
Cd (mg/kg)	1.0 ns	3.8 ns	0.081 ns
Pb (mg/kg)	0.46 ns	1.1 ns	0.073 ns

5.5 Bioswale Soil Analyses between Years.

For soil analytes studied at the Dual Highway sites, there was a strong trend in the levels of TP present in the bioswale material, with TP ranging from 47.3 to 85.5 mg/kg, far exceeding the TP concentrations present (3.4 – 24.7 mg/kg) in both the median and control soils (Table 21). However, the upper soil profile at the two median sites and the control site was higher than either the middle or lower profiles. TOC and TC (as %) were also elevated, again in the upper soil profile. TN values were not low given that 0.1% TN is equivalent to 1 g/kg or 1000 mg/kg (TN in agricultural soils are typically around 0.075% to 0.15% TN). It should be noted that the upper soil profile in the medians and control site contained high levels of TN (0.22 to 0.36%).

Table 21. Analyte comparison between years for means of soil TP (mg/kg), TOC (%), TC (%) and TN (%) by site and depth. Gray shading represents a dominant trend in an analyte.

SITE (N)	DEPTH	TP 2014	TP 2015	TOC 2014	TOC 2015	TC 2014	TC 2015	TN 2014	TN 2015
BS-Alpha (9)	U	**69.8**	**85.5**	2.7	2.1	2.4	2.4	0.097	0.088
BS-Alpha (9)	M	**57.2**	**54.2**	2.9	2.0	2.7	2.7	0.11	0.082
BS-Alpha (9)	L	**58.7**	**52.8**	2.8	2.1	2.6	2.6	0.10	0.082
BS-Beta (9)	U	**62.3**	**84.2**	2.6	2.2	2.5	2.5	0.15	0.088
BS-Beta (9)	M	**51.9**	**47.3**	2.5	1.9	2.5	2.5	0.11	0.064
BS-Beta (9)	L	**52.4**	**46.1**	2.4	2.0	2.6	2.6	0.10	0.077
M-Alpha (6)	U	14.5	13.5	2.7	3.4	3.3	3.3	0.22	0.24
M-Alpha (6)	M	5.4	6.0	2.0	2.4	2.3	2.3	0.12	0.15
M-Alpha (6)	L	3.7	3.4	1.1	1.4	1.2	1.2	0.045	0.088
M-Beta (5)	U	19.4	10.7	3.2	4.1	3.6	3.6	0.30	0.27
M-Beta (5)	M	7.6	5.0	1.9	2.2	1.8	1.8	0.13	0.12
M-Beta (5)	L	3.8	5.7	1.5	1.1	1.8	1.8	0.092	0.039
C-Gamma (3)	U	24.7	10.0	3.4	5.0	4.6	4.6	0.32	0.36
C-Gamma (3)	M	11.4	3.8	2.0	2.9	2.2	2.2	0.13	0.15
C-Gamma (3)	L	5.0	3.9	1.4	-	1.7	1.7	0.067	-

For all soil metals studied at the Dual Highway sites, there was a strong signal in the levels of Cr, Zn and Pb, with observed concentrations higher in the medians and control versus the two bioswales (Table 22). Zn levels in the upper soil profile at the Gamma Control were high (124 - 190 mg/kg). Normally, Cr ranges from 20 to 85 mg/kg in U.S. soils, Zn from 34 to 84 mg/kg, and Pb from 17 to 26 mg/kg (McBride 1994).

There were no discernable patterns in Cu or Cd among sites or depths at the study sites. Cu ranges from 14 to 29 mg/kg in U.S. soils and Cd from 0.06 to 1.1 mg/kg worldwide (McBride 1994).

Table 22. Analyte comparison between years for means of soil Cr, Cu, Zn, Cd, and Pb (all in mg/kg). Gray shading represents a dominant trend in an analyte.

SITE – DEPTH	Cr 2014	Cr 2015	Cu 2014	Cu 2015	Zn 2014	Zn 2015	Cd 2014	Cd 2015	Pb 2014	Pb 2015
BS-Alpha – U	19.2	20.0	25.2	21.5	41.5	54.4	0.90	0.73	17.8	21.1
BS-Alpha – M	19.5	20.5	25.8	21.7	37.7	50.6	0.59	0.86	17.2	17.8
BS-Alpha – L	16.4	20.7	24.9	23.4	41.2	50.9	0.51	0.40	38.4	18.6
BS-Beta – U	17.9	15.8	20.1	20.8	30.2	37.6	0.42	0.35	12.6	13.4
BS-Beta – M	19.2	17.3	20.8	20.5	30.5	36.2	0.31	0.41	13.4	13.6
BS-Beta – L	20.3	16.4	20.6	19.1	31.3	35.0	0.39	0.65	12.8	13.3
M-Alpha – U	**48.5**	**36.8**	23.0	22.3	**87.4**	**91.3**	0.46	0.71	**81.9**	**86.3**
M-Alpha - M	**60.7**	**54.4**	24.5	22.8	**96.0**	**88.5**	0.93	1.4	**83.3**	**82.1**
M-Alpha – L	**53.0**	**53.8**	36.1	25.3	**82.1**	**75.5**	0.64	0.77	**47.9**	**54.8**
M-Beta - U	**47.0**	**42.0**	29.4	27.0	**93.8**	**101.7**	1.2	0.54	**77.0**	**94.0**
M-Beta – M	**58.6**	**51.7**	27.2	28.3	**72.7**	**91.9**	1.1	0.55	**63.1**	**73.3**
M-Beta – L	**55.5**	**40.6**	29.1	36.6	**67.8**	**88.4**	1.2	0.32	**51.4**	**39.5**
C-Gamma – U	**42.8**	**48.8**	30.9	36.0	**123.9**	**190.5**	1.3	1.2	**148.2**	**214.5**
C-Gamma – M	**53.2**	**53.3**	25.4	30.4	**78.9**	**121.3**	0.90	0.67	**105.3**	**157.0**
C-Gamma – L	**54.5**	**46.3**	26.2	21.6	**61.6**	**75.5**	0.62	0.31	**60.9**	**70.8**

5.6 Bioswale Soil Profiles and Vegetation

Alpha and Beta Bioswales – Soil profiles taken at the Alpha and Beta bioswales on 16 November 2015 exhibited little soil stratification throughout the entire 30 cm depth section. From the plant assemblage (mainly grasses) growing on the bioswale material, there were small, thin roots present that extended down about 5-10 cm. The upper 2 cm was starting to form a discrete O horizon, representing the start of organic material accumulation at the bioswale surface. In these two soil profiles, there were no visible signs of faunal pedoturbation from invertebrates throughout the entire soil profile.

The bioswale material removed from the profile was uniform, varying in color from a medium gray at the Alpha bioswale to a slightly darker gray at the Beta bioswale. The texture of the material was fine, with only a few small clumps present.

Alpha and Beta Medians – The typical soil profile present at the two medians adjoining the bioswales showed discrete layering, especially with the presence of a well-defined O horizon. However, plant roots did not extend far down into the median material at either site. In addition, the middle and lowest layers of the soil profile were basically clay-like material, presumably placed during road construction a long time ago. The soil material was compacted, making it difficult to take soil cores at the lowest level. There was little evidence of animal activity.

Gamma Control – The soil profile observed at the control was very similar to the two median sites, with discrete layering present. There was a well-defined O horizon. However, plant roots did not extend far down into the material. In addition, the lowest layer of the soil profile was basically a clay-like material, again presumably placed during road construction a long time ago. The soil material was compacted, making it difficult to take soil cores at the lowest level. There was little evidence of animal activity at the Gamma Control.

Animal Activity – We observed along the perimeters of the two bioswales very strong evidence of mammal activity. The friable nature of the bioswale material makes it easy for mice, moles, etc. to construct burrows right on the edge of the bioswale material versus in the more compacted median material.

Vegetation – Over the last two years, we have attempted to survey the plant assemblages associated with the bioswales, medians and controls (both old and new). This has been a very futile exercise as these areas are frequently mowed, and usually just before we planned to collect plants. Although some plants are easily identifiable (e.g., milkweed, vetch, dandelions, etc.), it is important to collect some of the plants in either flowering or seed production (grasses) for exact species identification. We were also interested in biomass production and plant spacing but cleaving the above ground plants by mowing would make this exercise meaningless.

5.7 Soil Analysis Conclusions

In general, infiltration capacity measurements and soil chemical analyses revealed an overall homogeneity in bioswale soils and heterogeneity in native soils in regard to depth. Some of the factors responsible for this pattern could include: 1) age and the associated differences in pollutant loading; 2) variation in runoff composition between catchments; 3) physical homogeneity of bioswale soil relative to native soils; 4) structural differences between soils; and 5) variations in vegetation cover. Variability within the native soils – particularly at the Gamma control site – may also be magnifying or masking the differences among the sites as well.

The large variation in pollutant concentration and infiltration capacities observed in the control (Gamma) site soils may be due to the topographical heterogeneity of the site. Unlike the other sites where soil slope and elevation were relatively constant, control samples were collected along the sloped, higher edges of the site (A1 and A3), and from the flat basin at the bottom of the catchment (A2). The most glaring example of this variation was observed in the TP values obtained during the May 2014 sampling where values across all depths for the A2 site were 2 – 4 times greater than those for A1 and A3. This could suggest a scenario in which infiltration is minimal along the sloped edges with most runoff pooling in the flat basin at the bottom of the catchment where infiltration and pollutant deposition is greater. Furthermore, the same is likely to be occurring at the Alpha and Beta sites where the bioswale media is located solely in the basin of the catchment. As such, samples collected from the basin of the relocated control catchment may act as a superior control for bioswale soils as they occupy the same space within a catchment and are hypothetically subjected to more similar pollutant loads.

It is also worth noting that the upper layer TP concentration obtained from the Gamma A2 site was the only native soil sample to fall within the range of concentrations observed in the

bioswale soils. While the source of this phosphorous is unknown, this overlap in TP concentration coupled with the much higher value in Gamma A2 versus A1 and A3 suggests that runoff entering these catchments likely contains significant levels of phosphorous that are being either deposited or stored in soils located near the outlet of the site. However, this was only a single sample, and even in comparison to the Gamma A2 sample, bioswale TP concentrations were higher on average. Liu et al. (2014) noted that soil P should be balanced between meeting the growth needs of plants and reducing the potential for leaching nutrients. The Virginia Department of Conservation and Recreation (2005) recommends that soil P fall within 18-40 mg/kg when determined by the Mehlich III extraction method. While the Hagerstown bioswale soils contain concentrations that are in excess of this range, it is unclear whether this is due to the parent material used in bioswale construction or elevated TP concentrations from runoff and/or precipitation. If the former is true, it is likely that the bioswales will act as a source rather than a sink.

Whether the bioswales ultimately act as a source or sink for phosphorus or nitrogen species will depend partly on the vegetation cover. Little vegetation cover was observed within the bioswales during 2014, while significant vegetation was present during 2015 sampling with the vegetation cover in the Alpha swale being dominated by grasses and clover, and vegetation in the Beta swale being more diverse with a mix of grasses, clover, thistle and larger-rooted plants. Davis et al. (2006) noted that vegetation may be capable of 90% uptake of captured N and 100% of P. We thus theorized that as vegetation cover increases, reductions of N and P could occur within the bioswales, effectively increasing their retention capacity. However, time series analyses revealed a large increase in P in the upper layer coupled with a slight to negligible decrease in the middle and lower depths suggesting very limited uptake unless pollution loading is extremely high.

Other studies have also shown that maintenance of vegetation is important as the breakdown and presence of organic matter can act as both a nutrient source (Hatt et al. 2007) and limit infiltration (Ingvertsen et al. 2011). Interestingly, soil analysis revealed a decrease in TOC concentrations in the bioswale soils and increase in the native soils despite identical maintenance treatments. The lack of differentiation with depth for the bioswale suggests the possibility for TOC to leach from these systems while native soils have a higher retention capacity, possible due to their much higher clay content. Native soils may also be saturated in regards to nitrogen

with time series analysis indicating no significant changes over the sampling period in these soils. However, like with TOC, our analysis also revealed a statistically significant decrease in TN for both Hagerstown bioswale sites which could suggest an inability of these systems to retain N. Multiple studies have noted increased N releases from bioswale systems (Davis et al. 2006, Hatt et al. 2007, etc.), largely attributing these increases to enhanced rates of oxidation leading to the formation of easily leachable nitrates and nitrites. Significant increases in vegetative cover may offer an alternative explanation for decreases in both TOC and TN through nutrient uptake however.

Overall, the two bioswales, Alpha and Beta, were different in their metal concentrations compared to the two medians and the control. These differences were in part due to the 'newness' of the material placed into the bioswales. There were differences observed at the three depths with a few significant observed interactions. Additionally, the bioswale depth profiles exhibited differing patterns from the controls with some metals. The differential response between the two bioswales may be a function of their location in the median with the Alpha bioswale having a larger drainage area than the Beta bioswale.

6.0 ONGOING AND FUTURE WORK

After consultation with SHA personnel, we have decommissioned the Beta bioswale at the Hagerstown complex as of December 2016. All instrumentation has been removed and will be relocated to the Delta bioswale in Ellicott City before the spring of 2017. Instrumentation remains at the Alpha bioswale and Gamma control for use in phase III, while additional equipment will be installed at a suitable control site in Ellicott City upon approval.

Thus far, no rain event has been sufficiently intense to produce either runoff or subsurface flow at the Hagerstown complex. Indeed, our steady-state model suggests that a rainfall intensity in excess of 4.0 in/hr (frequency occurrence greater than 25 years) may be necessary to produce runoff from even a non-bioswale site depending on preceding climatic conditions. Conversely, both subsurface drainage and surface runoff have been observed at the Delta bioswale and proposed Kappa control, respectively, as recently as 1 December 2016. Grab samples were collected from both Delta and Kappa on 29 September 2016 following heavy rainfall associated with Hurricane Matthew (Table 23); although it is impossible to draw any conclusions given a single sample and limited discharge information (e.g. time, volume, etc.).

Infiltration measurements will be repeated at least once more at both locations with the possibility of additional tests if deemed useful. While results thus far have shown minimal variation in infiltration rates for the bioswale sites over time, the large observed increase at the Gamma control sites from 2014 to 2015 has highlighted the impact of preceding climatic conditions on soil infiltration capacity. By taking several measurements over multiple days immediately after a major rain event we could track the ability of both bioswale and non-bioswale medians to absorb runoff over time. Furthermore additional measurements might improve our ability to develop a lifespan model for the bioswale systems.

Soil cores collected from the Ellicott City complex in September 2016 are in the process of being run for the standard suite of analytes. Soil coring is scheduled to be repeated in March 2017 at the Hagerstown complex and March 2018 at the Ellicott City complex. If analysis reveals any trends in pollutant accumulation, perhaps we will be able to develop a lifespan model similarly to our goal with infiltration measurements. Results from all coring analyses will be included in the future phase III report.

Table 23. Chemical analyses results of stormwater grab samples in Ellicott City on 29 September 2016. SPC = specific conductance in µS/cm, all other analytes in mg/L.

Site	SPC	TSS	Cl	Ca	SO_4	PO_4	TP	NH_3	NO_2	NO_3	TN
Delta	285	11.4	32.9	12.8	9.2	0.10	0.23	0.028	0.007	1.8	3.6
Kappa	140	2.8	10.9	11.1	2.3	0.68	0.75	0.034	0.023	0.34	1.4

7.0 Literature Cited

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APPENDIX A. Soil chemistry results for May 2014 and June 2014.

Table A1. Results (mean plus standard error – SE) for soil total phosphorus (TP - mg/kg), total organic carbon (TOC - %), total carbon (TC – %), total nitrogen (TN – %) and H^+ (µM) for May 9, 2014 field work. (BS = bioswale – Alpha or Beta, M = median, and C = Control - Gamma. U = upper soil profile, M = middle soil profile and L = lower soil profile).

SITE (N)	DEPTH	TP Mean	TP SE	TOC Mean	TOC SE	TC Mean	TC SE	TN Mean	TN SE	H^+ Mean pH
BS-Alpha (9)	U	69.8	4.88	2.7	0.121	2.4	0.06	0.097	0.0094	0.018 7.74
BS-Alpha (9)	M	57.2	3.27	2.9	0.120	2.7	0.20	0.110	0.0107	0.012 7.92
BS-Alpha (9)	L	58.7	3.19	2.8	0.148	2.6	0.10	0.102	0.0080	0.010 8.00
BS-Beta (9)	U	62.3	2.66	2.6	0.087	2.5	0.11	0.152	0.0524	0.027 7.56
BS-Beta (9)	M	51.9	1.13	2.5	0.094	2.5	0.12	0.105	0.0065	0.017 7.77
BS-Beta (9)	L	52.4	0.92	2.4	0.097	2.6	0.14	0.104	0.0065	0.015 7.82
M-Alpha (6)	U	14.5	2.41	2.7	0.246	3.3	0.25	0.215	0.0226	0.018 7.74
M-Alpha (6)	M	5.4	1.60	2.0	0.220	2.3	0.22	0.123	0.0199	0.018 7.74
M-Alpha (6)	L	3.7	0.48	1.1	0.095	1.2	0.09	0.045	0.0126	0.027 7.56
M-Beta (5)	U	19.4	3.02	3.2	0.179	3.6	0.21	0.300	0.0187	0.038 7.42
M-Beta (5)	M	7.6	1.63	1.9	0.116	1.8	0.11	0.126	0.0024	0.032 7.49
M-Beta (5)	L	3.8	0.37	1.5	0.058	1.8	0.14	0.092	0.0049	0.012 7.92
C-Gamma (3)	U	24.7	12.20	3.4	0.445	4.6	0.98	0.317	0.0491	0.024 7.62
C-Gamma (3)	M	11.4	5.38	2.0	0.593	2.2	0.73	0.130	0.0503	0.027 7.56
C-Gamma (3)	L	5.0	1.57	1.4	0.087	1.7	0.34	0.067	0.0033	0.033 7.48

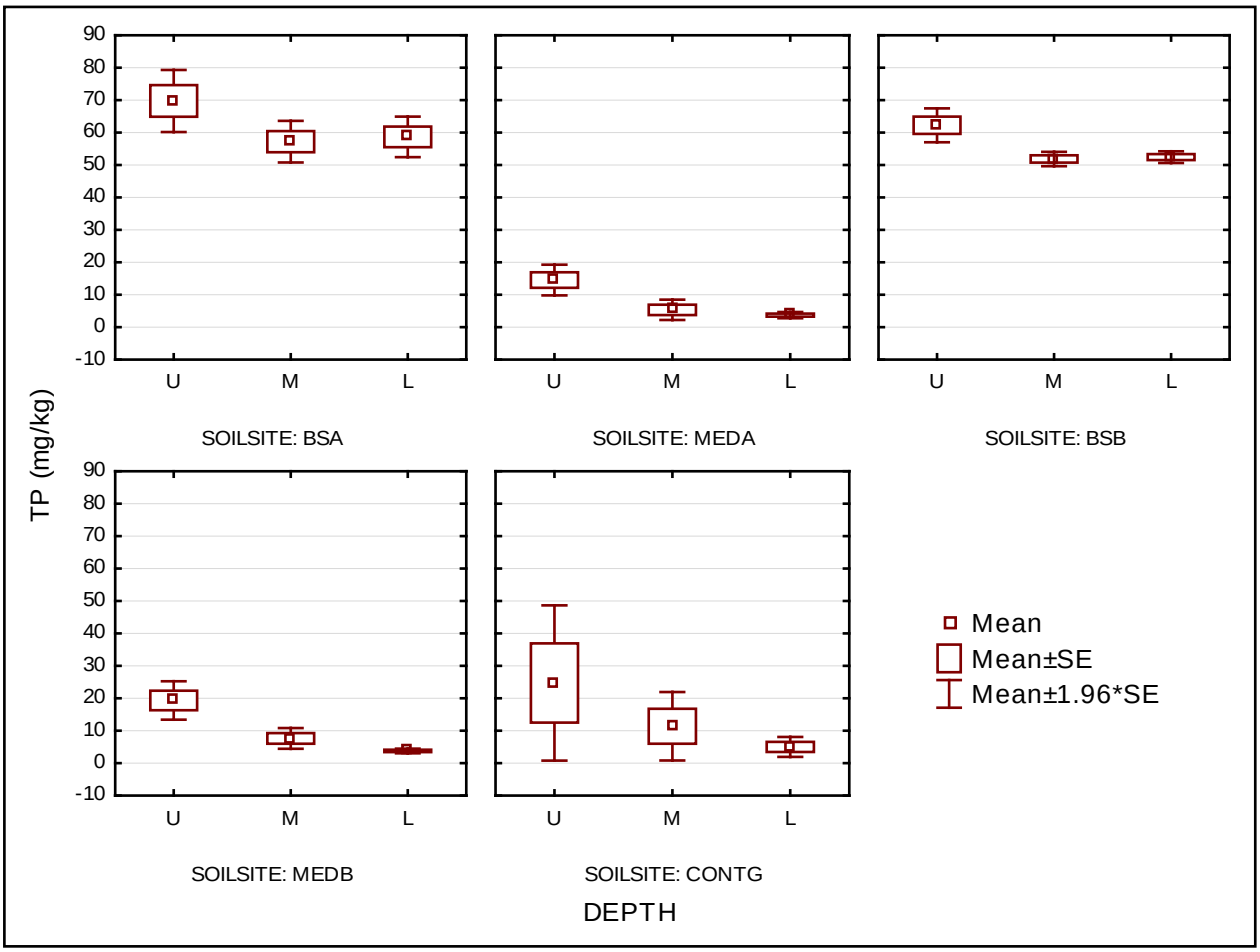

Figure A1. Mean TP (mg/kg) for bioswale sites Alpha (BSA) and Beta (BSB), median sites adjoining Alpha (MEDA) and Beta (MEDB) and the control site (CONTG) as a function of three soil depths.

Table A2. Summary of ANOVA for TP at three sites and three soil profiles (Figure A1).

	SS	df	MS	F	P
SOILSITE	56852	4	14213	211	0.000000
DEPTH	2841	2	1420	21	0.000000
SOILSITE*DEPTH	190	8	24	0.35	0.94
Error	5464	81	68		

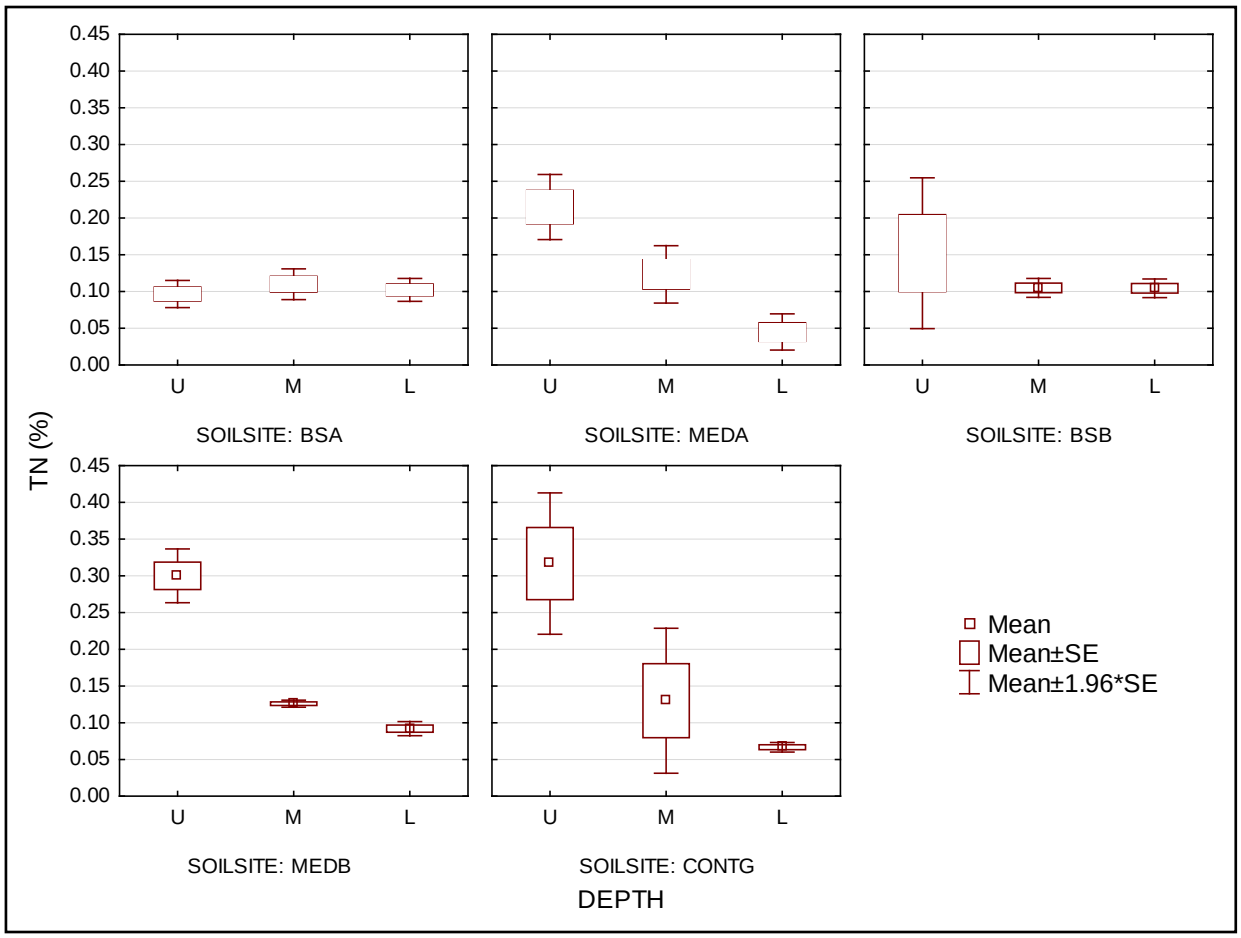

Figure A2. Mean TN (%) for bioswale sites Alpha (BSA) and Beta (BSB), median sites adjoining Alpha (MEDA) and Beta (MEDB) and the control site (CONTG) as a function of three soil depths.

Table A3. Summary of ANOVA for TN at three sites and three soil profiles (Figure A2).

	SS	df	MS	F	p
SOILSITE	0.0646	4	0.0162	4.37	0.003060
DEPTH	0.252	2	0.126	34.2	0.000000
SOILSITE*DEPTH	0.154	8	0.0193	5.22	0.000031
Error	0.288	78	0.00370		

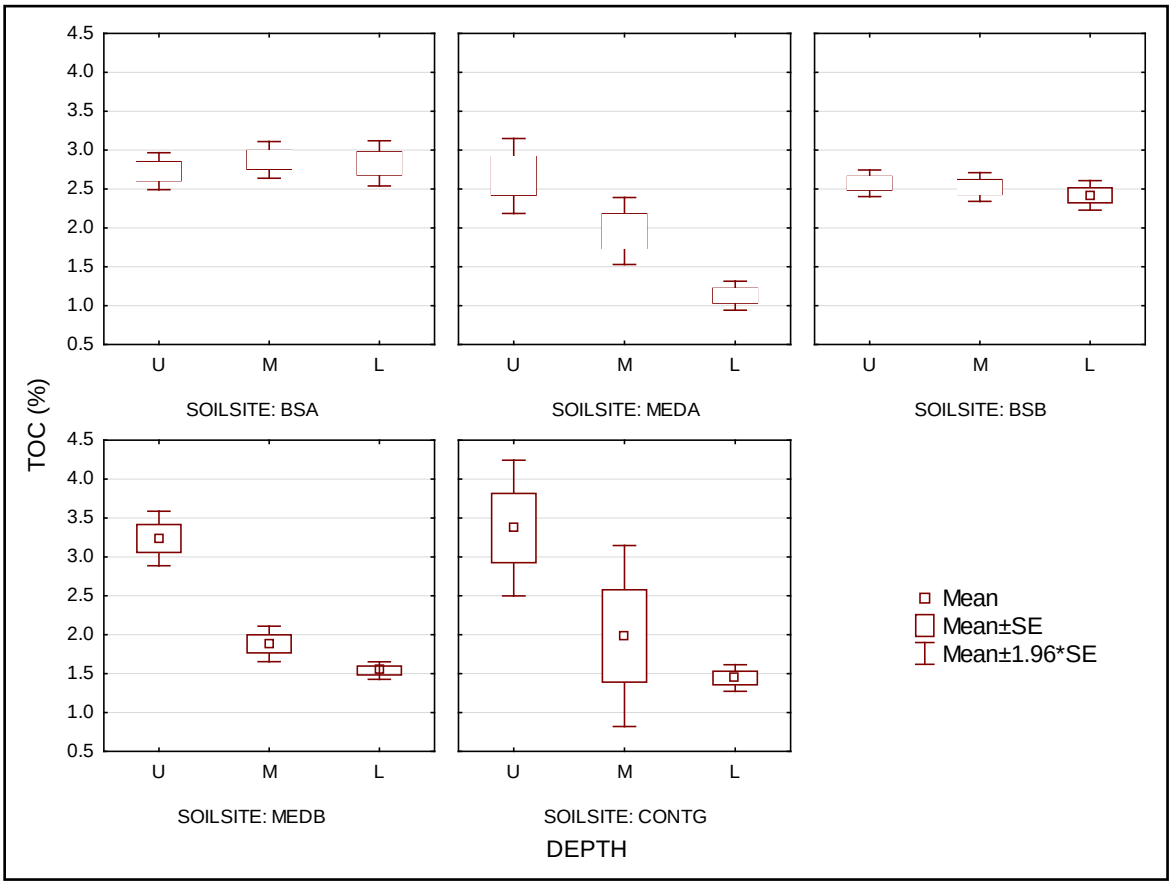

Figure A3. Mean TOC (%) for bioswale sites Alpha (BSA) and Beta (BSB), median sites adjoining Alpha (MEDA) and Beta (MEDB) and the control site (CONTG) as a function of three soil depths.

Table A4. Summary of ANOVA for TOC at three sites and three soil profiles (Figure A3).

	SS	df	MS	F	p
SOILSITE	9.7	4	2.4	14.6	0.000000
DEPTH	15.2	2	7.6	45.9	0.000000
SOILSITE*DEPTH	12.2	8	1.5	9.2	0.000000
Error	13.4	81	0.17		

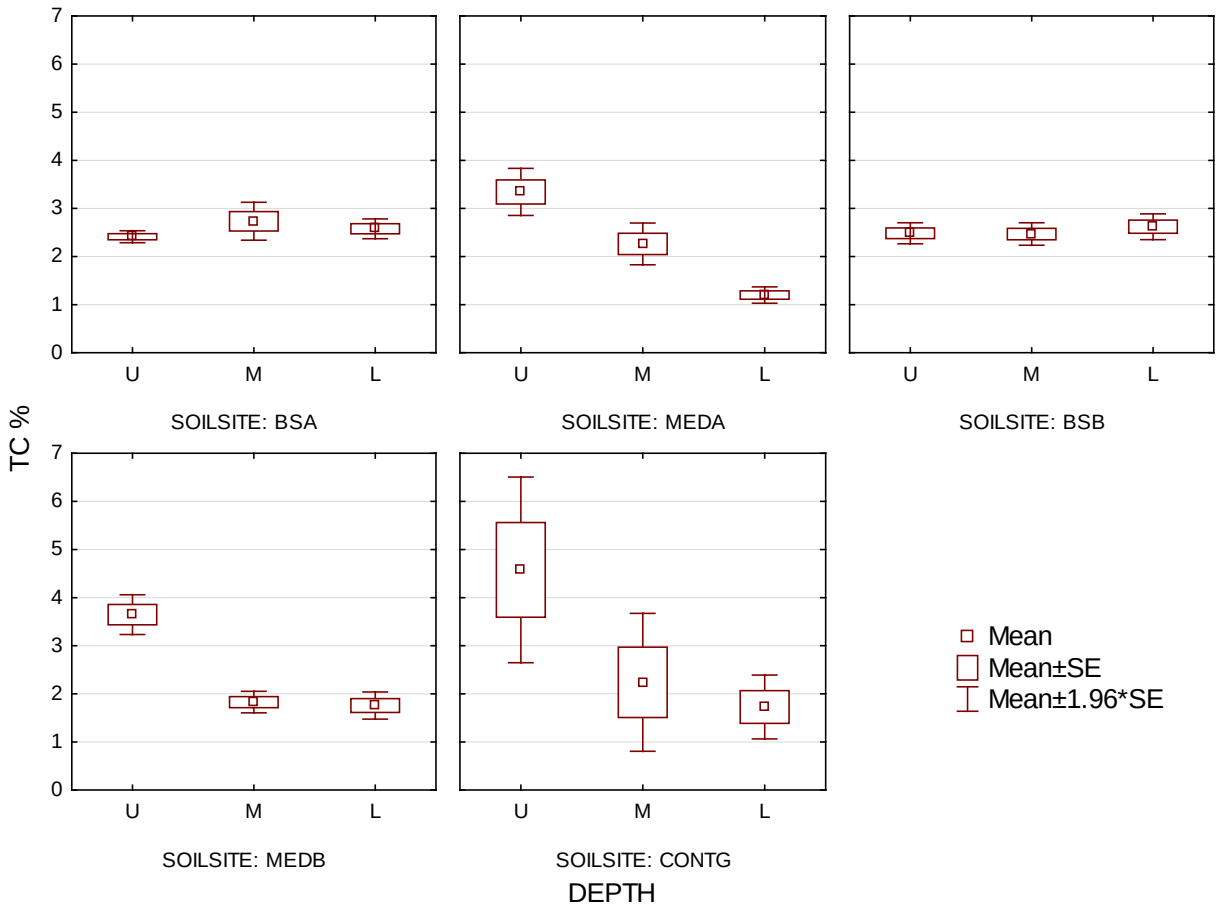

Figure A4. Mean TC (%) for bioswale sites Alpha (BSA) and Beta (BSB), median sites adjoining Alpha (MEDA) and Beta (MEDB) and the control site (CONTG) as a function of three soil depths.

Table A5. Summary of ANOVA for TC at three sites and three soil profiles (Figure A4).

	SS	df	MS	F	p
SOILSITE	2.34	4	0.58	2.14	0.084
DEPTH	25.4	2	12.7	46.5	0.000000
SOILSITE*DEPTH	26.6	8	3.3	12.2	0.000000
Error	21.8651	80	0.2733		

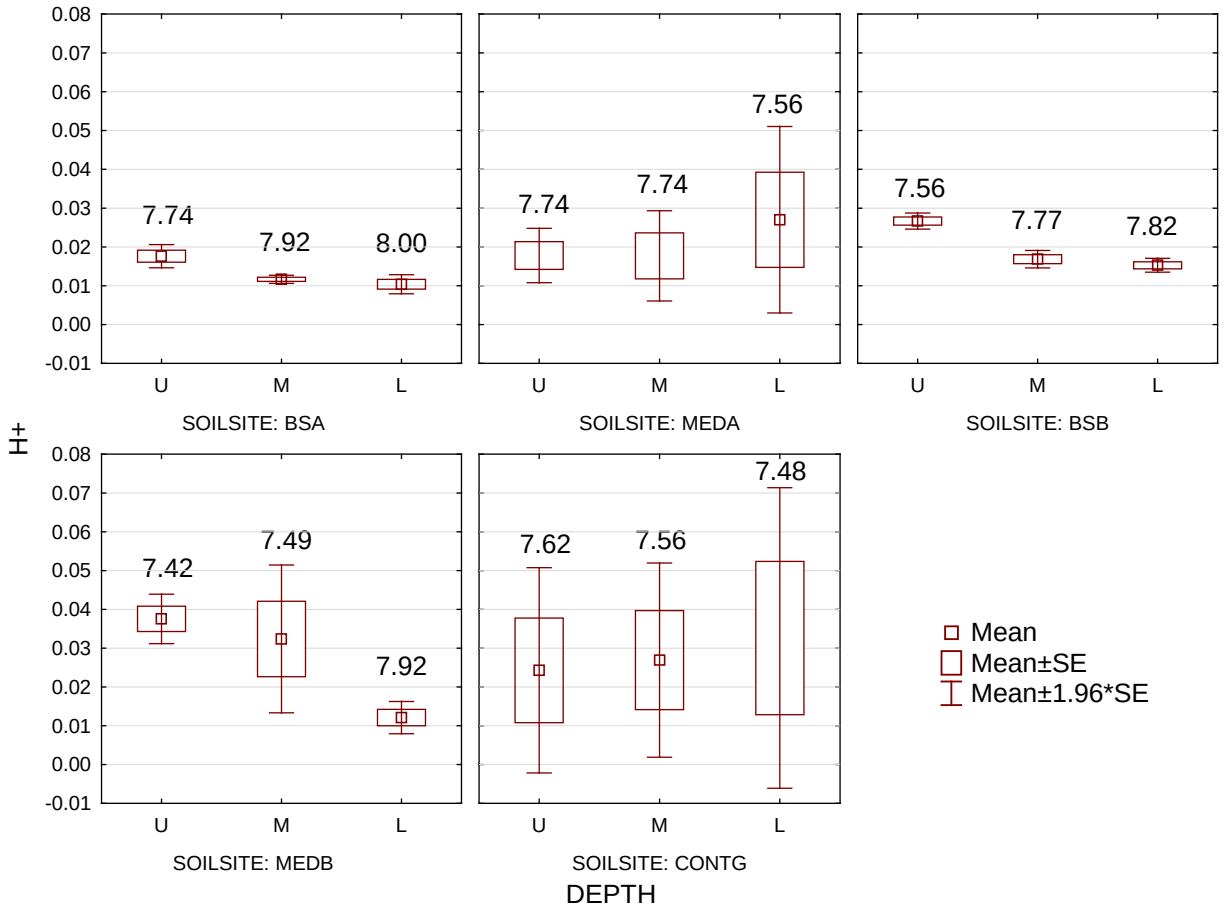

Figure A5. Mean H^+ (µM) for bioswale sites Alpha (BSA) and Beta (BSB), median sites adjoining Alpha (MEDA) and Beta (MEDB), and the control site (CONTG) as a function of three soil depth profiles. The pH value for each site-depth combination is above the box-whisker plot.

Table A6. Summary of ANOVA for H^+ (µM) at three sites and three soil profiles (Figure A5).

	SS	df	MS	F	p
SOILSITE	0.0026	4	0.00066	4.08	0.0046
DEPTH	0.00040	2	0.00020	1.24	0.30
SOILSITE*DEPTH	0.0024	8	0.00031	1.89	0.074
Error	0.013	81	0.00016		

Table A7. Results for soil total phosphorus (TP - mg/kg), total organic carbon (TOC - mg/L), total carbon (TC – mg/L), total nitrogen (TN – mg/kg), pH and H^+ (µM) for 13 June 2014 field work (Sigma set). (BS = Alpha bioswale at 25 and 35 m from collection point; M = median at 25 and 35 m from collection point, MED = median east of the bioswale and CONT = 25 m from collection point in ramp median. U = upper soil profile, M = middle soil profile and L = lower soil profile).

SOIL	DEPTH	TP	TOC	TC	TN	pH	H+
BS-25	U	79.1	2.43	2.57	0.08	7.24	0.058
BS-25	M	56.8	2.48	2.45	0.08	7.55	0.028
BS-25	L	49.4	2.46	2.63	0.08	7.80	0.016
MED-25	U	10.9	2.16	1.97	0.09	7.76	0.017
MED-25	M	7.2	1.97	1.78	0.10	7.97	0.011
MED-25	L	5.2	1.48	1.18	0.06	7.93	0.011
BS-35	U	73.8	2.47	2.66	0.09	7.66	0.022
BS-35	M	63.2	2.00	2.25	0.07	7.94	0.012
BS-35	L	58.5	2.87	2.34	0.09	8.08	0.0083
MED-35	U	7.7	2.76	2.72	0.18	7.22	0.060
MED-35	M	5.4	1.64	1.48	0.10	7.24	0.058
MED-35	L	4.4	1.20	1.40	0.07	7.45	0.036
MED	U	11.9	3.01	2.74	0.19	7.50	0.032
MED	M	4.3	1.80	1.81	0.13	7.93	0.012
MED	L	3.4	1.03	0.93	0.06	8.12	0.0076
CONT	U	6.8	2.85	3.16	0.23	7.28	0.053
CONT	M	3.6	1.81	2.03	0.08	7.80	0.016
CONT	L	2.6	1.46	1.62	0.06	7.84	0.015

Table A8. Results (mean plus standard error – SE) for soil chromium (Cr - mg/kg), copper (Cu - mg/L), zinc (Zn – mg/L), cadmium (Cd – mg/kg) and lead (Pb – mg/kg) for May 9, 2014 field work. (BS = bioswale – Alpha or Beta, M = median, and C = Control - Gamma. U = upper soil profile, M = middle soil profile and L = lower soil profile).

SITE – DEPTH (N)	Cr Mean	Cr SE	Cu Mean	Cu SE	Zn Mean	Zn SE	Cd Mean	Cd SE	Pb Mean	Pb SE
BS-Alpha - U (9)	19.2	1.3	25.2	2.3	41.5	2.6	0.90	0.19	17.8	0.97
BS-Alpha - M (9)	19.5	1.5	25.8	1.5	37.7	4.4	0.59	0.17	17.2	1.3
BS-Alpha - L (9)	16.4	1.9	24.9	1.9	41.2	3.0	0.51	0.13	38.4	22.6
BS-Beta - U (9)	17.9	0.52	20.1	0.88	30.2	2.9	0.42	0.12	12.6	4.4
BS-Beta - M (9)	19.2	0.60	20.8	0.99	30.5	1.4	0.31	0.060	13.4	0.74
BS-Beta – L (9)	20.3	0.75	20.6	0.45	31.3	1.6	0.39	0.13	12.8	1.5
M-Alpha – U (6)	48.5	6.5	23.0	2.3	87.4	11.7	0.46	0.12	81.9	13.9
M-Alpha - M (6)	60.7	5.7	24.5	2.1	96.0	14.6	0.93	0.33	83.3	10.5
M-Alpha – L (6)	53.0	4.8	36.1	2.7	82.1	2.0	0.64	0.13	47.9	4.4
M-Beta - U (5)	47.0	2.6	29.4	1.4	93.8	4.3	1.2	0.36	77.0	2.8
M-Beta – M (5)	58.6	9.1	27.2	3.4	72.7	5.9	1.1	0.57	63.1	3.1
M-Beta – L (5)	55.5	8.1	29.1	1.9	67.8	0.96	1.2	0.31	51.4	7.6
C-Gamma – U (3)	42.8	6.2	30.9	5.5	123.9	42.4	1.3	0.36	148.2	78.4
C-Gamma – M (3)	53.2	9.8	25.4	1.9	78.9	18.2	0.90	0.19	105.3	44.5
C-Gamma – L (3)	54.5	3.6	26.2	4.2	61.6	5.6	0.62	0.074	60.9	9.5

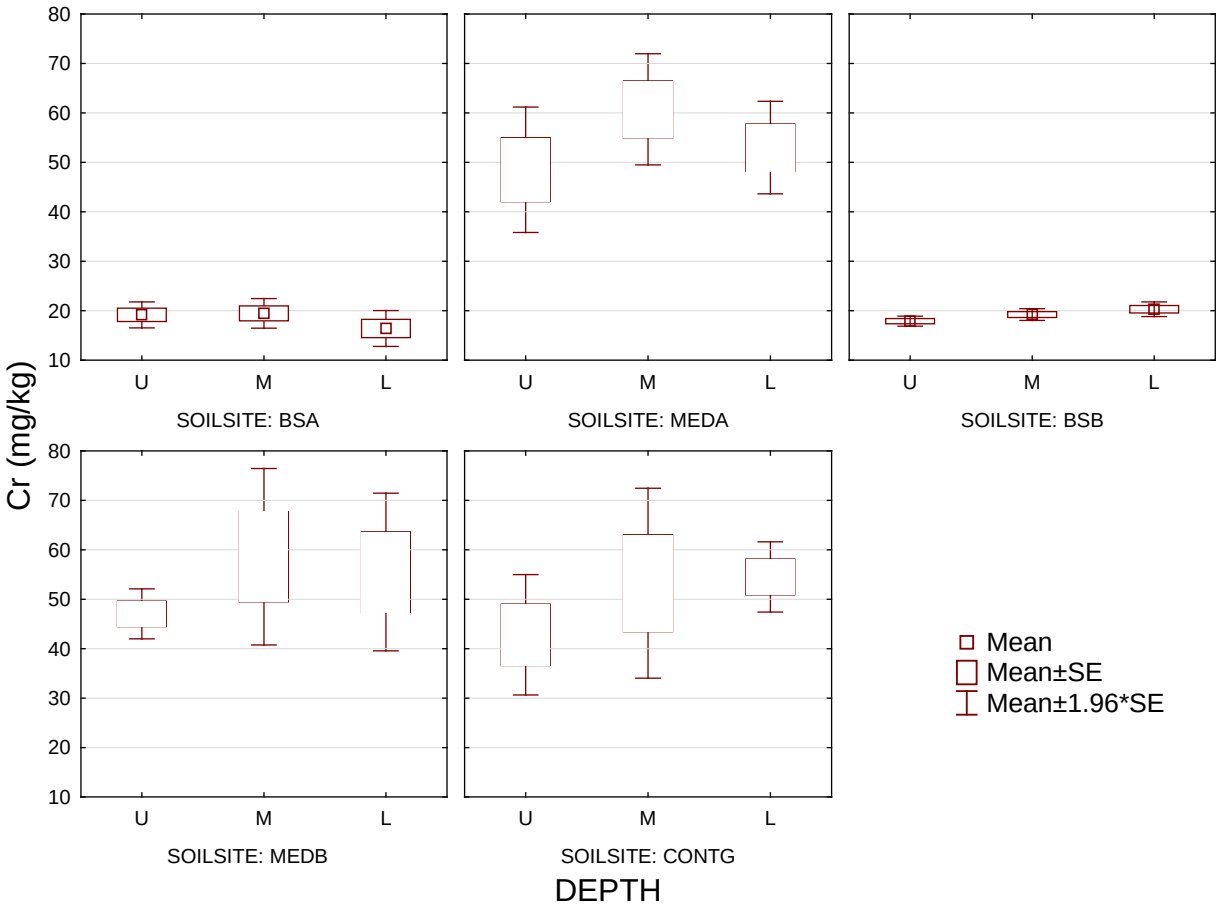

Figure A6. Mean Cr (mg/kg) for bioswale sites Alpha (BSA) and Beta (BSB), median sites adjoining Alpha (MEDA) and Beta (MEDB), and the control site (CONTG) as a function of three soil depth profiles.

Table A9. Summary of ANOVA for Cr (mg/kg) at three sites and three soil profiles (Figure A6).

EFFECT	SS	df	MS	F	p
SOILSITE	28025	4	7006	75	0.000000
DEPTH	725	2	363	3.9	0.024
SOILSITE*DEPTH	647	8	81	0.87	0.55
Error	7560	81	93		

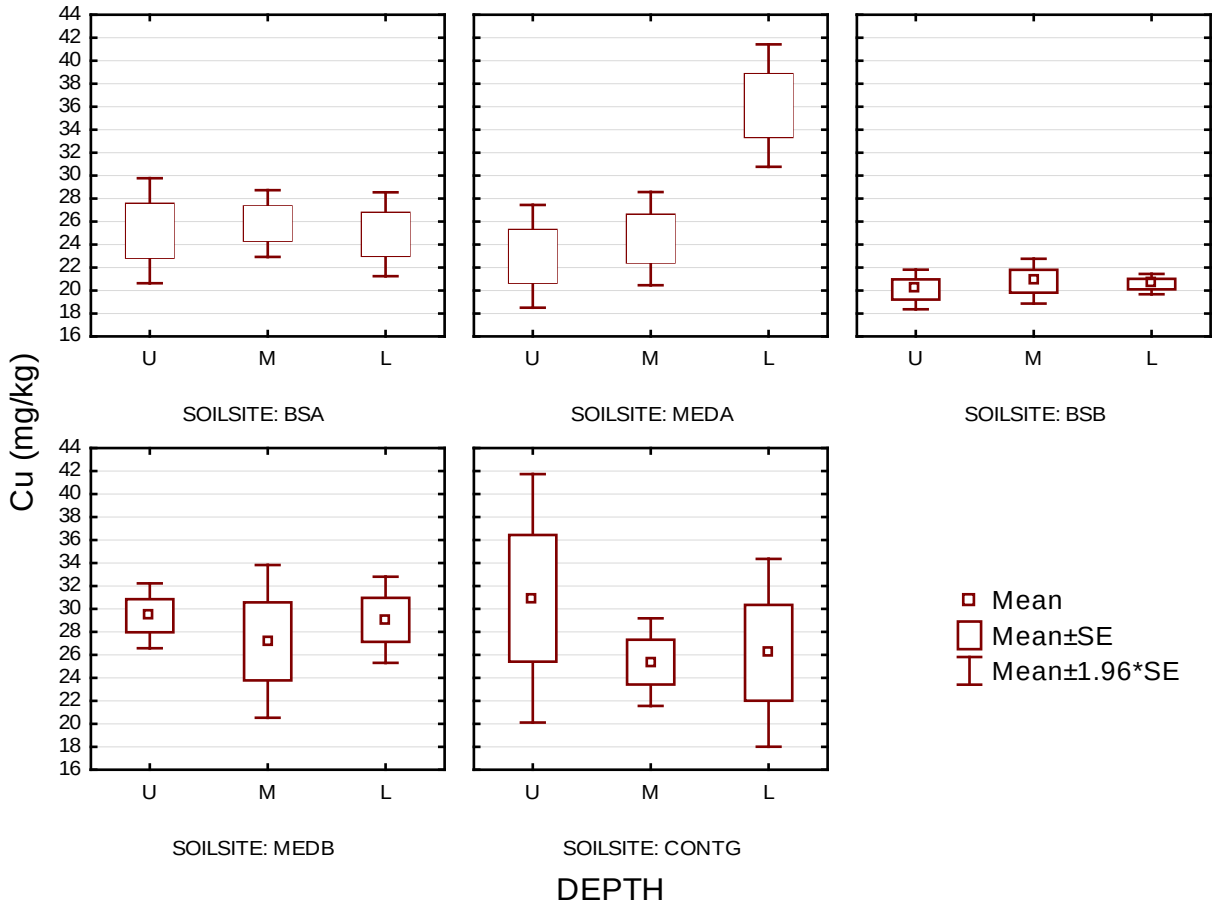

Figure A7. Mean Cu (mg/kg) for bioswale sites Alpha (BSA) and Beta (BSB), median sites adjoining Alpha (MEDA) and Beta (MEDB), and the control site (CONTG) as a function of three soil depth profiles.

Table A10. Summary of ANOVA for Cu (mg/kg) at three sites and three soil profiles (Figure A7).

EFFECT	SS	df	MS	F	p
SOILSITE	943	4	236	9.1	0.000004
DEPTH	95	2	47	1.8	0.17
SOILSITE*DEPTH	597	8	75	2.9	0.0073
Error	2104	81	26		

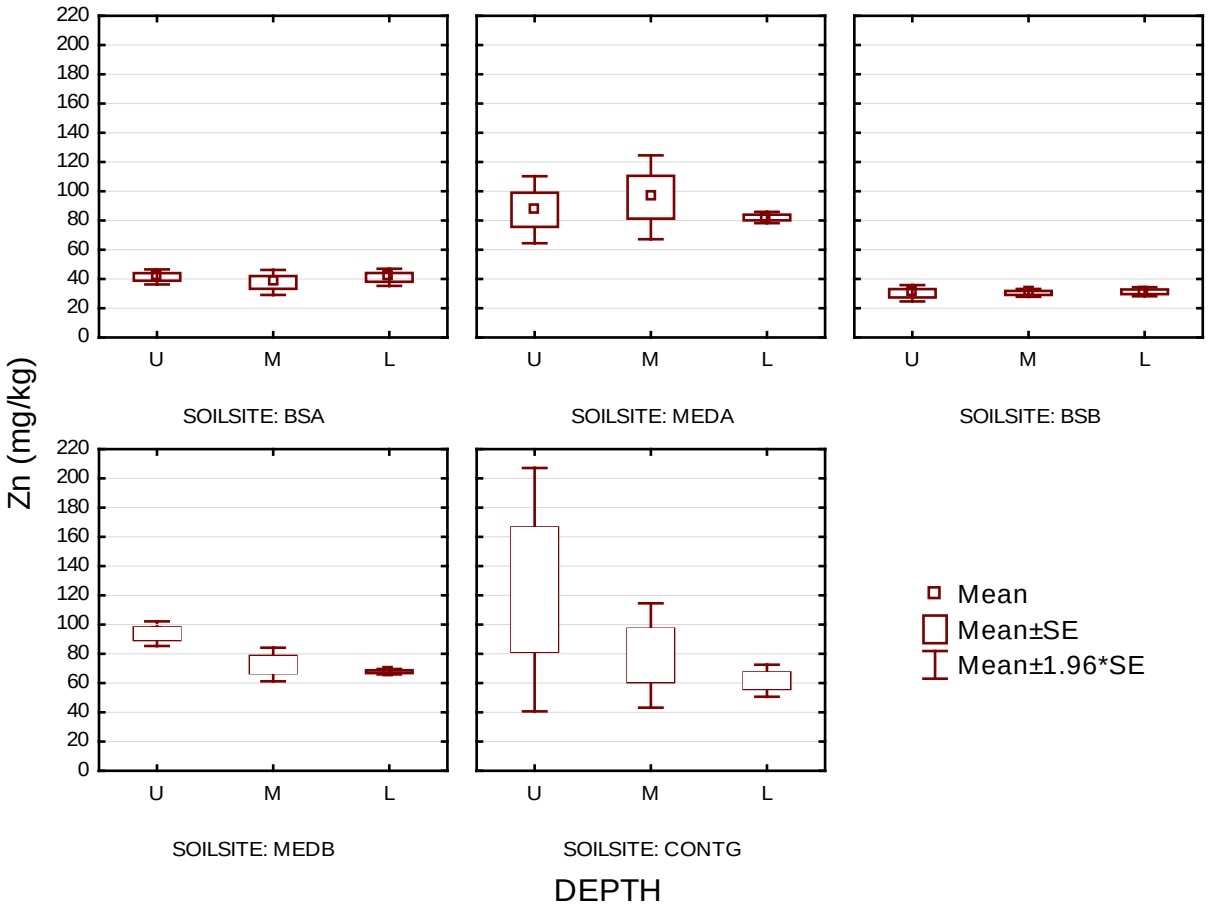

Figure A8. Mean Zn (mg/kg) for bioswale sites Alpha (BSA) and Beta (BSB), median sites adjoining Alpha (MEDA) and Beta (MEDB), and the control site (CONTG) as a function of three soil depth profiles.

Table A11. Summary of ANOVA for Zn (mg/kg) at three sites and three soil profiles (Figure A8).

EFFECT	SS	df	MS	F	p
SOILSITE	59650	4	14913	42.9758	0.000000
DEPTH	4830	2	2415	6.9595	0.001625
SOILSITE*DEPTH	6900	8	862	2.4854	0.018286
Error	281078	81	347		

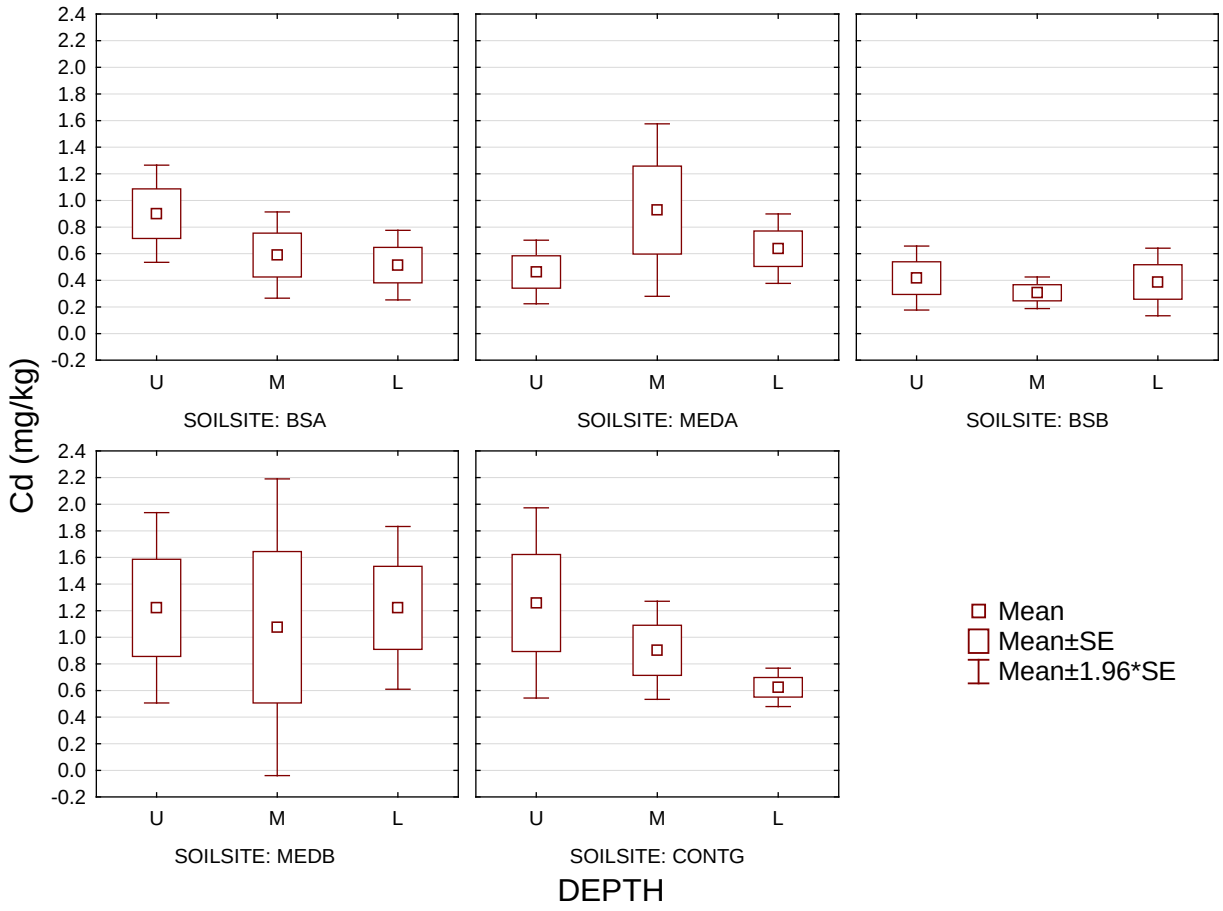

Figure A9. Mean Cd (mg/kg) for bioswale sites Alpha (BSA) and Beta (BSB), median sites adjoining Alpha (MEDA) and Beta (MEDB), and the control site (CONTG) as a function of three soil depth profiles.

Table A12. Summary of ANOVA for Cd (mg/kg) at three sites and three soil profiles (Figure A9).

EFFECT	SS	df	MS	F	p
SOILSITE	6.8	4	1.7	5.6	0.00052
DEPTH	0.42	2	0.21	0.68	0.51
SOILSITE*DEPTH	1.82	8	0.23	0.75	0.65
Error	24.7	81	0.30		

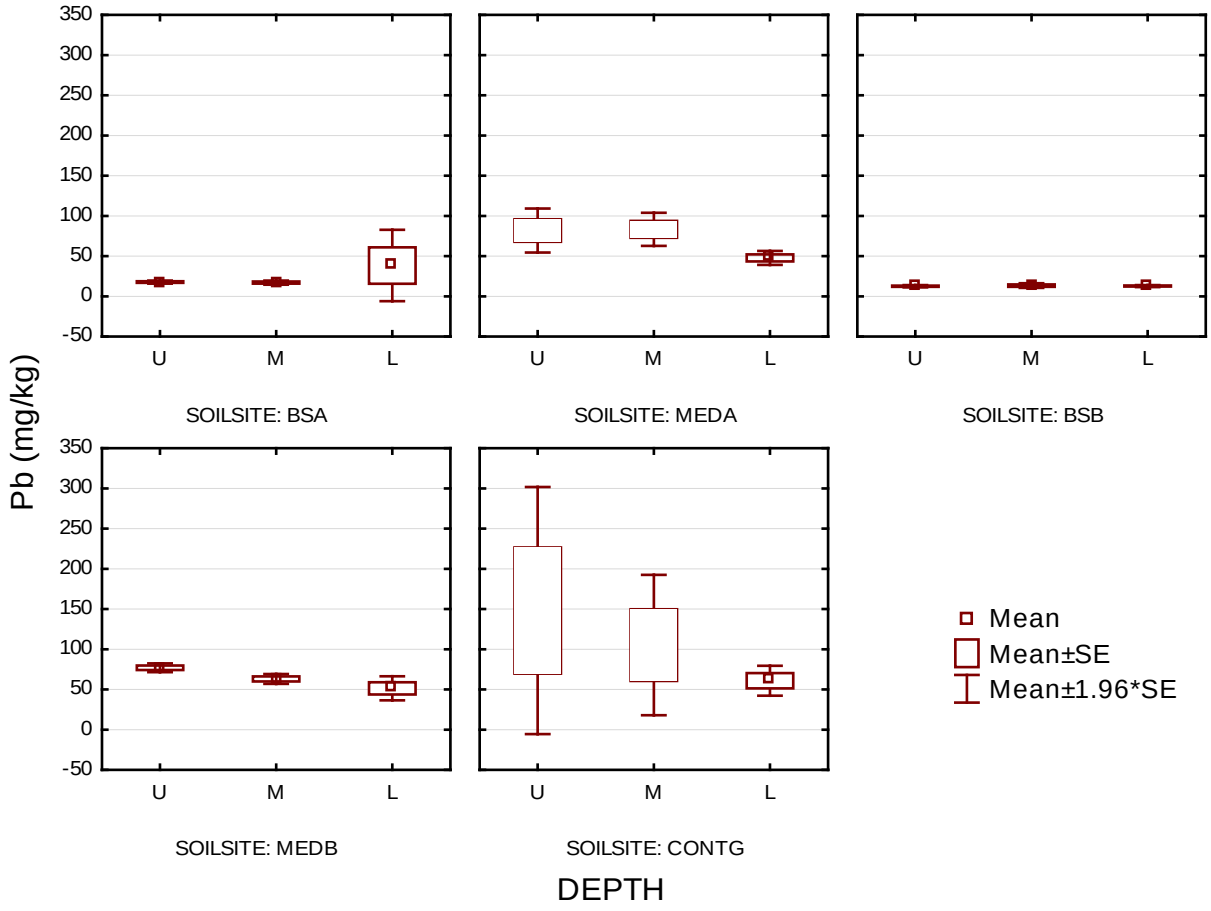

Figure A10. Mean Pb (µM) for bioswale sites Alpha (BSA) and Beta (BSB), median sites adjoining Alpha (MEDA) and Beta (MEDB), and the control site (CONTG) as a function of three soil depth profiles. The pH value for each site-depth combination is above the box-whisker plot.

Table A13. Summary of ANOVA for Pb (mg/kg) at three sites and three soil profiles (Figure A10).

EFFECT	SS	df	MS	F	p
SOILSITE	88609	4	22152	18.3	0.000000
DEPTH	8653	2	4326	3.6	0.032
SOILSITE*DEPTH	17916	8	2240	1.85	0.079
Error	97884	81	1208		

Table A14. Results for soil chromium (Cr - mg/kg), copper (Cu - mg/L), zinc (Zn – mg/L), cadmium (Cd – mg/kg) and lead (Pb – mg/kg) for 13 June 2014 field work. (BS = Alpha bioswale at 25 and 35 m from collection point; M = median at 25 and 35 m from collection point, MED = median east of the bioswale and CONT = 25 m from collection point in ramp median control. U = upper soil profile, M = middle soil profile and L = lower soil profile).

SOIL	DEPTH	Cr (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	Cd (mg/kg)	Pb (mg/kg)
BS-25	U	20.9	21.8	37.6	0.20	15.0
BS-25	M	21.1	23.6	42.3	0.21	16.7
BS-25	L	21.1	19.7	30.8	0.15	16.4
MED-25	U	43.7	18.4	55.1	0.58	59.0
MED-25	M	48.8	24.2	65.9	0.39	57.3
MED-25	L	42.4	40.6	89.0	0.70	47.7
BS-35	U	23.0	22.9	39.6	0.30	16.5
BS-35	M	20.2	22.3	37.6	0.18	16.1
BS-35	L	22.1	21.7	35.7	0.42	15.7
MED-35	U	50.4	22.1	88.9	1.6	101.6
MED-35	M	61.0	22.2	75.7	0.65	75.9
MED-35	L	54.4	33.8	77.3	0.45	44.1
MED	U	46.3	23.4	94.5	0.49	123.5
MED	M	54.0	23.2	75.3	1.5	78.1
MED	L	52.5	31.8	78.5	0.54	45.5
CONT	U	64.9	24.4	97.3	0.34	84.8
CONT	M	62.3	20.5	68.0	0.27	52.7
CONT	L	66.4	21.2	61.1	0.61	41.4

APPENDIX F
RESEARCH ACTIVITY

USE OF COMPOST TO ESTABLISH PERMANENT VEGETATION

2017 QUARTERLY PROGRESS REPORT

Form Quarterly
(Last Updated April 2015)

Maryland State Highway Administration
SPR Research Projects
Quarterly Progress Report

SHA Project Number (i.e, SP509B4X)	**Report Period**
SHAUM423	☑ Quarter 1 (January 1 - March 31) ☐ Quarter 2 (April 1 - June 30) ☐ Quarter 3 (July 1 - September 30) ☐ Quarter 4 (October 1 - December 31)

Project Title:
Use of Compost to Establish Permanent Vegetation

Project Start Date:	June 15, 2016
Original Project End Date:	November 1, 2018
Current Project End Date:	November 1, 2018
% of Work Completed to Date:	40

Project Schedule Status:

☑ On Schedule ☐ On Revised Schedule ☐ Ahead of Schedule ☐ Behind Schedule

	Name	Agency	Phone	Email
Project Manager				
Principal Investigator	Ahmet AYDILEK	UMCP	(301) 314-2692	aydilek@umd.edu
Principal Investigator	Allen DAVIS	UMCP	(301) 758-7559	apdavis@umd.edu
Researcher	Dylan OWEN	UMCP	(336) 692-2678	Owen.dylan15@gmail.com
Researcher				

Project Description

*Attach a progress schedule consisting of graphical information depicting (1) a schedule of research activities tied to **each task** defined in the proposal; (2) a percentage completion of each task.*

TASK NO.	DESCRIPTION	DELIVERABLES	% TIME	% COMPLETED
1	Installation of the Field Units	Representative site for erosion studies	5	100
2	Monitoring of the Field Units	Chemical and physical description of soil loss and surface water flow	40	28
3	Supporting Greenhouse Investigations	More specific and controlled modeling of erosion aspects involved. In depth look at elements of the erosion process and key elements involved.	40	12
4	Final Report	Model and analysis of variables involved and a final report	5	20

Project Deliverables

Important deliverables to SHA will be a comprehensive analysis of vegetation establishment, erosion implications, and surface water runoff characteristics with various slope media coverage. A final deliverable will be a set of guidelines for the SHA that describe optimal slope blanket applications for highway environments in Maryland.

Progress this Quarter (includes meetings, work plan status, significant progress, etc.)

1. Continued collection and analysis of soil capture mesh bags and stormwater sample bottles.
2. Continued photo capture of hill slopes through the growing season.
3. A single box set up has been completed and initial greenhouse testing is scheduled to begin soon.
4. Algorithm has been used to analyze photos from the fall.
5. Sieve analysis of different soil types completed.

Photo analysis for plot coverage results are presented in Appendix A for the fall season 2016. Grass height measurements Appendix B. Sieve analysis Appendix C. Photos of the completed greenhouse box setup Appendix D.

Anticipated Work for next Quarter

Continued monitoring of the sites with photo analysis, surface runoff chemical characteristics, and soil erosion capture.

Continued work on the image analysis algorithm and analysis of collected photos.

Calibrate and tune all elements involved in the greenhouse investigation and begin the greenhouse investigation.

Initial greenhouse testing will determine boundaries for the different soils and their respective losses. Boundaries are defined as vegetation growth/coverage rates without slope effects and erosion rates with a set slope, no vegetation, and an increasing rainfall intensity. This increasing rainfall will help to define an initial intensity at which the soil destabilizes.

Written proposals for the above mentioned tests will also be finalized.

Investigation into the algorithm originally designed for this project and the eCognition resource to define plot coverage will continue as well.

Significant Results

Analysis of photos through the designed algorithm have shown a rapid establishment of grass for the biosolids plot located at Hanover and the control top soil located at Upper Marlboro. Other plots in each of these locations have shown similar growth patterns to each other.

Although results are not presented here, sediment capture from cheese cloth bags has shown that the 2:1 mixes tend to have a greater mass of soil loss compared to other treatment styles.

Circumstance affecting project or budget.

N/A

Potential Implementation

N/A

Appendix A

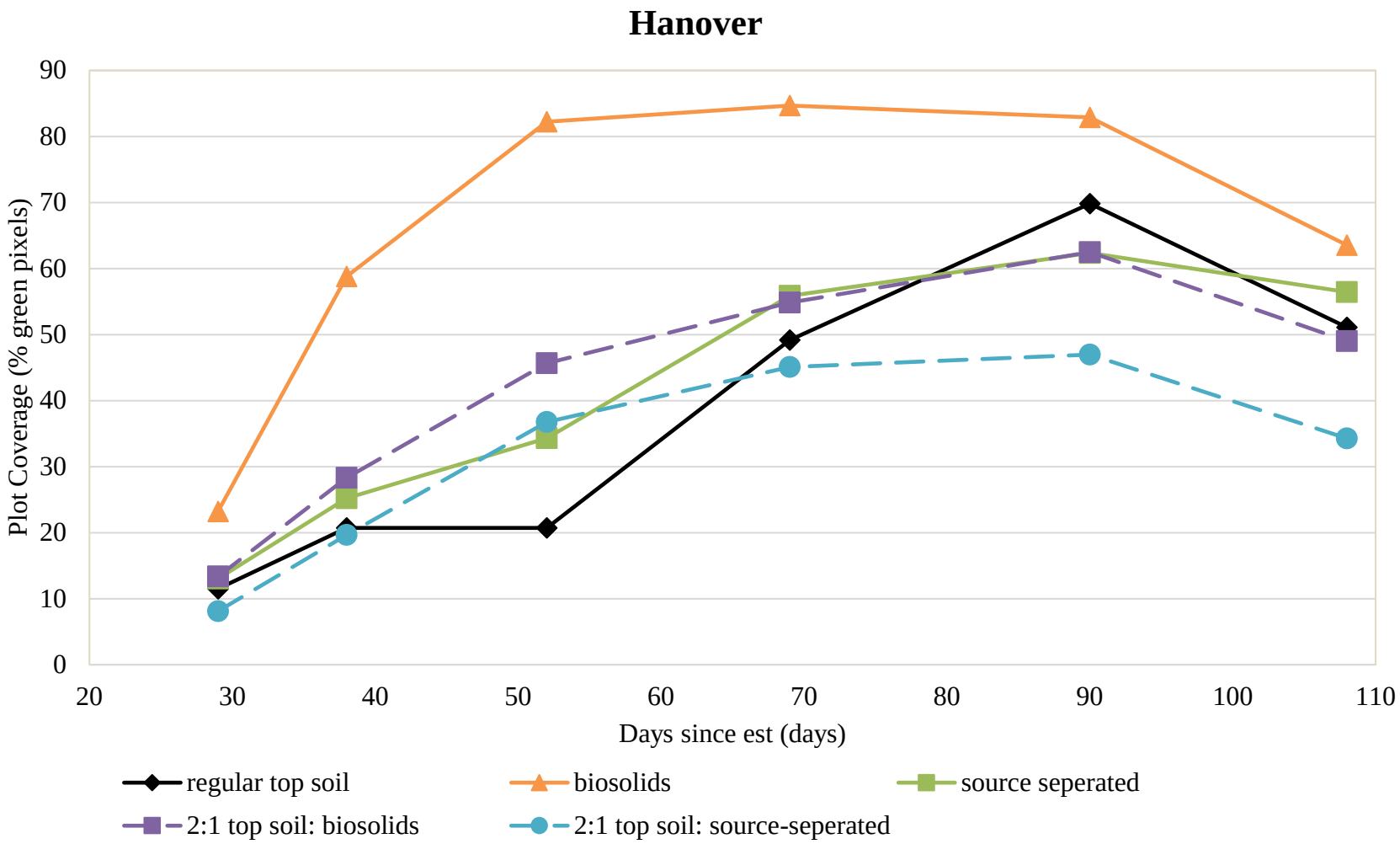

Figure 1: Initial results from photo analysis using the designed algorithm for the Hanover site. These results begin 30 days after establishment and end after the first Maryland frost. Site pictures taken 90 days after establishment were the final photos taken before the frost. Biosolid compost coverage shows a significant increase in grass establishment to other forms of coverage.

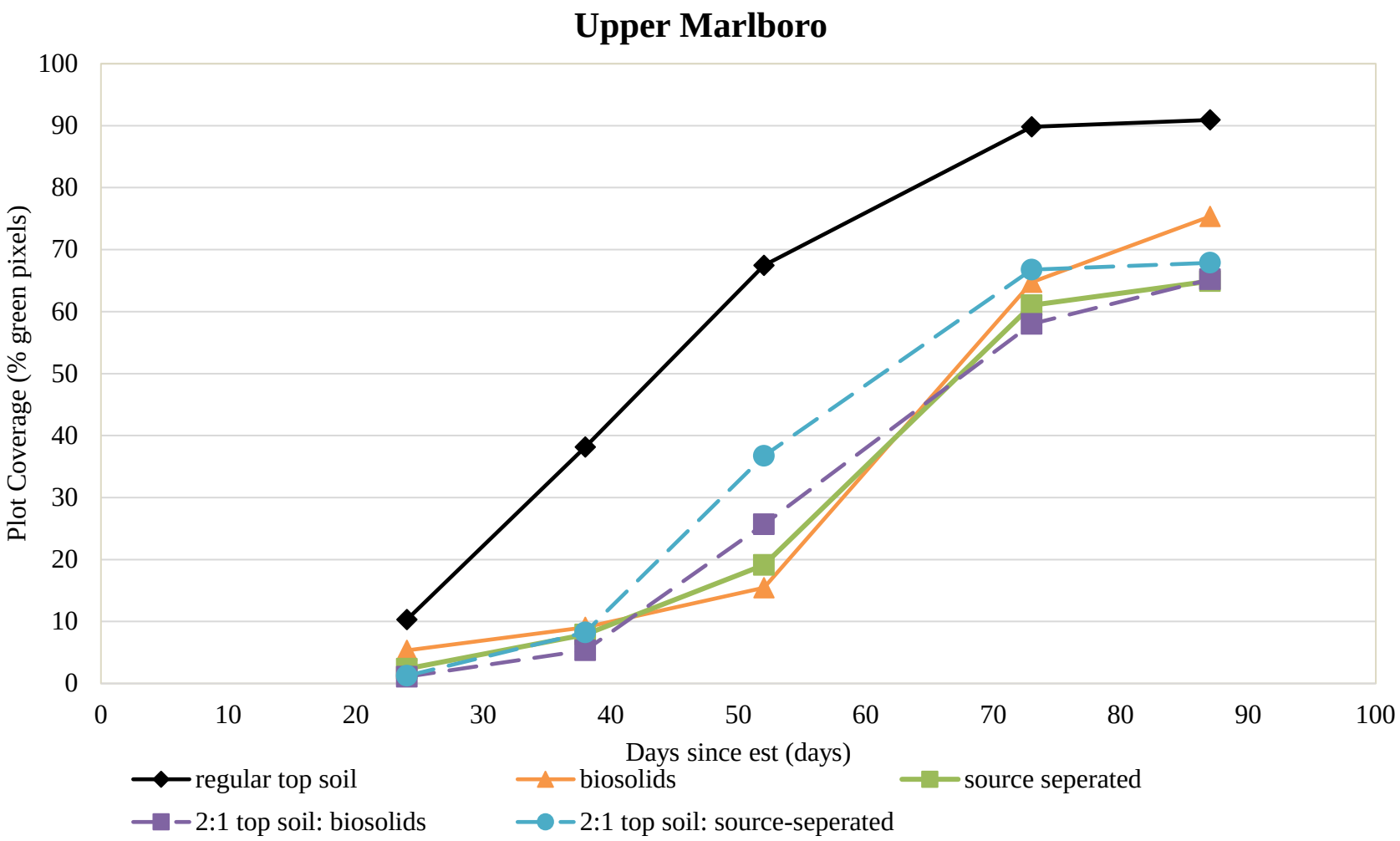

Figure 2: Initial results from photo analysis using the designed algorithm for the Upper Marlboro site. These results begin 30 days after establishment and end before the first Maryland frost.

Appendix B

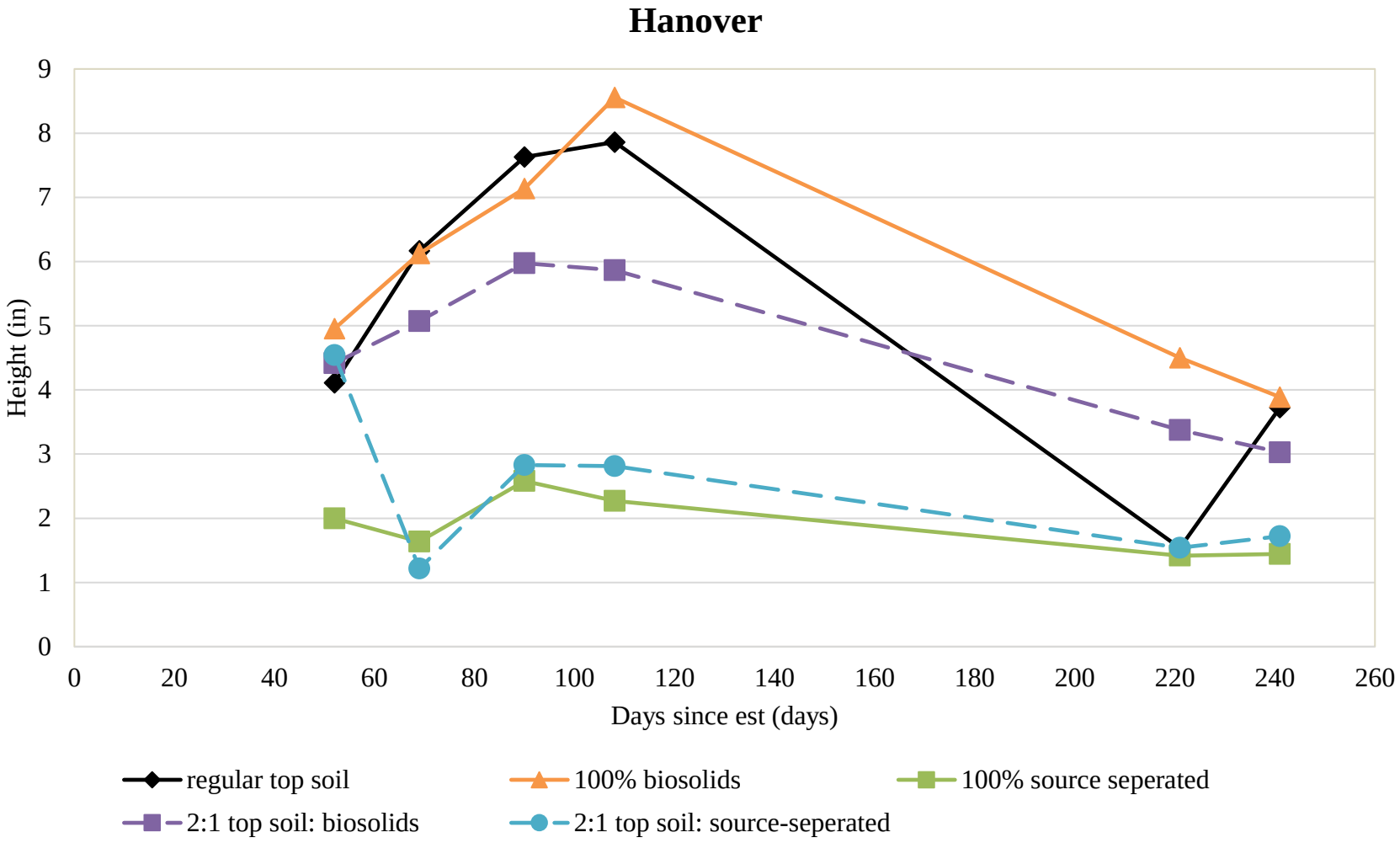

Figure 3: Physical measurements of grass heights for the Hanover site. Measurements are taken from 50 days after establishment and end after the first Maryland frost. Measurements begin again 220 days after establishment during the spring growing season.

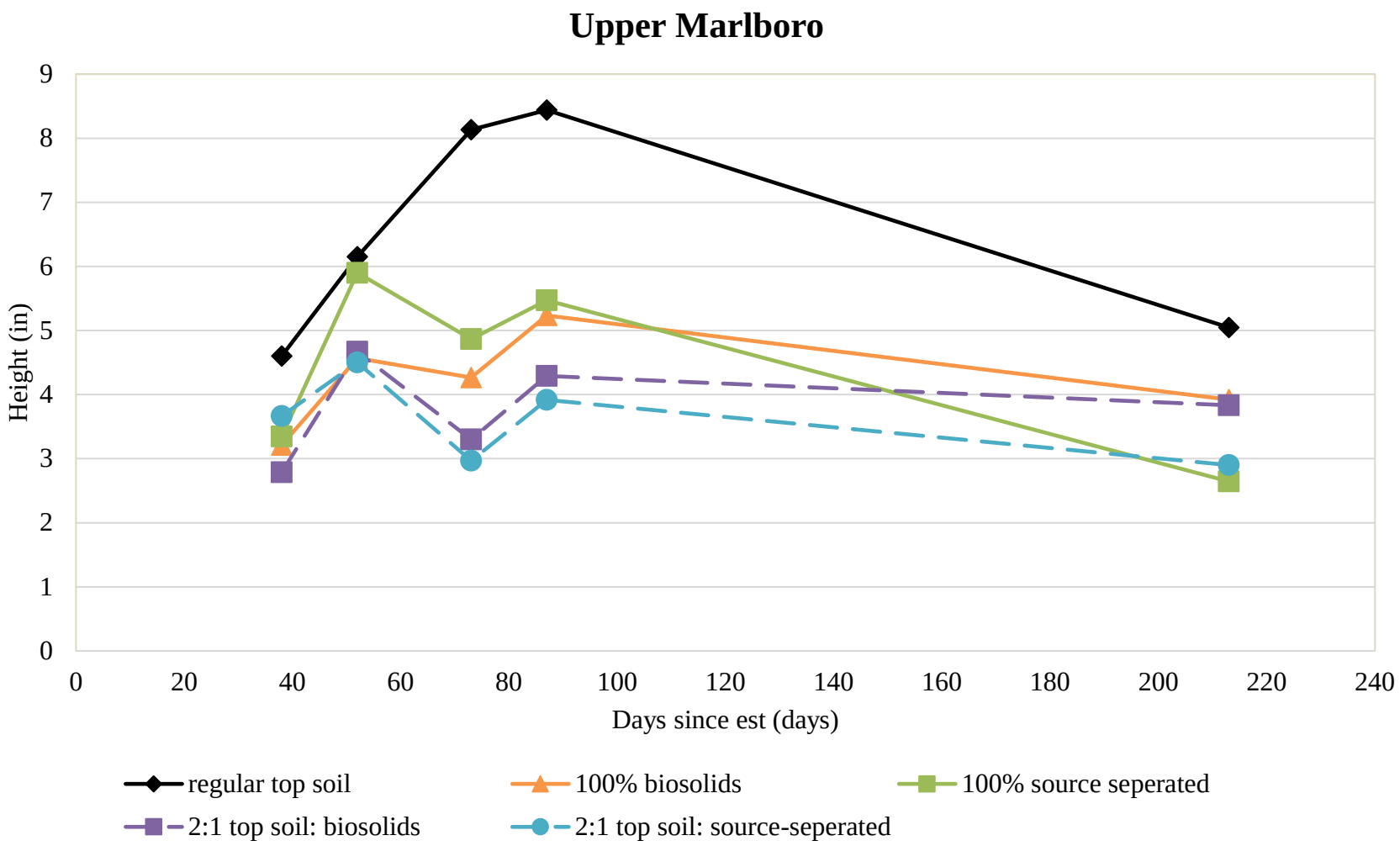

Figure 4: Physical measurements of grass heights for the Upper Marlboro site. Measurements are taken from 40 days after establishment and end before the first Maryland frost. Measurements begin again 220 days after establishment during the spring growing season.

Appendix C

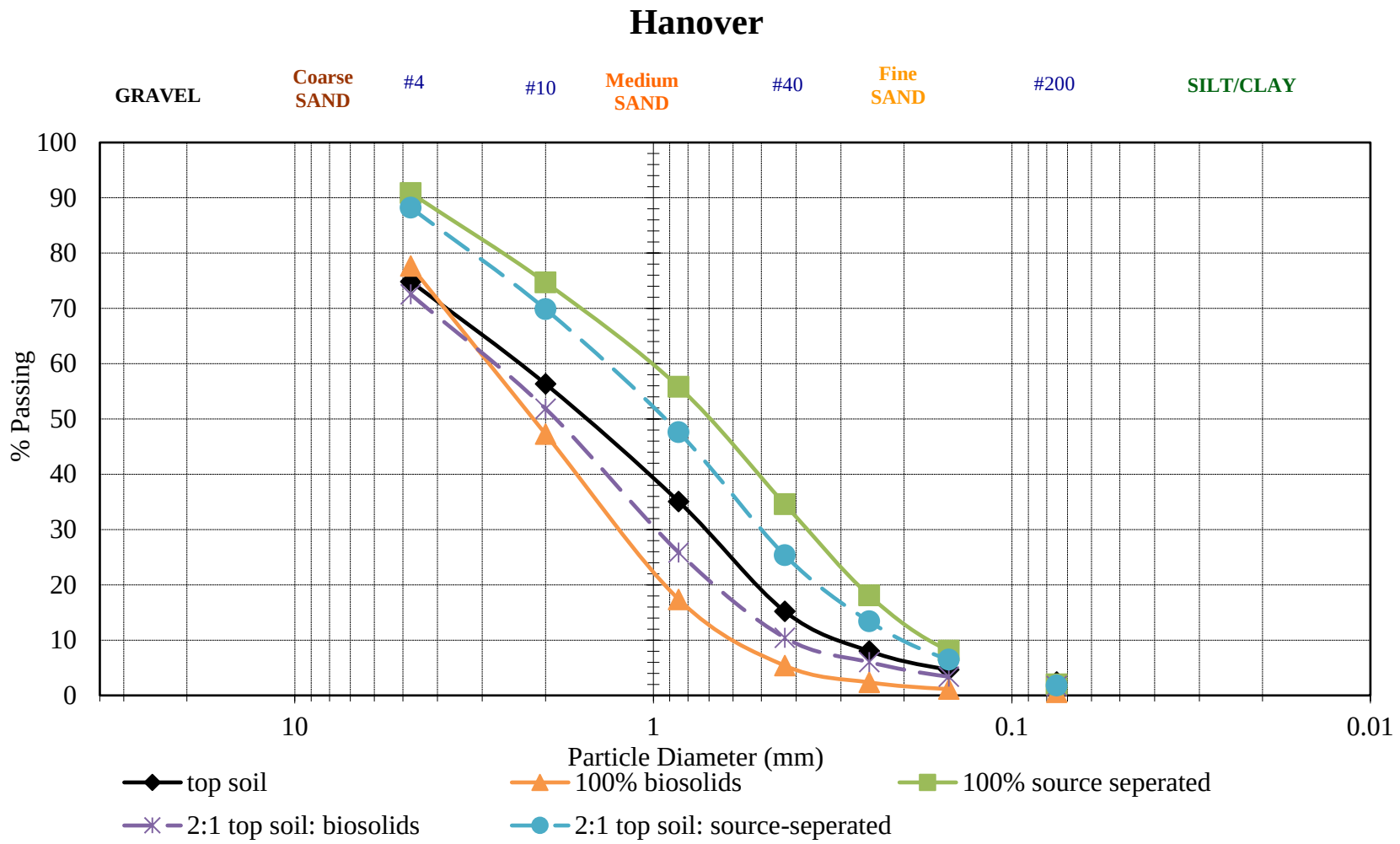

Figure 5: Sieve analysis of the soils used at the Hanover site.

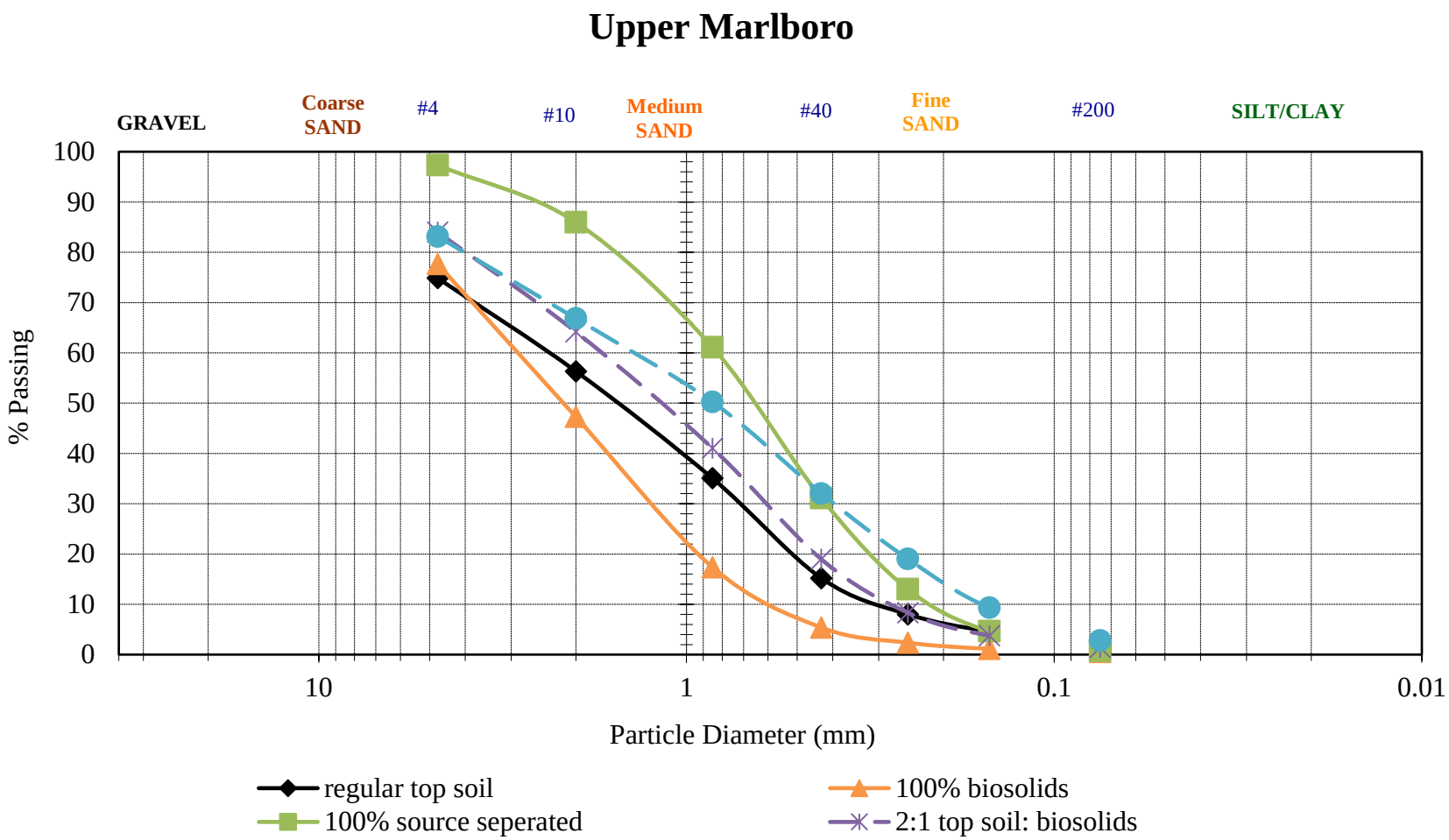

Figure 6: Sieve analysis of soils used at the Upper Marlboro site.

Appendix D

Figure 7: Greenhouse box setup. This design allows for multiple studies tested simultaneously. Located at the base of the slope is a gutter system designed to capture runoff from the slope for further analysis. There is also an opening under the gutter system to allow for infiltrated water to drain from the system. Located above this setup will be a spray nozzle to simulate rainfall, similar to the design used in Humphry et al (2002). The surface of the box is covered in a rough textured roofing mat to provide a frictional surface for the infiltration media located below the study material. The frame is designed to allow for an adjustable slope depending on the research objective. Currently the slope is set to a 1:1 ratio.

APPENDIX F
RESEARCH ACTIVITY

IDENTIFICATION OF LOW GROWING, SALT TOLERANT TURFGRASS SPECIES SUITABLE FOR USE ALONG HIGHWAY RIGHT OF WAY – EXPERIMENTAL FIELD TRIALS

2017 QUARTERLY PROGRESS REPORT

MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

MDOT SHA
SPR Research Projects
Quarterly Progress Report

MDOT SHA Task Number (i.e, SHA/UM/4-18)	**Report Period**
SHA/UMCES/7-01	☐ Quarter 1 (January 1 - March 31) ☒ Quarter 2 (April 1 - June 30) ☐ Quarter 3 (July 1 - September 30) ☐ Quarter 4 (October 1 - December 31)

Project Title:
Identification of Low Growing, Salt Tolerant Turfgrass Species Suitable for Use Along Highway Right of Way – Experimental Field Trials

Project Start Date: January 1, 2017
Original Project End Date: December 31, 2019
Current Project End Date: December 31, 2019
% of Work Completed to Date: 25

Project Schedule Status:

☒ On Schedule ☐ On Revised Schedule ☐ Ahead of Schedule ☐ Behind Schedule

	Name	Agency	Phone	Email
Project Manager	*Hua Xiang*	*Maryland State Highway Administration*	*410-545-2953*	*hxiang@sha.state.md.us*
Principal Investigator	Katharina Engelhardt	University of Maryland Center for Environmental Science	301-689-7140	kengelhardt@umces.edu
Researcher	Kristin Ratliff	University of Maryland Center for Environmental Science		kratliff@umces.edu

Project Description

*Attach a progress schedule consisting of graphical information depicting (1) a schedule of research activities tied to **each task** defined in the proposal; (2) a percentage completion of each task.*

	YEAR 1											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Task	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Task 1 - Select field sites with SHA												
First Quarterly Report	1/15											
Task 2 - Quantify roadside conditions												
Sample analysis												
Final selection of field sites												
Second Quarterly Report				4/15								
Task 3 - Establish field experiment												
Task 4 - Monitor field experiment												
Third Quarterly Report							7/15					
Fourth Quarterly Report										10/15		

	YEAR 2											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Task	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Task 4 continued: Monitoring												
Quarterly Reports	1/15			4/15			7/15			10/15		

	YEAR 3											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Task	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Task 4 continued: Monitoring												
Quarterly Reports	1/15			4/15			7/15			10/15		
Draft Final Report and Two-Page Summary									9/30			
Draft Report review and comments from SHA											11/15	
Final Presentation												
Final Report and Two-Page Summary												12/31

Task 1: 100% complete

Task 2: 85% complete

Task 3: 100% complete

Task 4: 8% complete

Project Deliverables

Please include a list of deliverables that will be provided to SHA at the end of the project (e.g. final report, software, users manual, data files, etc.)

Products:			
No.	**Stand-Alone Product Description**	**Due Date**	**Comments**
Product 1	Plot establishment	June 30, 2017	
Reports:			
Report Type	**Report Description**	**Due Date**	**Comments**
Quarterly Reports	Documentation of all work tasks and results	The 15th of January, April, July, October of 2017, 2018, and 2019	Will be submitted to the Research Division.
Draft Report and Two-Page Summary	Draft summary of work performed, findings, and conclusions.	September 30, 2019	Due 90 days prior to the project completion date.
Final Report	Detailed description of work performed, findings, and conclusions.	December 31, 2019	Will use SHA's Report Guidelines

Progress this Quarter (includes meetings, work plan status, significant progress, etc.)

The second quarter of 2017 was very busy. Field trips to scope out potential field sites ended with a visit to western Maryland on April 6. The Frostburg scale east-bound on I68 was visited first, followed by the Finzel west-bound on-ramp. The latter was chosen as the site for the western MD experimental set-up.

Sites were delineated (10 ft wide by 360 ft long) and treated with herbicide on April 18 and 20, respectively at the Easton field site; April 25 and 27, respectively at the Frederick field site; and May 15 at the Finzel field site.

Plots were constructed on May 9 at the Easton field site, May 23 at the Finzel field site, and May 24 at the Frederick field site. The soil of each 10x360ft site was excavated to 4 inches deep and soil replaced with topsoil from a local landscaping firm (Bramble Inc. for Easton, Harvest RGI for Frederick and Shaffer for Finzel). Each site was then divided into 36 10x10ft plots that were then limed (Easton, and Frederick) or fertilized (Easton and Finzel) depending on previously available soil tests for the delivered topsoil. Plots were seeded with 12 treatments of grass species or mixtures with each treatment replicated 3 times. Four cultivars each of tall fescue and hard fescue were planted in subplots as were three species of Sporobolus. After one month of growth, each site was fertilized with sulfur-coated urea.

Monitoring of plots started at approximately 3-weeks of growth and proceeded at 3-week intervals. The exact monitoring date depends on weather conditions as light conditions at the soil surface in each plot are measured with a light wand and visible and near-infrared pictures are taken for each plot, requiring stable light conditions. Point intercept data to estimate plant cover in the field and validate image analyses were also collected.

Protocols for analyzing images were developed in the second quarter and will continue to be refined. A camera was purchased and converted to take near-infrared / red images for vegetation analysis. The goal of the analyses will be to measure greenness of each plot as well as stress. Visible images will also be used to identify commonness of prominent weeds.

Anticipated Work for next Quarter

After 90 days of growth (August), monitoring frequency will slow down to every 6 weeks. Plots will need to be mowed in August. Effort will be focused especially on analyzing images and soils for stable isotopes to determine how different plant species contribute to soil organic matter through time.

Significant Results

No statistical analyses have been conducted thus far but observations seem to indicate that all sites and plots greened up well. Fescues established fastest with some tall fescues establishing faster than others. Growth of weeds within the bare plot control was substantial and did not appear to differ from growth in many of the plots sown with native plant species.

Circumstance affecting project or budget.

Describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope, and fiscal constraints set forth in the agreement, along with recommended solutions to those problems.

No challenges have been encountered and expenses are within the anticipated budget.

Potential Implementation

Appendix G

MDOT SHA 2016 Impervious Restoration and Coordinated TMDL Implementation Plan - Revised Pages

Appendix G

MDOT SHA 2016 Impervious Restoration and Coordinated TMDL Implementation Plan, Part III

Revised Pages 3-12 Through 3-16

Note:

Pages 3-12 through 3-16 within Part III, Section E of the 2016 MDOT SHA TMDL Implementation Plan have been updated to reflect changes to MDOT SHA's model, and now identify revised final dates for achieving SW-WLAs. These pages, which include Tables 3-2 and 3-3, have been revised based on the modeling approach outlined in MDE's comments dated April 26, 2017. These tables are updated to include re-calculated baseline loads, load reduction targets, and target years for achieving the reductions.

Revised pages 2-3 through 2-8 from Part II of the implementation plan were delivered to MDE on 7/31/2017.

The MDOT SHA 2016 TMDL Implementation plan with revised pages is available at the following link:

http://www.roads.maryland.gov/Index.aspx?pageid=336

MARYLAND DEPARTMENT OF TRANSPORTATION

STATE HIGHWAY ADMINISTRATION

Table 3-2: MDOT SHA Nutrient, Sediment, PCB and Trash Modeling Results

Watershed Name	Watershed Number	County	Pollutant	EPA Approval Date	WLA Type	Baseline Year	Unit	MDOT SHA Baseline	MDOT SHA % Reduction Target	MDOT SHA Reduction Target	MDOT SHA WLA	Target Year
Nutrient and Sediment TMDLs												
Antietam Creek	02140502	WA	Phosphorus	09/25/2013	Individual	2009	EOS-lbs/yr	1,307	21.4%	280	1,027	2050
			Sediment	12/18/2008	Aggregate by County	2000	EOS-lbs/yr	1,758,141	58.1%	1,021,480	736,661	2050
Bynum Run	02130704	HA	Sediment	09/30/2011	Individual	2005	EOS-lbs/yr	135,225	19.3%	26,098	109,127	2032
Cabin John Creek	02140207	MO	Sediment	09/30/2011	Individual	2005	EOS-lbs/yr	1,052,663	22.9%	241,060	811,603	2041
Catoctin Creek	02140305	FR	Phosphorus	09/24/2013	Individual	2009	EOS-lbs/yr	1,730	9.0%	156	1,575	2025
			Sediment	07/31/2009	Aggregate by County	2000	EOS-lbs/yr	1,237,170	49.1%	607,450	629,719	2025
Conococheague Creek	02140504	WA	Sediment	11/24/2008	Aggregate by County	2000	EOS-lbs/yr	1,187,462	45.3%	537,920	649,542	2050
Double Pipe Creek	02140304	FR	Phosphorus	04/26/2013	Individual	2009	EOS-lbs/yr	1,593	66.0%	1,052	542	2045
		CL										
		FR	Sediment	02/20/2009	Aggregate by County	2000	EOS-lbs/yr	983,774	46.8%	460,406	523,368	2030
		CL										
Gwynns Falls	02130905	BA	Sediment	3/10/2010; WLA revised 8/31/2015	Individual	2005	EOS-lbs/yr	1,410,346	36.4%	513,366	896,980	2045
Jones Falls	02130904	BA	Sediment	09/29/2011	Individual	2005	EOS-lbs/yr	448,519	21.7%	97,329	351,190	2043
Liberty Reservoir	02130907	BA	Phosphorus	05/07/2014	Individual	2009	EOS-lbs/yr	1,311	45.0%	590	721	2036
		CL										
		BA	Sediment		Individual	2009	EOS-lbs/yr	1,190,032	45.0%	535,514	654,518	2040
		CL										
Little Patuxent River	02131105	AA	Sediment	09/30/2011	Individual	2005	EOS-lbs/yr	1,591,900	36.1%	574,676	1,017,224	2042
		HO										

Table 3-2: MDOT SHA Nutrient, Sediment, PCB and Trash Modeling Results

Watershed Name	Watershed Number	County	Pollutant	EPA Approval Date	WLA Type	Baseline Year	Unit	MDOT SHA Baseline	MDOT SHA % Reduction Target	MDOT SHA Reduction Target	MDOT SHA WLA	Target Year
Nutrient and Sediment TMDLs Continued												
Lower Monocacy River	02140302	CL	Phosphorus	05/22/2013	Individual	2009	EOS-lbs/yr	4,781	25.0%	1,195	3,586	2040
		FR										
		MO										
		FR	Sediment	03/17/2009	Aggregate by County	2000	EOS-lbs/yr	1,770,817	60.8%	1,076,657	694,160	2040
		MO										
Patapsco LN Branch	02130906	AA	Sediment	09/30/2011	Individual	2005	EOS-lbs/yr	2,731,330	18.0%	491,639	2,239,690	2041
		BA										
		HO										
Patuxent River Upper	02131104	AA	Sediment	09/30/2011	Individual	2005	EOS-lbs/yr	377,849	11.4%	43,075	334,774	2040
		HO										
		PG										
Potomac River MO County	02140202	MO	Sediment	06/19/2012	Individual	2005	EOS-lbs/yr	933,141	36.2%	337,797	595,344	2040
Rock Creek	02140206	MO	Sediment	09/29/2011	Individual	2005	EOS-lbs/yr	1,824,727	37.9%	691,572	1,133,156	2025
			Phosphorus	09/26/2013	Individual	2009	EOS-lbs/yr	1,114	32.0%	356	758	Met
Seneca Creek	02140208	MO	Sediment	09/30/2011	Individual	2005	EOS-lbs/yr	1,449,248	44.9%	650,712	798,536	2042
Swan Creek	02130706	HA	Sediment	09/30/2016	Individual	2010	EOS-lbs/yr	60,078	13.0%	7,810	52,268	2030
Upper Monocacy River	02140303	FR	Phosphorus	05/07/2013	Individual	2009	EOS-lbs/yr	1,914	3.0%	57	1,857	Met
		CL										
		FR	Sediment	12/9/2009	Aggregate by County	2000	EOS-lbs/yr	894,222	49.0%	438,169	456,053	2034
		CL										

Table 3-2: MDOT SHA Nutrient, Sediment, PCB and Trash Modeling Results

Watershed Name	Watershed Number	County	Pollutant	EPA Approval Date	WLA Type	Baseline Year	Unit	MDOT SHA Baseline	MDOT SHA % Reduction Target	MDOT SHA Reduction Target	MDOT SHA WLA	Target Year
PCB TMDLs												
Anacostia River Tidal	02140205	PG	PCBs	10/31/2007	Aggregate by County	2005	g/yr	16.9	99.9%	16.9	0.0	2050
Back River Oligohaline Tidal	MD-BACOH	BA	PCBs	10/01/2012	Aggregate by County	2001	g/yr	19.8	53.4%	10.6	9.2	2045
Baltimore Harbor Embayment	MD-PATMH-02130903	AA BA	PCBs	10/01/2012	Aggregate by County	2004	g/yr	6.3	91.1%	5.8	0.6	2038
Bear Creek	MD-PATMH-BEAR-CREEK	BA	PCBs	10/01/2012	Aggregate by County	2004	g/yr	6.5	91.5%	6.0	0.6	2038
Bird River	02130803	BA	PCBs	10/03/2016	Aggregate by County	2010	g/yr	1.3	70.0%	0.9	0.4	2050
Bush River Oligohaline	MD-BSHOH-02130701	HA	PCBs	08/02/2016	Aggregate by County	2010	g/yr	11.3	62.0%	7.0	4.3	2050
Curtis Creek/Bay	MD-PATMH-CURTIS_BAY_CREEK	AA	PCBs	10/01/2012	Aggregate by County	2004	g/yr	33.4	93.5%	31.2	2.2	2038
Gunpowder River Oligohaline	MD-GUNOH-02130801	BA HA	PCBs	10/03/2016	Aggregate by County	2010	g/yr	0.2	0.0%	-	-	N/A
Lake Roland	MD-02130904-Lake_Roland	BA	PCBs	6/30/2014	Aggregate by County	2010	g/yr	16.2	29.3%	4.8	11.5	2025
Magothy River Mesohaline	MD-MAGM-02131001	AA	PCBs	03/16/2015	Aggregate by County	2010	g/yr	1.4	0.0%	-	-	N/A
NE Branch Anacostia River	02140205	MO PG	PCBs	09/30/2011	Aggregate by County	2005	g/yr	8.1	98.6%	8.0	0.1	2045
NW Branch Anacostia River	02140205	MO PG	PCBs	09/30/2011	Aggregate by County	2005	g/yr	7.8	98.1%	7.7	0.1	2045
Potomac River Lower Tidal	02140101	CH	PCBs	10/31/2007	Aggregate by County	2005	g/yr	0.5	5.0%	-	-	N/A
Potomac River Middle Tidal	02140102	CH PG	PCBs	10/31/2007	Aggregate by County	2005	g/yr	0.3	5.0%	-	-	N/A

Table 3-2: MDOT SHA Nutrient, Sediment, PCB and Trash Modeling Results

Watershed Name	Watershed Number	County	Pollutant	EPA Approval Date	WLA Type	Baseline Year	Unit	MDOT SHA Baseline	MDOT SHA % Reduction Target	MDOT SHA Reduction Target	MDOT SHA WLA	Target Year
PCB TMDL Continued												
Potomac River Upper Tidal	02140201	CH	PCBs	10/31/2007	Aggregate by County	2005	g/yr	1.3	5.0%	0.1	1.3	2050
		PG										
Severn River Mesohaline	MD-SEVMH-02131002	AA	PCBs	07/19/2016	Aggregate by County	2010	g/yr	9	0.0%	-	-	N/A
South River Mesohaline	MD-SOUMH-02131003	AA	PCBs	04/27/2015	Aggregate by County	2010	g/yr	2.8	0.0%	-	-	N/A
West and Rhode Rivers Mesohaline	MD-WST-RHDMH-02131004	AA	PCBs	01/08/2016	Aggregate by County	2010	g/yr	0.2	0.0%	-	-	N/A
Note: MDOT SHA does not have a PCB WLA reduction responsibility for the following watersheds presented in this table: Gunpowder River, Magothy River Mesohaline, Potomac River Lower Tidal, Potomac River Middle Tidal, Potomac River Upper Tidal-Charles County portion, Potomac River Upper Tidal-Prince George's County portion, Severn River Mesohaline, South River Mesohaline and West and Rhode Rivers Mesohaline. Table 1-1 indicates that these watersheds list MDOT SHA for PCB responsibility and the reasons there are no reduction requirements for MDOT SHA are mentioned in Section E.4.													
Trash TMDLs												
Anacostia	2140205	MO	Trash	09/21/2010	Individual	2009	Lbs/ Yr	60,585	100.0%	6,044	6,044	2045
		PG						107,692	100.0%	14,134	14,134	2045
Patapsco -Gwynns Falls	MD-PATMH-0213095	BA	Trash & Debris	01/05/2015	Individual	2011	Lbs/ Yr	83,729	100.0%	2,415	2,415	2026
Patapsco - Jones Falls	MD-PATMH-02130904	BA	Trash & Debris	01/05/2015	Individual	2011	Lbs /Yrs	47,251	100.0%	1,490	1,490	2026
Note: For the Trash WLA MDOT SHA is require to remove the existing Trash baseline load plus an individual load set by MDE, thus the WLA here is equal to the reduction target.												

Table 3-3: MDOT SHA Bacteria Modeling Results

Watershed Name	Watershed Number	County	Pollutant	EPA Approval Date	WLA Type	Baseline Year	Unit	MS4 Baseline Load	MS4 % Reduction Target	MDOT SHA Reduction Target	MDOT SHA WLA	Target Year
Baltimore Harbor-Marley Creek	MD-PATMH-MARLEY_CREEK	AA	*Enterrococci*	03/10/2011	Aggregate by County	2006	billion MPN /yr	29,507	75.80%	22,366	7,141	2050
Baltimore Harbor - Furnace Creek	MD-PATMH FURNACE_CREEK	AA	*Enterrococci*	03/10/2011	Aggregate by County	2006	billion MPN /yr	40,454	77.80%	31,473	8,981	2050
Loch Raven Reservoir	02130805	BA	*E. coli*	12/03/2009	Aggregate by County	2004	billion MPN /yr	114,408	87.60%	100,221	14,187	2048
		CL										
		HA										
Patapsco River LN Branch	02130906	AA	*E. coli*	12/03/2009	Aggregate by County	2003	billion MPN /yr	234,029	14.80%	34,636	199,393	2046
		BA										
		CL										
		HO										
Patuxent	02131104	AA	*E. coli*	08/09/2011	Aggregate by County	2009	billion MPN /yr	26,605	45.30%	12,052	14,553	2048
		PG										

Appendix H

MDOT SHA Automated Modeling Protocol – Revised (October, 2017)

MDOT SHA AUTOMATED MODELING PROTOCOL - REVISED

Developed for Chesapeake Bay and Non-Tidal Waters

TMDL Requirements for NPDES MS4 Permit Compliance

MARYLAND DEPARTMENT OF TRANSPORTATION

STATE HIGHWAY ADMINISTRATION

October 2017

TABLE OF CONTENTS

I. Introduction 2
Summary 2
Background 3
Modeling Approach 4
Calibration 4
Model Structure 5
Pollutant Reduction Planning Scenarios 5
II. Data Sources 6
Databases 6
Lookup Tables 6
III. Model Description 8
Data Export 8
GIS Data Processing 13
Bay TMDL Modeling 13
Spreadsheet Analysis 13
IV. References 15

I. INTRODUCTION

Summary

The Maryland Department of Transportation (MDOT) State Highway Administration (SHA) has updated the initial version of its Automated Modeling Tool (AMT) originally submitted to Maryland Department of the Environment (MDE) on June 30, 2016, to take into account changes in the modeling approach resulting from MDE's comments on MDOT SHA's 2016 Annual Report, along with other modifications to improve accuracy. The most significant changes are as follows:

- Revise local TMDL baseline loads, target load reductions, and progress load reductions to reflect the percent reduction method described in MDE's guidance documents.
- Improve the estimates of stormwater treatment by incorporating P_E, Runoff Depth Treated in inches, data developed from BMP research instead of using the default value of 1.0 inch and using revised ESD/Runoff Reduction (RR) and Stormwater Treatment (ST) practices removal rate curve equations.
- Improve reduction calculations for stormwater retrofits by incorporating the reduction efficiencies from existing and retrofit BMP types explicitly rather than relying on the MAST rates for retrofits.
- Add the ability to model load reductions by BMP.

The AMT makes use of current data from several production databases to estimate pollutant load reductions for various BMPs and to adhere to approved modeling parameters defined in *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated* (MDE 2014). The modeling tool will be used to produce planning scenarios and to track progress towards meeting nutrient (TN and TP) and sediment (TSS) pollutant load reductions for non-tidal waters and Chesapeake Bay (Bay) TMDLs.

MDE 2014 allows for alternative modeling methods to be employed to demonstrate permit compliance. The design and use of AMT adheres with MDE 2014 as stated below:

> *"While different models may generate different baseline pollutant loads, the reductions from implementing water quality improvement projects will be the same because they will all be based on the approved set of CBP urban BMPs and pollutant reduction efficiencies. As a result, all models will be comparable on a percent reduction basis as long as one model is consistently used throughout the permit term."*

Although this is a custom model, it draws on BMP efficiencies, loading rates and delivery factors from MDE 2014, MAST and published Chesapeake Bay Program (CBP) BMP protocols, as follows. Pollutant loads are based on CBP loading rates by land-river segment for edge of stream (EOS) for non-tidal waters and delivered (DEL) loads for the Bay. Pollutant reductions are calculated using the revised removal rate equations from the urban stormwater retrofit Expert Panel report (Schueler and Lane, 2015) for BMPs approved for water quality treatment in MDE 2014.

Background

The current MDOT SHA MS4 permit covers eleven Maryland counties that cross 84 8-digit watersheds representing larger (3rd order) rivers or streams, with 43 TMDLs written for 35 of the watersheds. This has resulted in complex load reduction modeling and tracking issues. To further complicate the modeling, these local TMDLs have been written at different times, based on monitoring data from different years. TMDLs for different pollutants in the same watershed may have a different suite of existing stormwater treatment BMPs which could also be different from the baseline BMPs used in developing the Bay TMDL.

The baseline year published on the MDE Data Center will be used for MDOT SHA's implementation planning. This usually correlates to the time period when monitoring data was collected for MDE's TMDL analysis.

When the Bay TMDL and associated watershed implementation plans were under development (2010-2012), MDOT SHA developed our WIP and milestone reports by modeling nutrient and sediment reductions using MAST. The complexity of modeling multiple counties, baselines and watersheds has resulted in the need for a significant number of exports of treatment data from our geodatabases, as well as a burdensome number of MAST scenarios. In addition, MAST does not currently account for the revised BMP treatment reductions from the Expert Panel report (Schueler and Lane, 2012 and revised in 2015) which were adopted by MDE in MDE 2014.

As described in Section II, MDOT SHA is managing restoration BMP data associated with planning, design, construction, inspection, maintenance and credit verification through spatial geodatabases and a Microsoft Access database. Depending upon where the BMP is in the project development process, different levels of data and tracking are required. Also, the level of effort over the initial eleven Phase I and II counties has resulted in extensive and complex data tracking, which is anticipated to increase with MDE's determination that five additional county jurisdictions will fall under the new Phase II permit. Developing and preparing input data for model runs was proving to be overwhelming and fraught with error. In order to reduce the effort, improve the data management process and increase accuracy, MDOT SHA developed the AMT that uses scripts within a Geographical Information System (GIS) to extract BMP treatment data from multiple sources and then apply algorithms derived from MAST and MDE guidance documents to calculate loads and load reductions.

This model has multiple benefits:

- Uses MDOT SHA production stormwater infrastructure and restoration BMP databases for the most up-to-date source of constructed, under-design and future BMPs at any given time.
- Allows flexibility to easily develop, test and adjust planning scenarios at the Bay and non-tidal watershed levels.
- Utilizes the latest MAST loading and MDE 2014 load reduction data. Revisions to these parameters can be made within the AMT easily.
- By including loads in a table by land-river segment and land use, the AMT provides the ability to assess the effects of potential 2017 changes in the Phase 6 Chesapeake Bay Watershed Model with a table modification, so that MDOT SHA can quickly determine if changes in restoration strategies or approaches would be warranted.

Modeling Approach

For both the Chesapeake Bay TMDL and local TMDLs, the modeling approach is based on MDE's guidance (MDE 2014, MDE 2014b) regarding the process for determining whether WLA requirements have been met:

> *"… it is recommended that local jurisdictions demonstrate their progress towards achieving SW-WLAs by comparing reduction percentages rather than absolute loads."*

It is understood that by using this approach the absolute loads listed in the TMDL and the loads modeled by MDOT SHA will vary, because the modeling used to develop the TMDL is different from what is currently available. Demonstrating progress by percent reduced will allow MDOT SHA to meet the TMDL based on the best and most accurate data available on land use, loading rates, and treatment, as follows.

Land Use

MDOT SHA's land use and impervious area spatial data are currently based on analysis of aerial imagery dated 2011. This is consistent with the baseline for the Bay TMDL, but it poses a challenge for modeling local TMDLs. TMDL dates published by MDE on the TMDL Data Center (MDE 2014c) range from 2000 to 2010. Accurate MDOT SHA data for land use prior to 2011 is under review by MDOT SHA; so, baseline loads are currently modeled using 2011 land use but in the future we may have the ability to model using baselines consistent with TMDL dates. Using 2011 baselines is likely to overstate the amount of land area and imperviousness compared to the TMDL analysis, which will lead to a higher restoration requirement; in other words, a conservative approach.

Loading Rates

Loading rates have been calculated at the most detailed level feasible: the land-river segments from the Chesapeake Bay model / MAST. Untreated loads and acres, per land-river segment, were derived from a No BMPs scenario in MAST at the Maryland statewide geographic scale using 2010 conditions, to correspond with MDOT SHA's as-of date for land use.

Treatment

MDOT SHA has committed significant resources to researching and updating BMP and other treatment data to the point where as-built or implementation dates are considered accurate enough for TMDL modeling and calculation of baseline treated loads for Bay and local TMDLs. Pollutant removal rates in the AMT are based on revised ESD/Runoff Reduction (RR) and Stormwater Treatment (ST) removal rate curve equations (Schueler and Lane, 2013) and Expert Panel reports (Schueler and Lane, 2015) from the Bay Program.

Calibration

Baseline load and target reductions translated to AMT modeling methodologies will allow MDOT SHA to accurately compare progress and planned load reductions to the target.

Baseline

Baseline loads have been calculated in two steps: first, to model the untreated load, and next, to apply treatment as of the baseline year for each TMDL. Untreated baseline loads were modeled by multiplying MDOT SHA pervious and impervious acres by land-river segment using MDOT SHA

spatial data with loading rates calculated as described above. Load reductions from baseline BMPs were calculated from MDOT SHA database information, then applied to the untreated load to determine the treated baseline load.

Load Reduction

In order to show that TMDL goals are being met, the reduction target and WLA for each TMDL is calculated based on MDOT SHA data. The reduction target is calculated by applying percent reduction as published in the TMDL to the calibrated treated baseline load. The modeled WLA is calculated by subtracting the calibrated reduction target from the calibrated treated baseline load.

Model Structure

The AMT consists of three elements:

- Database / Scripts: Several databases are the repository for the treatment data needed to calculate load reductions from baseline and restoration BMPs. The data are exported for further analysis. Additional information is calculated directly with scripts that make calculations from the data prior to export. One example is the use of P_E to calculate the removal rate for each BMP.
- Lookup Tables: Lookup tables are used for data that are not necessarily attributes for a BMP, but which are needed for loading calculations, and which will not change often. Loading rates per land-river segment are an example.
- Spreadsheet / Worksheets: Calculations of treatment and load reductions for each TMDL are made in a spreadsheet, with worksheets for each combination of TMDL watershed and pollutant.

Pollutant Reduction Planning Scenarios

For planning and reporting purposes, MDOT SHA needs to be able to track implementation status against the permit and TMDL goals. Status is based on progress in planning, design, and construction of structural, ESD, and alternative BMPs, including operational practices such as inlet cleaning. As described in Section II, this information is stored in databases with the project development status identified as completed, under construction or in-design for each restoration BMPs. This allows MDOT SHA to assess pollutant reduction progress in near real time and plan BMPs needed to meet the remaining reduction goal. The database queries status and built dates allowing MDOT SHA to group the amount of unit treatment based on project phase:

- Completed BMPs: Queries TMDL geospatial database using statuses that depict a functioning, built site.
- Under Construction or Design: Queries TMDL geospatial database using statuses that depict sites currently in design and construction phases.
- Future BMPs: Determined through a query that evaluates the delta between completed, under construction, or in design projects compared to estimates for planned projects derived from the non-spatial Task Management Access database, which would prevent over counting.

II. DATA SOURCES

Databases

Restoration BMPs

The core of the AMT is the databases, both spatial and tabular, which MDOT SHA uses to manage its restoration BMPs from planning through compliance reporting, as follows:

- TMDL Database: Structural and ESD restoration BMPs and alternative BMPs that are completed, under construction, or in-design are stored within a geospatial data management system. This geodatabase includes spatial locations and drainage areas for stormwater treatment. The database also contains tables with and operational information for alternative load reduction BMPs, along with regulatory information. Each BMP type has individual attributes, design criteria, inspection criteria, pollutant load reduction potential, establishment, verification and maintenance requirements that are addressed in the data management system.
- NPDES Database: New development and restoration BMPs that are structural and ESD stormwater controls are housed in a separate geodatabase that also contains structures built in association with highway projects. This is MDOT SHA's traditional NPDES MS4 geodatabase with all MDOT SHA storm sewer system assets. This database is not linked directly to the AMT. Prior to model runs, relevant restoration treatment data will be exported into the TMDL Database.
- Task Management Database: Future projects are stored within a non-spatial MS Access database. For these projects, the database includes information on the type of planned restoration, target watershed, amount of anticipated credit and target milestone year.

Lookup Tables

Several lookup tables are incorporated in the AMT to provide input parameters for model calculations, as follows:

- **LOADING RATE LOOKUP TABLE** - provides pollutant loading rates by land use.
- **BMP EFFICIENCIES AND LOAD REDUCTION LOOKUP TABLE** - provides BMP efficiencies
- **UNTREATED BASELINE LOADS LOOKUP TABLE** - used to define MDOT SHA baseline loads

LOADING RATE LOOKUP TABLE This table provides untreated loading rates (lb/ac) for each land-river segment. This is the basis for calculating baseline loads and restoration load reductions. It is calculated using MAST data as follows:

- Run a No BMPs scenario in MAST at the Maryland statewide geographic scale using "2010, revised 10/2014" Initial Conditions and "2010 Loads" Processed Water Base Data.
- Export loads from MAST scenario into Excel workbook. 2010 MAST land use acres and loads for the loading rate calculations to correspond with 2011 MDOT SHA ROW and impervious land use data.

- Export "Source Data" file from MAST documentation to obtain land-river segment data from Geographic References tab in order to identify land-river segments within a particular local TMDL 8-digit watershed.
- Create 2 pivot tables to display Sum of Acres and TN/TP/TSS EOS and DEL loads by land-river segment filtered to 1) SHA Phase I/II MS4 Impervious land use, and 2) SHA Phase I/II MS4 Pervious land use.
- Calculate loading rates per land-river segment from impervious and pervious pivot tables described above using the following equations:
    - MDOT SHA impervious loading rates = $\frac{TN/TP/TSS\ EOS\ or\ DEL\ impervious\ loads}{Impervious\ acres}$
    - MDOT SHA pervious loading rates = $\frac{TN/TP/TSS\ EOS\ or\ DEL\ pervious\ loads}{Pervious\ acres}$

The result is two lookup tables for loading rates for impervious and pervious land use in each land-river segment.

BMP EFFICIENCIES AND LOAD REDUCTION LOOKUP TABLE This table is used in conjunction with planned structural and ESD stormwater control BMP efficiencies (RR and ST) and planned alternative BMPs (e.g. stream restoration, catch basin cleaning, and street sweeping) and was created following MDE 2014a. The BMP efficiencies in the lookup table are used in conjunction with the loads developed for each 8-digit watershed to determine specific amount-removed for individual BMP types within an 8-digit watershed.

UNTREATED BASELINE LOADS LOOKUP TABLE This table is based on calculated baseline loads from the loading rate lookup table and MDOT SHA land use data.

- Intersect GIS layers for MDOT SHA ROW and impervious cover with land-river segments from MAST data to calculate the MDOT SHA area in each TMDL watershed.
- Untreated baseline loads were modeled by multiplying MDOT SHA pervious and impervious acres by land-river segment using MDOT SHA spatial data with loading rates calculated by land-river segment.
- Create a pivot table of land-river segment untreated baseline loads table showing the sum of TN/TP/TSS EOS loads by 8-digit watershed/land-river segment

For local untreated baseline loads, local TMDLs are defined at various scales including multi-8-digit watersheds, 8-digit watershed, and subwatershed (i.e., smaller than 8-digit watershed scale). Untreated baseline loads were modeled with different procedures for local TMDLs defined at the 8-digit watershed scale (including whole land-river segments) and those defined at a smaller, subwatershed scale (including partial land-river segments).

MDOT SHA baseline TN/TP/TSS EOS loads for all statewide 8-digit watersheds are included in this pivot table. Therefore, if a new nutrient or sediment TMDL at the 8-digit watershed scale comes online, MDOT SHA will have untreated baseline loads calculated at the ready. For TMDLs that area a subset of an 8-digit watershed, additional manual processing is needed.

III. MODEL DESCRIPTION

Data Export

The outcome / output of the automated modeling process is the creation of a series of data tables which are imported into Excel workbooks. The output is essentially a list of every BMP within MDOT SHA's databases and the summary of total reductions (nutrients and sediments) for each individual BMP generated on demand. The amount of pollutant removal attributed to each BMP type is calculated within the AMT based on the procedures described below.

For each BMP facility where impervious/pervious loading rates are used, pollutant reduction is calculated by determining the removal in pounds per unit. The logic uses lookup tables to multiply loading rate by BMP efficiency and area of treatment:

Step 1: Calculate Load Removed for Each BMP and Land Use:

1A. Look up specific land use (impervious/pervious) loading rates for TN EOS/DEL, TP EOS/DEL, and TSS EOS/DEL from LOADING RATE LOOKUP TABLE

1B. Derive or look up BMP efficiency rates for each BMP based on each individual BMP type. Detailed for each BMP type in the following sections

1C. Multiply loading rates by BMP efficiency rates to find removal in lb/unit of each BMP within the specific county or-watershed

Step 2: Calculate Pollutant Pounds Removed by Each BMP

2A. Multiply removal lb/unit calculated in 1C by the BMP impervious/pervious area treated

For load reduction BMPs such as streams, outfall stabilizations, inlet cleaning, and street sweeping, the model uses project specific data when available, and rates provided by MDE 2014 for planning level data.

Step 3: Extract Data for Filtering Results

3A. Extract Built Date, Status, County, and other MDOT SHA operational fields

The data tables describing BMP pollutant removal are used in subsequent spreadsheet analysis (described below) to aggregate reductions by TMDL watershed, by baseline / restoration classification, or other parameters to assist MDOT SHA staff in planning and tracking progress. Treatment Calculation Details

New Stormwater Efficiency BMPs

Load reductions are modeled per facility using RR/ST curves (see tables below) and facility P_E. P_E is captured from design plans, and ultimately, as-builts for new restoration projects, and assumed 1.0 inch for programmed facilities where the information is unknown. This component of the modeling is an enhancement from the original AMT where a P_E assumption of 1.0 inch was used for all facilities.

RR and ST Removal Rate Curve Equations (Schueler and Lane, 2013):

TP	RR	$y = 0.0304x^5 - 0.2619x^4 + 0.9161x^3 - 1.6837x^2 + 1.7072x - 0.0091$
	ST	$y = 0.0239x^5 - 0.2058x^4 + 0.7198x^3 - 1.3229x^2 + 1.3414x - 0.0072$
TN	RR	$y = 0.0308x^5 - 0.2562x^4 + 0.8634x^3 - 1.5285x^2 + 1.501x - 0.013$
	ST	$y = 0.0152x^5 - 0.131x^4 + 0.4581x^3 - 0.8418x^2 + 0.8536x - 0.0046$
TSS	RR	$y = 0.0326x^5 - 0.2806x^4 + 0.9816x^3 - 1.8039x^2 + 1.8292x - 0.0098$
	ST	$y = 0.0304x^5 - 0.2619x^4 + 0.9161x^3 - 1.6837x^2 + 1.7072x - 0.0091$

Removal rates for a P_E of 1.0 inch using these curve equations are slightly higher than removal rates for a P_E of 1.0 inch using the curves presented in MDE 2014 because the curve equations presented above were revised by Schueler and Lane (2015). Alternatively, above 1.0 inch treatment removal rates are slightly lower than removal rates presented in MDE 2014. The curves presented in MDE's Guidance are from the original publication by Schueler and Lane in 2012 defining removal rates for New SW BMPs.

All the examples shown below have been made with the assumption that the built date is after the TMDL date so that they all represent reductions that can be applied to restoration credit.

Example 1

A bioswale and sand filter each treating 0.5 acres of impervious area and 0.8 acres of pervious area in the Anne Arundel County portion of the Little Patuxent River watershed. The facilities fall within the land-river segment: A24003XU2_4270_4650 and have a P_E value of 1.5. The Little Patuxent watershed has a TMDL for sediment with a baseline year of 2005. Using the steps outlined above, the sediment load removed for each land use and BMP is derived, as follows:

1A. Loading rate lookup value is queried by land-river segment for SHA MS4 Phase I/II Impervious and SHA MS4 Phase I/II Pervious.

Loading Rates for Example 1, Step 1A		
Land-River Segment	**MAST Land Use**	**TSS-EOS lb/ac**
A24003XU2_4270_4650	SHA Phase I/II MS4 Impervious	495.3
A24003XU2_4270_4650	SHA Phase I/II MS4 Pervious	75.9

1B. BMP efficiency value is derived for each BMP type using the revised curves from Schueler and Lane (2015). In this case the efficiencies for sediment removal are used with 1.5 inch treatment over the impervious area:

BMP Efficiencies for Example 1, Step 1B		
BMP Type	**BMP Category**	**TSS Removal**
Bioswale	RR	82%
Sand Filter	ST	76%

1C. Multiply loading rates by BMP efficiencies to obtain reduction by lb/unit:

Results for Example 1, Step 1C					
BMP Type	Land use	TSS EOS lb/unit	TSS Removal Efficiency	Calculation	TSS Reduction (lb/unit)
Bioswale	Impervious	495.3	82%	495.3 * 82%	406.1
	Pervious	75.9	82%	75.9 * 82%	62.2
Sand Filter	Impervious	495.3	76%	495.3 * 76%	376.4
	Pervious	75.9	76%	75.9 * 76%	57.7

2. Multiply reduction by lb/unit by units treated by BMP. In this case the units treated are acres of impervious and pervious.

Results for Example 1, Step 2					
BMP Type	Land use	TSS Reduction (lb/unit)	Unit Treated (Acres)	Calculation	TSS Reduction (lb)
Bioswale	Impervious	406.1	0.5	406.1*0.5	203.1
	Pervious	62.2	0.8	62.2*0.8	49.8
Sand Filter	Impervious	376.4	0.5	376.4*0.5	188.2
	Pervious	57.7	0.8	57.7*0.8	46.2
				Total	**487.3**

For these two facilities, 487.3 pounds of sediment are removed annually, counting as progress towards the local sediment TMDL for Little Patuxent watershed.

DEL loads are calculated in the same manner, but with the appropriate loading rates to track progress towards the Chesapeake Bay TMDL.

Stormwater Retrofits:

Stormwater retrofit BMPs use the same modeling process applied to new efficiency BMPs, but before and after specifications are used to determine the net number of pounds reduced by a facility for each nutrient. The previous conditions are subtracted from the proposed conditions to provide the delta of nutrient reduction provided by the facility. If the facility was providing some water quality prior to being retrofit, its prior treatment will also be counted towards the baseline.

Tree Plantings and Impervious Removal:

For tree plantings and impervious surface removal, BMP efficiencies are derived from table '3.E. Alternative Urban BMPs' from MDE's Guidance 2014. The pervious loading rate for the land-river segment is used alongside the efficiency to calculate the amount of nutrient reduced by the facility.

Example 2

A tree planting project has an area of 1.65 acres in the Catoctin Creek watershed in Frederick County. The Catoctin Creek watershed has a TMDL for sediment with a baseline year of 2000 and a TMDL for phosphorus with a baseline year of 2009. Using the steps outlined above, the sediment load removed for the BMP is derived:

1A. Loading rate lookup value is queried by land-river segment for SHA MS4 Phase I/II Pervious.

Loading Rates for Example 1, Step 1A		
Land-River Segment	MAST Land Use	TSS-EOS lb/ac
B24021PM1_4000_4290	SHA Phase I/II MS4 Pervious	339.63

1B. BMP efficiency lookup value is queried for each BMP type. In this case the efficiencies for sediment removal are used for Reforestation on Pervious Urban:

BMP Efficiencies for Example 1, Step 1B		
BMP Type	BMP Category	TSS Removal
FPU	Alternative	57%

1C. Multiply loading rates by BMP efficiencies to obtain reduction by lb/unit:

Results for Example 1, Step 1C					
BMP Type	Land use	TSS EOS lb/unit	TSS Removal Efficiency	Calculation	TSS Reduction (lb/unit)
Tree Planting	Pervious	339.63	57%	339.63 * 57%	193.59

2. Multiply reduction by lb/unit by units treated by BMP. In this case the units treated are acres of impervious and pervious.

Results for Example 1, Step 2					
BMP Type	Land use	TSS Reduction (lb/unit)	Unit Treated (Acres)	Calculation	TSS Reduction (lb)
Tree Planting	Pervious	193.59	1.65	193.59*1.65	319.42
				Total	**319.42**

For this facility, 319.42 pounds of sediment are removed annually, counting as progress towards the local sediment TMDL for Catoctin Creek watershed.

DEL loads are calculated in the same manner, but with the appropriate loading rates to track progress towards the Chesapeake Bay TMDL.

Stream Restoration:

Load reductions are calculated per project by the stream restoration design team during the design process. For projects where MDOT SHA design teams have not provided project level load reduction information, interim rates based on MDE 2014 will be used. Currently, Coastal/Non Coastal lbs/lf removed were used for all stream restoration projects until project specific load reductions are migrated into the database. As designs progress and project-level information is available, load reductions based on stream design protocols will be incorporated.

Example 3

A stream restoration project is estimated to treat 2,000 linear feet in the Double Pipe Creek watershed in Frederick County. The Double Pipe Creek watershed has a TMDL for sediment with a baseline year of 2000 and a TMDL for phosphorus with a baseline year of 2009. Using the steps outlined above, the phosphorus load removed for the BMP is derived:

1A. Loading rate lookup value is not required for load reduction BMPs such as this one. Reductions are based on a fixed amount of pollutant removed instead of a percentage of the load delivered to the BMP. Therefore, the first step in this analysis is the same as the second step in Example 1.

1B. BMP load reduction is queried for stream restoration. In this case, the project is not far enough along in design to estimate reductions from the Expert Panel protocols (Schueler and Stack, 2014) so the interim rate per linear foot is used.

BMP Load Reduction for Example 2, Step 1B	
BMP Type	**TP Removal (lb/LF)**
Stream Restoration	0.068

1C. It is also not necessary to determine reduction by lb/unit by multiplying loading rates by BMP efficiencies. This reduction factor is given in the lookup table.

2. Multiply reduction by lb/unit by units treated by BMP. In this case the units treated are linear feet of restoration.

Results for Example 1, Step 2				
BMP Type	**TP Reduction (lb/unit)**	**Unit Treated (LF)**	**Calculation**	**TP Reduction (lb)**
Stream Restoration	0.068	2,000	2,000* 0.068	136.0
			Total	**136.0**

For this project, 136.0 pounds of phosphorus are removed annually, counting as progress towards the local phosphorus TMDL for Double Pipe Creek watershed.

Outfall Stabilization:

Outfall stabilization projects are expected to have project-specific load reduction information available at the time the facility is built. For planning purposes, MDOT SHA has incorporated its own research on load reductions from outfall stabilization. Based on the results, the assumption for linear feet of treatment provided by planned outfall projects was doubled to 400 linear feet of stream restoration credit as opposed to the maximum of 200 linear feet in MDE 2014. Based on initial research by the stream and outfall teams and individual project results, this is still believed to be a conservative estimate. This number will be adjusted in the future as more project specific data will help determine planning estimates.

GIS Data Processing

Once the calculated load reduction for each facility is determined through the automated script, all treatment data is joined to a point file based on BMP location. This layer is subsequently intersected with TMDL polygons provided on MDE's TMDL Data Center website in order to apply the appropriate treatment to each TMDL. The resulting table lists every BMP within a TMDL along with the load reductions for each facility. Subsequent spreadsheet analysis defined below applies filtering and queries to the data, providing a dynamic view of MDOT SHA's treatment scenarios within a local TMDL.

Bay TMDL Modeling

For Bay TMDL modeling, the sum of load reductions from all MDOT SHA BMPs within MS4 jurisdictions will be compared to reduction goals when developed by MDE.

Spreadsheet Analysis

Treatment and Load Reduction Pivot Tables

The scripts described above result in a raw data export which lists load reductions for each facility found within a MDOT SHA local TMDL. A series of pivot tables are created in an Excel workbook from the data export generated by the AMT to calculate the sum of treatment and sum of load reductions by TMDL pollutant and level of treatment (i.e., baseline, progress, and future). Because baseline dates vary by TMDL, separate pivot tables must be created in order to isolate the treatment from a subset of BMPs by built date. Therefore, multiple pivot tables are required per TMDL pollutant to accurately calculate load reductions per level of treatment.

AMT functionality varies by TMDL pollutant, as follows:

- TP AMT result: sum of treatment and sum of TP EOS lbs/yr removed by treatment level
- TSS AMT result: sum of treatment and sum of TSS EOS lbs/yr removed by treatment level
- PCBs AMT result: sum of treatment and sum of TSS EOS lbs/yr removed by treatment level. TSS EOS lbs/yr removed is then converted to g/yr removed and then multiplied by the average sediment tPCB concentration from the TMDL document to calculate load reduction in PCB g/yr (SHA, 2016).
- Bacteria AMT result: sum of treatment by treatment level is used in the WTM and described in the Bacteria Modeling Protocol to calculate bacteria load reductions from stormwater BMPs (SHA, 2016).

The following pivot table filters are applied per TMDL pollutant:

Baseline Pivot Tables

Pollutant: varies by TMDL

Baseline year: varies by TMDL

BMP type:

TP and TSS: Excludes BMPs coded as XDED, XDPD, XOGS, XOTH, or blank

PCB: Excludes tree planting, outfall stabilization, and stream restoration in addition to BMPs coded as XDED, XDPD, XOGS, XOTH, or blank

Bacteria: Excludes tree planting, impervious surface reduction, grass swales, outfall stabilization, and stream restoration in addition to BMPs coded as XDED, XDPD, XOGS, XOTH, or blank

Status: BMPs coded as construction complete

Built date: BMPs with a built date before July 1 of the baseline year (e.g., For a TMDL with a baseline year of 2005: BMPs before 7/1/2005 are filtered)

Progress Pivot Tables

Pollutant: varies by TMDL

Baseline year: varies by TMDL

BMP type:

TP and TSS: Excludes BMPs coded as XDED, XDPD, XOGS, XOTH, or blank

PCB: Excludes tree planting, outfall stabilization, and stream restoration in addition to BMPs coded as XDED, XDPD, XOGS, XOTH, or blank

Bacteria: Excludes tree planting, impervious surface reduction, grass swales, outfall stabilization, and stream restoration in addition to BMPs coded as XDED, XDPD, XOGS, XOTH, or blank

Construction purpose: Restoration BMPs (excludes new development BMPs)

Status: BMPs coded as construction completed

Built date: BMPs with a built date between the TMDL baseline year and end of current fiscal year (e.g., FY17 progress BMPs for a TMDL with a baseline year of 2005: BMPs between 7/1/2005 and 6/30/2017)

Future BMP Pivot Tables

Pollutant: varies by TMDL

BMP type:

TP and TSS: Excludes BMPs coded as XDED, XDPD, XOGS, XOTH, or blank

PCB: Excludes tree planting, outfall stabilization, and stream restoration in addition to BMPs coded as XDED, XDPD, XOGS, XOTH, or blank

Bacteria: Excludes tree planting, impervious surface reduction, grass swales, outfall stabilization, and stream restoration in addition to BMPs coded as XDED, XDPD, XOGS, XOTH, or blank

Construction purpose: Restoration BMPs (excludes new development BMPs)

Status: BMPs coded as under construction, proposed, in design concept, potential, and planned

Fiscal year: 2017 and after, excluding blanks

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Appendix I

Comprehensive List of Restoration Practices by Contract

Appendix I

Comprehensive List of Restoration Practices by Contract

MARYLAND DEPARTMENT OF TRANSPORTATION

STATE HIGHWAY ADMINISTRATION

List of Tables

Table **Page Number**

Table I-1: FMIS # AA16655182 ..... I-1

Table I-2 FMIS # AA8955182 ..... I-2

Table I-3 FMIS # AT0415182 ..... I-3

Table I-4 FMIS # AT0425182 ..... I-5

Table I-5 FMIS # AT0445182 ..... I-7

Table I-6 FMIS # AT0685282 ..... I-8

Table I-7 FMIS # AT0685382 ..... I-10

Table I-8: FMIS # AT0685482 ..... I-12

Table I-9: FMIS # AT0685582 ..... I-14

Table I-10 FMIS # AT0865182 ..... I-15

Table I-11 FMIS # AT0875182 ..... I-16

Table I-12: FMIS # AT0885182 ..... I-17

Table I-13: FMIS # AT0895182 ..... I-18

Table I-14: FMIS # AT4285282 ..... I-19

Table I-15: FMIS # AT5025182 ..... I-20

Table I-16: FMIS # AT5025282 ..... I-22

Table I-17: FMIS # AT5025382 ..... I-24

Table I-18: FMIS # AT5025482 ..... I-25

Table I-19: FMIS # AT7995382 ..... I-26

Table I-20: FMIS # AW0465182 ..... I-27

Table I-21: FMIS # AW0825282 ..... I-28

Table I-22: FMIS # AX2645182 ..... I-31

Table I-23: FMIS # AX2645282 ..... I-32

Table I-24: FMIS # AX2645382 ..... I-33

Table I-25: FMIS # AX2645482 ..... I-34

Table I-26: FMIS # AX3765360 ..... I-35

Table I-27: FMIS # AX3765560 ..... I-36

Table I-28: FMIS # AX3765D60 ..... I-37

Table I-29: FMIS # AX3765E60 ..... I-38
Table I-30: FMIS # AX3765F60 ..... I-39
Table I-31: FMIS # AX3765K60 ..... I-40
Table I-32: FMIS # AX3765L60 ..... I-41
Table I-33: FMIS # AX3765N60 ..... I-42
Table I-34: FMIS # AX3765U60 ..... I-43
Table I-35: FMIS # AX3785R60 ..... I-44
Table I-36: FMIS # AX7665182 ..... I-45
Table I-37: FMIS # AX9295182 ..... I-46
Table I-38: FMIS # DNR – Million Tree I-47
Table I-39: FMIS # HA4075182 ..... I-49
Table I-40: FMIS # HA4095182SBR I-50
Table I-41: FMIS # HO1695182 ..... I-51
Table I-42: FMIS # HO2065182 ..... I-52
Table I-43: FMIS # HO3255124 ..... I-53
Table I-44: FMIS # HO4085174 ..... I-54
Table I-45: FMIS # PG0735182 ..... I-55
Table I-46: FMIS # WA2445182 ..... I-56
Table I-47: FMIS # WA2775182 ..... I-57

Comprehensive List of Restoration Practices By Contract						
Table I-1: FMIS # AA1665182						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH16ALN000002	Stream Restoration	Severn River	02131002	523235.90	1417157.01	2.50
SH15ALN000035	Outfall Stabilization	Severn River	02131002	523317.26	1417329.97	2.00
					Complete BMP Acreage Total	**4.50**

Comprehensive List of Restoration Practices By Contract						
Table I-2: FMIS # AA8955182						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH16ALN000031	Stream Restoration	South River	02131003	478723.62	1439457.82	23.00
				Complete BMP Acreage Total		**23.00**

Comprehensive List of Restoration Practices By Contract Table I-3: FMIS # AT0415182						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH16APY001444	Tree Planting	Mattawoman Creek	02140111	353994.80	1297773.95	0.03
SH16APY001381	Tree Planting	Anacostia River	02140205	501450.77	1314376.64	0.33
SH16APY001382	Tree Planting	Anacostia River	02140205	501781.97	1314809.58	0.70
SH16APY001384	Tree Planting	Cabin John Creek	02140207	483011.99	1267677.48	0.11
SH16APY001385	Tree Planting	Seneca Creek	02140208	557213.06	1237858.02	0.07
SH16APY001386	Tree Planting	Seneca Creek	02140208	552350.11	1239776.69	0.10
SH16APY001387	Tree Planting	Seneca Creek	02140208	569608.51	1232018.70	0.05
SH16APY001388	Tree Planting	Seneca Creek	02140208	555160.11	1239027.51	0.22
SH16APY001389	Tree Planting	Seneca Creek	02140208	531005.57	1207101.03	0.20
SH16APY001390	Tree Planting	Seneca Creek	02140208	538672.32	1251278.63	0.06
SH16APY001391	Tree Planting	Potomac River MO Cnty	02140202	521848.73	1260193.58	0.11
SH16APY001392	Tree Planting	Seneca Creek	02140208	536297.94	1251868.76	0.24
SH16APY001393	Tree Planting	Seneca Creek	02140208	570480.32	1231768.60	0.10
SH16APY001394	Tree Planting	Seneca Creek	02140208	552517.89	1239295.52	0.24
SH16APY001395	Tree Planting	Rocky Gorge Dam	02131107	545822.40	1295252.76	0.03
SH16APY001396	Tree Planting	Rocky Gorge Dam	02131107	546082.90	1295302.76	0.07
SH16APY001397	Tree Planting	Cabin John Creek	02140207	485811.04	1262117.16	0.07
SH16APY001398	Tree Planting	Cabin John Creek	02140207	485605.89	1262501.35	0.04
SH16APY001399	Tree Planting	Seneca Creek	02140208	558009.55	1237224.66	0.16
SH16APY001400	Tree Planting	Seneca Creek	02140208	557759.58	1237283.58	1.02
SH16APY001401	Tree Planting	Seneca Creek	02140208	558423.10	1237418.59	0.13
SH16APY001402	Tree Planting	Seneca Creek	02140208	558712.04	1237090.87	0.04
SH16APY001403	Tree Planting	Seneca Creek	02140208	559859.05	1236060.32	0.18
SH16APY001404	Tree Planting	Potomac River MO Cnty	02140202	497590.47	1245550.72	0.05
SH16APY001405	Tree Planting	Potomac River MO Cnty	02140202	497781.62	1245242.62	0.01
SH16APY001406	Tree Planting	Potomac River MO Cnty	02140202	497852.71	1245128.87	0.01
SH16APY001407	Tree Planting	Seneca Creek	02140208	546253.93	1232500.62	0.04
SH16APY001408	Tree Planting	Seneca Creek	02140208	556695.70	1243401.15	0.44
SH16APY001409	Tree Planting	Potomac River MO Cnty	02140202	530903.01	1261679.53	1.10
SH16APY001410	Tree Planting	Cabin John Creek	02140207	482856.97	1267750.06	0.13
SH16APY001411	Tree Planting	Seneca Creek	02140208	557049.38	1237961.70	0.07
SH16APY001412	Tree Planting	Seneca Creek	02140208	557714.99	1237054.48	0.15
SH16APY001413	Tree Planting	Seneca Creek	02140208	557783.46	1236966.13	0.15
SH16APY001414	Tree Planting	Seneca Creek	02140208	557902.13	1236933.75	0.03
SH16APY001415	Tree Planting	Potomac River MO Cnty	02140202	497349.69	1245950.49	0.03
SH16APY001416	Tree Planting	Seneca Creek	02140208	538575.76	1251266.36	0.04
SH16APY001417	Tree Planting	Seneca Creek	02140208	529677.29	1240995.22	0.51
SH16APY001418	Tree Planting	Anacostia River	02140205	490713.45	1300059.34	0.11
SH16APY001419	Tree Planting	Seneca Creek	02140208	557377.63	1236844.41	0.18
SH16APY001420	Tree Planting	Seneca Creek	02140208	529452.09	1240940.86	0.06
SH16APY001421	Tree Planting	Anacostia River	02140205	513604.78	1324898.30	0.31
SH16APY001422	Tree Planting	Anacostia River	02140205	490811.16	1300188.87	0.03
SH16APY001423	Tree Planting	Anacostia River	02140205	529288.18	1319958.35	4.43
SH16APY001424	Tree Planting	Rocky Gorge Dam	02131107	530678.73	1333400.42	0.07
SH16APY001425	Tree Planting	Rocky Gorge Dam	02131107	530929.88	1333544.15	0.10
SH16APY001426	Tree Planting	Rocky Gorge Dam	02131107	526676.34	1332386.15	0.32
SH16APY001427	Tree Planting	Anacostia River	02140205	525315.03	1332301.73	0.16
SH16APY001428	Tree Planting	Anacostia River	02140205	525690.81	1332488.12	0.13
SH16APY001429	Tree Planting	Anacostia River	02140205	482962.68	1344289.04	0.10
SH16APY001430	Tree Planting	Western Branch	02131103	446296.65	1355278.52	0.29
SH16APY001431	Tree Planting	Mattawoman Creek	02140111	353544.34	1297339.43	0.04
SH16APY001432	Tree Planting	Anacostia River	02140205	465603.53	1350090.31	0.47
SH16APY001433	Tree Planting	Patuxent River upper	02131104	521259.03	1355621.76	0.30
SH16APY001434	Tree Planting	Potomac River U tidal	02140201	413796.71	1313264.43	0.07
SH16APY001435	Tree Planting	Potomac River U tidal	02140201	413011.51	1312516.86	0.06
SH16APY001436	Tree Planting	Potomac River U tidal	02140201	422736.85	1346648.09	0.51
SH16APY001437	Tree Planting	Potomac River M tidal	02140102	352999.98	1296577.07	0.04
SH16APY001438	Tree Planting	Piscataway Creek	02140203	366993.66	1310439.34	0.19
SH16APY001439	Tree Planting	Western Branch	02131103	417210.29	1386398.93	0.03
SH16APY001440	Tree Planting	Mattawoman Creek	02140111	361048.42	1309637.14	0.11
SH16APY001441	Tree Planting	Patuxent River upper	02131104	522264.57	1344102.27	0.24
SH16APY001442	Tree Planting	Anacostia River	02140205	459054.66	1348417.35	0.06
SH16APY001443	Tree Planting	Potomac River U tidal	02140201	413725.35	1312796.03	0.13
SH16APY001445	Tree Planting	Potomac River U tidal	02140201	427490.48	1349869.61	0.04
SH16APY001446	Tree Planting	Mattawoman Creek	02140111	353375.77	1297109.91	0.02
SH16APY001447	Tree Planting	Potomac River U tidal	02140201	427283.04	1349440.21	0.40
SH16APY001448	Tree Planting	Mattawoman Creek	02140111	362360.17	1307776.98	0.06
SH16APY001449	Tree Planting	Anacostia River	02140205	458150.40	1347917.91	0.08
SH16APY001450	Tree Planting	Anacostia River	02140205	459045.37	1347648.35	0.12
SH16APY001451	Tree Planting	Potomac River U tidal	02140201	413348.06	1312874.67	0.30
SH16APY001452	Tree Planting	Anacostia River	02140205	471527.44	1350378.73	0.17
SH16APY001453	Tree Planting	Anacostia River	02140205	459189.14	1348178.27	0.12
SH16APY001454	Tree Planting	Potomac River U tidal	02140201	413181.72	1312440.75	0.10
SH16APY001455	Tree Planting	Potomac River U tidal	02140201	425398.23	1329045.14	0.08
SH16APY001456	Tree Planting	Anacostia River	02140205	487820.12	1342617.85	0.06
SH16APY001457	Tree Planting	Western Branch	02131103	439867.79	1373903.35	0.17
SH16APY001458	Tree Planting	Western Branch	02131103	444578.84	1392105.75	0.16
SH16APY001459	Tree Planting	Anacostia River	02140205	488819.53	1343001.38	0.06
SH16APY001460	Tree Planting	Western Branch	02131103	436143.16	1355925.14	0.12

Comprehensive List of Restoration Practices By Contract						
Table I-3: FMIS # AT0415182						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH16APY001461	Tree Planting	Anacostia River	02140205	487865.36	1342498.63	0.25
SH16APY001462	Tree Planting	Western Branch	02131103	417774.49	1386228.49	0.13
SH16APY001463	Tree Planting	Western Branch	02131103	427720.57	1350807.04	0.36
SH16APY001464	Tree Planting	Potomac River U tidal	02140201	413332.31	1312455.12	0.09
SH16APY001465	Tree Planting	Potomac River U tidal	02140201	413252.45	1312449.93	0.03
SH16APY001466	Tree Planting	Potomac River U tidal	02140201	413199.60	1312986.58	0.17
SH16APY001467	Tree Planting	Western Branch	02131103	417622.72	1383694.28	0.07
SH16APY001468	Tree Planting	Western Branch	02131103	417699.10	1383891.62	0.08
SH16APY001469	Tree Planting	Western Branch	02131103	417095.46	1386488.50	0.04
SH16APY001470	Tree Planting	Potomac River M tidal	02140102	353200.34	1296862.79	0.04
				Complete BMP Acreage Total		**18.96**

Comprehensive List of Restoration Practices By Contract Table I-4: FMIS # AT0425182						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH16APY001473	Tree Planting	Antietam Creek	02140502	654088.98	1125310.64	0.33
SH16APY001472	Tree Planting	Antietam Creek	02140502	705261.48	1120441.59	0.05
SH16APY001471	Tree Planting	Antietam Creek	02140502	705135.24	1122714.26	0.12
SH16APY001474	Tree Planting	Antietam Creek	02140502	649090.43	1124403.07	0.34
SH16APY001475	Tree Planting	Antietam Creek	02140502	648528.92	1124393.75	0.04
SH16APY001476	Tree Planting	Antietam Creek	02140502	647975.21	1124454.51	0.23
SH16APY001477	Tree Planting	Antietam Creek	02140502	646754.05	1124777.44	0.05
SH16APY001478	Tree Planting	Antietam Creek	02140502	641732.35	1125557.92	1.77
SH16APY001479	Tree Planting	Antietam Creek	02140502	640371.23	1125068.71	0.32
SH16APY001480	Tree Planting	Potomac River FR Cnty	02140301	632134.23	1126787.94	0.54
SH16APY001481	Tree Planting	Antietam Creek	02140502	637664.47	1125000.15	0.86
SH16APY001482	Tree Planting	Potomac River FR Cnty	02140301	636710.64	1125292.30	0.59
SH16APY001483	Tree Planting	Potomac River FR Cnty	02140301	630292.90	1127539.08	0.08
SH16APY001484	Tree Planting	Potomac River FR Cnty	02140301	629425.51	1127421.27	0.34
SH16APY001485	Tree Planting	Antietam Creek	02140502	665684.79	1129472.58	0.05
SH15APY001237	Tree Planting	Antietam Creek	02140502	691699.54	1133453.54	0.25
SH15APY001238	Tree Planting	Antietam Creek	02140502	694054.42	1130380.19	0.37
SH15APY001239	Tree Planting	Antietam Creek	02140502	692501.99	1132358.30	0.11
SH16APY001486	Tree Planting	Antietam Creek	02140502	665530.89	1129573.50	0.50
SH16APY001487	Tree Planting	Antietam Creek	02140502	664531.77	1129270.35	1.03
SH16APY001488	Tree Planting	Antietam Creek	02140502	661260.13	1128101.12	0.08
SH16APY001489	Tree Planting	Antietam Creek	02140502	660341.95	1127822.97	0.08
SH16APY001490	Tree Planting	Potomac River FR Cnty	02140301	628477.19	1127093.32	0.10
SH16APY001491	Tree Planting	Potomac River FR Cnty	02140301	628256.78	1127007.59	0.17
SH16APY001492	Tree Planting	Potomac River FR Cnty	02140301	627961.47	1126888.40	0.22
SH16APY001493	Tree Planting	Potomac River FR Cnty	02140301	627053.37	1126546.20	0.21
SH16APY001494	Tree Planting	Potomac River FR Cnty	02140301	620447.81	1122835.39	0.26
SH16APY001495	Tree Planting	Potomac River FR Cnty	02140301	619979.80	1122668.10	0.04
SH16APY001496	Tree Planting	Potomac River FR Cnty	02140301	619862.77	1122623.80	0.06
SH16APY001497	Tree Planting	Potomac River FR Cnty	02140301	618976.52	1122250.71	0.13
SH16APY001498	Tree Planting	Potomac River FR Cnty	02140301	615271.77	1120366.23	0.30
SH16APY001499	Tree Planting	Potomac River FR Cnty	02140301	611318.89	1119380.08	0.15
SH16APY001500	Tree Planting	Potomac River FR Cnty	02140301	609743.40	1118954.59	0.11
SH16APY001501	Tree Planting	Potomac River FR Cnty	02140301	607456.82	1114917.13	0.24
SH16APY001502	Tree Planting	Potomac River FR Cnty	02140301	612514.75	1119616.89	0.06
SH16APY001503	Tree Planting	Potomac River FR Cnty	02140301	612172.04	1119532.34	0.33
SH16APY001504	Tree Planting	Potomac River FR Cnty	02140301	615866.91	1120437.49	0.16
SH16APY001505	Tree Planting	Antietam Creek	02140502	646944.05	1124714.75	0.07
SH15APY001240	Tree Planting	Antietam Creek	02140502	687005.84	1139428.89	0.07
SH15APY001241	Tree Planting	Antietam Creek	02140502	692962.95	1131751.80	0.14
SH15APY001242	Tree Planting	Antietam Creek	02140502	694629.52	1129934.42	0.09
SH16APY001506	Tree Planting	Antietam Creek	02140502	646708.39	1124980.69	0.84
SH16APY001507	Tree Planting	Antietam Creek	02140502	649893.94	1124428.10	0.23
SH16APY001508	Tree Planting	Antietam Creek	02140502	654618.28	1125853.06	0.99
SH15APY001243	Tree Planting	Antietam Creek	02140502	685079.99	1140341.45	0.37
SH15APY001244	Tree Planting	Antietam Creek	02140502	687111.62	1139101.27	0.16
SH15APY001245	Tree Planting	Antietam Creek	02140502	690385.59	1135284.93	0.16
SH15APY001246	Tree Planting	Antietam Creek	02140502	696281.28	1128055.29	0.15
SH15APY001247	Tree Planting	Antietam Creek	02140502	697176.30	1127036.98	0.03
SH15APY001248	Tree Planting	Antietam Creek	02140502	698623.11	1125387.71	0.12
SH15APY001249	Tree Planting	Antietam Creek	02140502	699067.63	1124882.92	0.11
SH15APY001250	Tree Planting	Antietam Creek	02140502	699473.96	1124421.27	0.08
SH16APY001509	Tree Planting	Antietam Creek	02140502	660929.52	1128002.57	0.04
SH16APY001510	Tree Planting	Antietam Creek	02140502	653594.33	1125269.24	0.13
SH16APY001511	Tree Planting	Antietam Creek	02140502	660623.61	1127906.24	0.05
SH15APY001251	Tree Planting	Antietam Creek	02140502	687148.72	1139267.80	0.02
SH16APY001512	Tree Planting	Antietam Creek	02140502	638467.72	1124759.56	0.22
SH15APY001252	Tree Planting	Antietam Creek	02140502	692678.96	1132098.69	0.23
SH16APY001513	Tree Planting	Potomac River FR Cnty	02140301	609859.05	1119014.92	0.04
SH16APY001514	Tree Planting	Marsh Run	02140503	706925.36	1102786.74	0.28
SH16APY001515	Tree Planting	Marsh Run	02140503	707001.11	1102235.46	0.25
SH15APY001253	Tree Planting	Antietam Creek	02140502	702730.62	1127681.37	0.13
SH16APY001516	Tree Planting	Antietam Creek	02140502	699287.41	1132158.17	0.19
SH15APY001254	Tree Planting	Conococheague Creek	02140504	707230.64	1095074.91	0.69
SH16APY001517	Tree Planting	Antietam Creek	02140502	696199.79	1127928.39	0.63
SH16APY001518	Tree Planting	Antietam Creek	02140502	702917.69	1127817.23	0.13
SH16APY001519	Tree Planting	Antietam Creek	02140502	698524.95	1133463.12	0.18
SH16APY001520	Tree Planting	Antietam Creek	02140502	703350.30	1127286.95	0.11
SH16APY001521	Tree Planting	Antietam Creek	02140502	703513.62	1127086.13	0.12
SH15APY001255	Tree Planting	Antietam Creek	02140502	699774.16	1132042.95	0.02
SH16APY001522	Tree Planting	Antietam Creek	02140502	699859.72	1131934.91	0.17
SH16APY001523	Tree Planting	Antietam Creek	02140502	704948.29	1122874.99	0.14
SH16APY001524	Tree Planting	Conococheague Creek	02140504	701052.60	1122463.34	0.05
SH16APY001525	Tree Planting	Antietam Creek	02140502	645879.58	1125265.66	0.13
SH16APY001526	Tree Planting	Potomac River FR Cnty	02140301	627328.04	1126638.49	0.08
SH16APY001527	Tree Planting	Potomac River FR Cnty	02140301	627673.25	1126787.08	0.17
SH16APY001528	Tree Planting	Potomac River FR Cnty	02140301	620141.25	1122724.72	0.13

Comprehensive List of Restoration Practices By Contract Table I-4: FMIS # AT0425182						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH16APY001529	Tree Planting	Antietam Creek	02140502	653805.42	1125400.21	0.08
SH16APY001530	Tree Planting	Conococheague Creek	02140504	724138.64	1101392.78	0.56
SH16APY001531	Tree Planting	Potomac River FR Cnty	02140301	630611.21	1127532.06	0.09
SH16APY001532	Tree Planting	Antietam Creek	02140502	700153.72	1131380.48	0.14
SH15APY001256	Tree Planting	Antietam Creek	02140502	699853.39	1132094.98	0.02
				Complete BMP Acreage Total		**19.47**

Comprehensive List of Restoration Practices By Contract Table I-5: FMIS # AT0445182						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH16RST021571	Grass Swale	Baltimore Harbor	02130903	556485.76	1416485.06	0.30
SH16RST021575	Grass Swale	Baltimore Harbor	02130903	552561.36	1416465.57	0.25
SH16RST021576	Grass Swale	Baltimore Harbor	02130903	543764.79	1412953.57	0.97
SH16RST021577	Grass Swale	Baltimore Harbor	02130903	542953.47	1412831.95	0.40
SH16RST021579	Grass Swale	Baltimore Harbor	02130903	536152.60	1413265.48	1.14
SH16RST021580	Grass Swale	Baltimore Harbor	02130903	535402.64	1413343.53	0.56
SH16RST021583	Grass Swale	Baltimore Harbor	02130903	529830.11	1414977.88	0.76
SH16RST021584	Grass Swale	Baltimore Harbor	02130903	529200.48	1415210.52	0.55
SH16RST021585	Grass Swale	Baltimore Harbor	02130903	528551.76	1415475.55	1.06
SH16RST021586	Grass Swale	Baltimore Harbor	02130903	526813.71	1416257.90	0.35
SH16RST021587	Grass Swale	Baltimore Harbor	02130903	526441.34	1416424.69	0.42
SH16RST021588	Grass Swale	Severn River	02131002	511308.10	1415345.23	0.53
SH16RST021591	Grass Swale	Severn River	02131002	509165.68	1414369.05	0.60
SH16RST021592	Grass Swale	Severn River	02131002	506019.79	1417291.10	0.40
SH16RST021593	Grass Swale	Severn River	02131002	505588.79	1417615.11	0.23
SH17RST021594	Bio-Swale	Severn River	02131002	504635.77	1418331.25	0.29
SH17RST021595	Bio-Swale	South River	02131003	500613.57	1421984.20	0.25
SH17RST021596	Bio-Swale	South River	02131003	499056.22	1422395.97	0.53
SH17RST021597	Bio-Swale	South River	02131003	498257.99	1422406.41	0.76
SH17RST021598	Bio-Swale	South River	02131003	497483.45	1422296.07	0.51
SH17RST021599	Bio-Swale	South River	02131003	496724.60	1422055.23	0.66
SH17RST021600	Bio-Swale	South River	02131003	496029.26	1421776.16	0.34
SH17RST021601	Bio-Swale	South River	02131003	495288.94	1421578.10	0.80
SH17RST021602	Bio-Swale	South River	02131003	494649.44	1421582.82	0.22
SH17RST021603	Bio-Swale	South River	02131003	494019.65	1421705.98	0.71
SH17RST021604	Bio-Swale	South River	02131003	493268.08	1421859.56	0.42
SH17RST021605	Bio-Swale	South River	02131003	491291.21	1422265.10	0.48
SH17RST021606	Bio-Swale	South River	02131003	489607.98	1422668.94	0.64
SH17RST021607	Bio-Swale	South River	02131003	489047.22	1423029.90	0.52
SH17RST021608	Bio-Swale	South River	02131003	488308.14	1424354.04	0.47
SH17RST021610	Bio-Swale	South River	02131003	487586.82	1425857.32	0.39
SH17RST021611	Bio-Swale	South River	02131003	487110.87	1426345.90	0.79
SH17RST021612	Bio-Swale	South River	02131003	486635.58	1426756.27	0.28
SH17RST021614	Bio-Swale	South River	02131003	485439.74	1427940.06	0.83
SH17RST021615	Bio-Swale	South River	02131003	485085.87	1428611.55	0.41
SH17RST021616	Bio-Swale	Baltimore Harbor	02130903	527534.87	1415934.41	1.30
SH16RST021617	Grass Swale	Severn River	02131002	511761.74	1415941.33	0.55
				Complete BMP Acreage Total		**20.67**

Comprehensive List of Restoration Practices By Contract Table I-6: FMIS # AT0685282						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH15APY000922	Tree Planting	Deer Creek	02120202	743570.69	1412550.26	1.02
SH16APY001313	Tree Planting	Patapsco River L N Br	02130906	577127.00	1403186.20	0.21
SH15APY000923	Tree Planting	Gwynns Falls	02130905	635941.35	1372460.77	0.70
SH16APY001314	Tree Planting	Gwynns Falls	02130905	596991.75	1385364.49	0.20
SH15APY000924	Tree Planting	Gwynns Falls	02130905	635408.93	1370638.83	0.18
SH15APY000925	Tree Planting	Back River	02130901	591496.68	1453622.42	0.22
SH15APY000926	Tree Planting	Gwynns Falls	02130905	633240.86	1369610.35	0.23
SH15APY000927	Tree Planting	Gwynns Falls	02130905	597472.95	1383714.49	0.08
SH16APY001315	Tree Planting	Patapsco River L N Br	02130906	564688.77	1397645.10	0.12
SH15APY000928	Tree Planting	Lower Gunpowder Falls	02130802	632522.39	1441213.36	0.15
SH15APY000929	Tree Planting	Gwynns Falls	02130905	625266.60	1381243.04	0.11
SH15APY000930	Tree Planting	Jones Falls	02130904	634610.34	1407488.39	0.34
SH15APY000931	Tree Planting	Bird River	02130803	619452.14	1474334.16	0.09
SH15APY000932	Tree Planting	Back River	02130901	578255.27	1466152.87	0.08
SH15APY000933	Tree Planting	Back River	02130901	582711.07	1465044.41	1.12
SH15APY000934	Tree Planting	Bird River	02130803	624888.45	1454997.81	0.31
SH15APY000935	Tree Planting	Patapsco River L N Br	02130906	566787.88	1396978.24	0.26
SH15APY000936	Tree Planting	Back River	02130901	606071.29	1458144.43	0.22
SH15APY000937	Tree Planting	Back River	02130901	603483.11	1463947.76	0.17
SH15APY000938	Tree Planting	Patapsco River L N Br	02130906	597668.98	1372721.63	0.14
SH15APY000939	Tree Planting	Gwynns Falls	02130905	597378.66	1382284.05	0.14
SH15APY000940	Tree Planting	Gwynns Falls	02130905	626380.34	1380912.33	0.50
SH16APY001316	Tree Planting	Patapsco River L N Br	02130906	576276.54	1401671.15	0.25
SH15APY000941	Tree Planting	Patapsco River L N Br	02130906	597281.91	1376957.29	0.02
SH15APY000942	Tree Planting	Gwynns Falls	02130905	631283.42	1378882.48	0.09
SH15APY000943	Tree Planting	Back River	02130901	617234.53	1452493.91	0.67
SH15APY000944	Tree Planting	Gwynns Falls	02130905	624006.27	1381800.32	0.02
SH15APY000945	Tree Planting	Bird River	02130803	625044.68	1448378.17	0.31
SH15APY000946	Tree Planting	Jones Falls	02130904	634161.30	1406266.91	0.06
SH15APY000947	Tree Planting	Jones Falls	02130904	633360.84	1404489.45	0.54
SH15APY000948	Tree Planting	Back River	02130901	593503.27	1452503.72	0.24
SH15APY000949	Tree Planting	Back River	02130901	600375.54	1466619.21	0.09
SH15APY000950	Tree Planting	Back River	02130901	601142.73	1466286.67	0.12
SH15APY000951	Tree Planting	Back River	02130901	601560.87	1466359.99	0.24
SH15APY000952	Tree Planting	Back River	02130901	574372.60	1466244.77	0.82
SH15APY000953	Tree Planting	Bird River	02130803	621919.43	1472948.14	0.10
SH16APY001317	Tree Planting	Gwynns Falls	02130905	624426.84	1382048.19	0.09
SH15APY000954	Tree Planting	Bird River	02130803	624348.16	1463071.02	0.03
SH15APY000955	Tree Planting	Back River	02130901	609198.45	1455652.57	0.08
SH15APY000956	Tree Planting	Gwynns Falls	02130905	597766.16	1384354.58	0.26
SH15APY000957	Tree Planting	Back River	02130901	620682.42	1449357.21	0.78
SH15APY000958	Tree Planting	Jones Falls	02130904	628298.25	1393906.86	0.13
SH15APY000959	Tree Planting	Bird River	02130803	618935.84	1474734.81	0.31
SH15APY000960	Tree Planting	Gwynns Falls	02130905	628308.95	1379450.23	0.13
SH15APY000962	Tree Planting	Gwynns Falls	02130905	636897.94	1369882.10	0.09
SH15APY000963	Tree Planting	Bird River	02130803	624374.83	1462751.73	0.04
SH15APY000964	Tree Planting	Lower Gunpowder Falls	02130802	635652.63	1431627.71	0.07
SH16APY001318	Tree Planting	Gwynns Falls	02130905	596246.67	1384425.48	0.37
SH16APY001319	Tree Planting	Patapsco River L N Br	02130906	577149.80	1402437.65	0.30
SH16APY001320	Tree Planting	Patapsco River L N Br	02130906	578445.79	1404085.64	0.29
SH15APY000965	Tree Planting	Gwynns Falls	02130905	628366.95	1379166.37	0.15
SH15APY000966	Tree Planting	Deer Creek	02120202	745808.97	1410837.01	0.02
SH15APY000967	Tree Planting	Bird River	02130803	624853.25	1449984.80	0.24
SH15APY000968	Tree Planting	Back River	02130901	593859.61	1452599.75	0.15
SH16APY001321	Tree Planting	Patapsco River L N Br	02130906	577992.91	1403122.69	0.14
SH15APY000969	Tree Planting	Back River	02130901	600714.71	1466481.52	0.19
SH15APY000970	Tree Planting	Back River	02130901	600266.98	1466918.72	0.14
SH15APY000971	Tree Planting	Back River	02130901	606447.15	1457873.89	0.07
SH16APY001322	Tree Planting	Gwynns Falls	02130905	624479.16	1381718.76	0.09
SH15APY000972	Tree Planting	Baltimore Harbor	02130903	586968.08	1461139.04	0.12
SH15APY000973	Tree Planting	Gwynns Falls	02130905	627450.88	1379999.67	0.31
SH15APY000974	Tree Planting	Back River	02130901	583671.44	1464555.47	0.08
SH15APY000975	Tree Planting	Back River	02130901	609047.21	1455725.70	0.08
SH16APY001323	Tree Planting	Patapsco River L N Br	02130906	577111.44	1402269.05	0.30
SH15APY000976	Tree Planting	Back River	02130901	610805.60	1463119.06	0.06
SH16APY001324	Tree Planting	Patapsco River L N Br	02130906	576534.84	1403072.29	0.27
SH15APY000977	Tree Planting	Jones Falls	02130904	628464.66	1394000.33	0.15
SH15APY000978	Tree Planting	Gwynns Falls	02130905	646628.27	1362486.94	0.78
SH16APY001325	Tree Planting	Gwynns Falls	02130905	597295.52	1383446.77	0.78
SH15APY000979	Tree Planting	Patapsco River L N Br	02130906	575685.40	1401404.81	0.09
SH15APY000980	Tree Planting	Gwynns Falls	02130905	597375.68	1385053.53	0.06
SH15APY000981	Tree Planting	Back River	02130901	589022.15	1457922.38	0.13
SH16APY001326	Tree Planting	Gwynns Falls	02130905	596314.19	1385284.63	0.05
SH15APY000982	Tree Planting	Gwynns Falls	02130905	597344.21	1385570.62	0.59
SH15APY000983	Tree Planting	Back River	02130901	607288.22	1456803.75	0.10
SH15APY000984	Tree Planting	Lower Gunpowder Falls	02130802	632767.44	1433851.33	0.24
SH15APY000985	Tree Planting	Deer Creek	02120202	747772.09	1409613.13	0.08

Comprehensive List of Restoration Practices By Contract Table I-6: FMIS # AT0685282						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH16APY001327	Tree Planting	Patapsco River L N Br	02130906	576797.04	1402977.64	0.11
SH15APY000986	Tree Planting	Gwynns Falls	02130905	624625.23	1381980.08	0.12
SH15APY000987	Tree Planting	Back River	02130901	608731.98	1456145.25	0.69
SH15APY000988	Tree Planting	Gwynns Falls	02130905	627108.13	1380295.76	0.31
SH15APY000989	Tree Planting	Gwynns Falls	02130905	634899.65	1374033.83	0.20
SH15APY000990	Tree Planting	Lower Gunpowder Falls	02130802	635423.14	1431623.19	0.03
SH15APY000991	Tree Planting	Jones Falls	02130904	628012.65	1390816.28	0.06
SH15APY000992	Tree Planting	Loch Raven Reservoir	02130805	701918.31	1404517.66	0.27
SH15APY000993	Tree Planting	Loch Raven Reservoir	02130805	715462.81	1405964.81	0.23
SH15APY000994	Tree Planting	Loch Raven Reservoir	02130805	635065.86	1430692.32	0.85
SH15APY000995	Tree Planting	Loch Raven Reservoir	02130805	701486.29	1404261.17	0.10
SH15APY000996	Tree Planting	Loch Raven Reservoir	02130805	636436.59	1425691.21	0.11
SH15APY000997	Tree Planting	Loch Raven Reservoir	02130805	712348.77	1406005.29	0.19
SH15APY000998	Tree Planting	Loch Raven Reservoir	02130805	684817.20	1406464.38	0.13
SH15APY000999	Tree Planting	Patapsco River L N Br	02130906	576313.97	1402334.04	0.02
SH15APY001000	Tree Planting	Loch Raven Reservoir	02130805	738378.41	1413024.08	0.42
SH15APY001001	Tree Planting	Patapsco River L N Br	02130906	576391.30	1402388.11	0.06
SH16APY001328	Tree Planting	Liberty Reservoir	02130907	659093.37	1360290.32	0.20
SH15APY001002	Tree Planting	Loch Raven Reservoir	02130805	714083.05	1405319.50	0.15
SH15APY001003	Tree Planting	Liberty Reservoir	02130907	657324.74	1358223.99	0.15
SH16APY001329	Tree Planting	Loch Raven Reservoir	02130805	662229.97	1394901.90	0.11
SH15APY001004	Tree Planting	Loch Raven Reservoir	02130805	662684.24	1394912.24	0.09
SH16APY001330	Tree Planting	Loch Raven Reservoir	02130805	663463.99	1394904.66	0.10
SH15APY001005	Tree Planting	Loch Raven Reservoir	02130805	734463.59	1412441.76	0.16
SH15APY001006	Tree Planting	Loch Raven Reservoir	02130805	739361.94	1413292.81	0.19
SH15APY001007	Tree Planting	Loch Raven Reservoir	02130805	725289.56	1409867.19	0.09
SH15APY001008	Tree Planting	Patapsco River L N Br	02130906	576235.92	1402164.85	0.16
SH16APY001331	Tree Planting	Loch Raven Reservoir	02130805	656089.27	1407910.96	0.30
SH16APY001332	Tree Planting	Gwynns Falls	02130905	596668.49	1385199.36	0.50
SH16APY001333	Tree Planting	Gwynns Falls	02130905	596655.20	1385513.08	0.51
SH15APY001009	Tree Planting	Gwynns Falls	02130905	597975.02	1385118.33	0.13
SH15APY001010	Tree Planting	Gwynns Falls	02130905	597662.12	1385265.14	0.67
SH15APY001011	Tree Planting	Patapsco River L N Br	02130906	597307.20	1377144.39	0.08
SH15APY001012	Tree Planting	Deer Creek	02120202	745567.73	1410958.17	0.19
SH15APY001013	Tree Planting	Gwynns Falls	02130905	631022.82	1378968.76	0.14
SH15APY001014	Tree Planting	Gwynns Falls	02130905	630769.44	1379039.76	0.03
SH15APY001015	Tree Planting	Gwynns Falls	02130905	624219.95	1381769.41	0.16
SH15APY001016	Tree Planting	Gwynns Falls	02130905	636316.48	1372460.61	0.08
SH16APY001334	Tree Planting	Bird River	02130803	625785.66	1454338.27	0.17
SH16APY001335	Tree Planting	Bird River	02130803	619766.38	1474673.33	0.68
SH16APY001336	Tree Planting	Gwynns Falls	02130905	612630.14	1383999.86	1.01
SH16APY001337	Tree Planting	Jones Falls	02130904	636257.68	1407535.73	0.13
SH16APY001338	Tree Planting	Jones Falls	02130904	635961.65	1407395.61	0.09
SH16APY001339	Tree Planting	Jones Falls	02130904	636500.89	1407127.14	0.16
SH16APY001340	Tree Planting	Back River	02130901	590811.48	1453876.82	0.09
SH16APY001341	Tree Planting	Back River	02130901	620926.78	1450188.44	0.08
SH16APY001342	Tree Planting	Bird River	02130803	625593.07	1454157.07	0.04
SH16APY001343	Tree Planting	Bird River	02130803	627230.50	1455761.79	0.14
SH16APY001344	Tree Planting	Liberty Reservoir	02130907	656915.88	1358378.98	0.25
SH16APY001345	Tree Planting	Loch Raven Reservoir	02130805	662783.25	1395189.07	0.03
SH16APY001346	Tree Planting	Loch Raven Reservoir	02130805	662843.92	1395253.57	0.01
SH16APY001347	Tree Planting	Patapsco River L N Br	02130906	576952.95	1402902.02	0.04
SH16APY001604	Tree Planting	Patapsco River L N Br	02130906	576619.22	1403603.13	0.20
SH16APY001597	Tree Planting	Back River	02130901	630035.49	1439570.58	0.36
SH16APY001612	Tree Planting	Loch Raven Reservoir	02130805	716263.23	1404870.55	0.35
SH16APY001602	Tree Planting	Deer Creek	02120202	744302.19	1411968.73	0.30
SH16APY001603	Tree Planting	Deer Creek	02120202	747213.20	1410289.24	0.22
SH14APY001630	Tree Planting	Bird River	02130803	624793.07	1449614.98	0.08
				Complete BMP Acreage Total		**31.15**

Comprehensive List of Restoration Practices By Contract Table I-7: FMIS # AT0685382						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH15APY001181	Tree Planting	Bynum Run	02130704	692453.93	1488290.95	0.09
SH14APY000815	Tree Planting	Deer Creek	02120202	696567.77	1535949.88	0.54
SH14APY000816	Tree Planting	Swan Creek	02130706	696837.19	1536598.11	0.29
SH14APY000817	Tree Planting	Lower Susquehanna River	02120201	695626.59	1547959.31	0.87
SH14APY000818	Tree Planting	Broad Creek	02120205	736519.69	1509934.35	0.12
SH14APY000819	Tree Planting	Broad Creek	02120205	737956.10	1508305.22	0.40
SH14APY000820	Tree Planting	Broad Creek	02120205	738209.45	1507899.77	0.11
SH14APY000821	Tree Planting	Broad Creek	02120205	748796.04	1495795.17	0.16
SH16APY001354	Tree Planting	Atkisson Reservoir	02130703	697271.57	1468229.97	0.40
SH14APY000822	Tree Planting	Lower Susquehanna River	02120201	695745.29	1553908.54	0.33
SH14APY000823	Tree Planting	Lower Susquehanna River	02120201	695219.80	1547009.80	0.30
SH16APY001355	Tree Planting	Bynum Run	02130704	695151.82	1489651.02	0.39
SH15APY001182	Tree Planting	Bynum Run	02130704	688697.84	1491521.85	0.24
SH15APY001183	Tree Planting	Bynum Run	02130704	692014.56	1494135.63	1.32
SH15APY001184	Tree Planting	Bush River	02130701	658675.29	1528001.37	0.12
SH14APY000824	Tree Planting	Broad Creek	02120205	739989.73	1503638.30	0.10
SH15APY001185	Tree Planting	Bynum Run	02130704	693595.14	1495498.88	0.63
SH14APY000825	Tree Planting	Broad Creek	02120205	742938.64	1498331.32	0.05
SH15APY001186	Tree Planting	Little Gunpowder Falls	02130804	678739.88	1470473.86	0.15
SH16APY001356	Tree Planting	Little Gunpowder Falls	02130804	682118.19	1464427.65	0.03
SH16APY001357	Tree Planting	Little Gunpowder Falls	02130804	682301.00	1464159.44	0.10
SH14APY000826	Tree Planting	Lower Susquehanna River	02120201	696193.78	1550108.45	0.36
SH15APY001187	Tree Planting	Little Gunpowder Falls	02130804	675652.45	1476810.60	0.17
SH15APY001188	Tree Planting	Atkisson Reservoir	02130703	675145.34	1477769.19	0.13
SH15APY001189	Tree Planting	Atkisson Reservoir	02130703	670767.10	1480743.59	0.25
SH14APY000827	Tree Planting	Broad Creek	02120205	748775.21	1497121.15	0.03
SH15APY001190	Tree Planting	Bynum Run	02130704	694345.10	1495794.25	0.20
SH15APY001191	Tree Planting	Lower Winters Run	02130702	645476.69	1497904.06	0.33
SH15APY001192	Tree Planting	Bush River	02130701	660131.26	1526373.69	0.89
SH15APY001193	Tree Planting	Swan Creek	02130706	674025.39	1549497.89	0.19
SH15APY001194	Tree Planting	Little Gunpowder Falls	02130804	679507.63	1469072.65	0.34
SH15APY001195	Tree Planting	Atkisson Reservoir	02130703	684545.19	1460006.69	0.48
SH15APY001196	Tree Planting	Atkisson Reservoir	02130703	691580.74	1488797.65	0.06
SH15APY001197	Tree Planting	Bynum Run	02130704	692141.86	1488473.04	0.05
SH14APY000828	Tree Planting	Lower Susquehanna River	02120201	695189.26	1546214.10	0.38
SH16APY001358	Tree Planting	Bynum Run	02130704	696986.01	1485328.79	0.07
SH16APY001359	Tree Planting	Bynum Run	02130704	697191.09	1485289.29	0.06
SH16APY001360	Tree Planting	Bynum Run	02130704	697784.17	1485146.18	0.04
SH14APY000829	Tree Planting	Broad Creek	02120205	738491.34	1507296.20	0.03
SH14APY000830	Tree Planting	Broad Creek	02120205	739173.85	1505694.95	0.10
SH14APY000831	Tree Planting	Broad Creek	02120205	739135.99	1505652.80	0.22
SH15APY001198	Tree Planting	Little Gunpowder Falls	02130804	677477.29	1473085.01	0.57
SH14APY000832	Tree Planting	Broad Creek	02120205	739126.70	1488842.79	0.57
SH14APY000833	Tree Planting	Broad Creek	02120205	746146.01	1495877.78	0.12
SH14APY000834	Tree Planting	Broad Creek	02120205	736132.45	1510563.42	0.05
SH15APY001199	Tree Planting	Lower Winters Run	02130702	648302.25	1510296.06	0.23
SH15APY001200	Tree Planting	Bush River	02130701	662873.35	1526167.52	0.10
SH15APY001201	Tree Planting	Atkisson Reservoir	02130703	675308.49	1477386.81	0.39
SH16APY001361	Tree Planting	Atkisson Reservoir	02130703	695591.82	1474209.19	0.28
SH16APY001362	Tree Planting	Broad Creek	02120205	735551.12	1487879.67	0.46
SH14APY000835	Tree Planting	Broad Creek	02120205	734077.40	1484811.20	0.07
SH14APY000836	Tree Planting	Lower Susquehanna River	02120201	695376.27	1547606.81	0.11
SH14APY000837	Tree Planting	Broad Creek	02120205	740069.78	1503616.45	0.03
SH15APY001202	Tree Planting	Atkisson Reservoir	02130703	690950.13	1489143.02	0.04
SH15APY001203	Tree Planting	Bynum Run	02130704	696181.65	1497812.59	0.15
SH14APY000838	Tree Planting	Broad Creek	02120205	747662.71	1496834.24	0.03
SH15APY001204	Tree Planting	Little Gunpowder Falls	02130804	679098.12	1469826.23	0.22
SH14APY000839	Tree Planting	Broad Creek	02120205	748315.89	1497016.82	0.01
SH14APY000840	Tree Planting	Broad Creek	02120205	736375.07	1488194.86	0.31
SH15APY001205	Tree Planting	Little Gunpowder Falls	02130804	685938.33	1458410.01	0.15
SH15APY001206	Tree Planting	Bynum Run	02130704	692960.72	1487910.41	0.18
SH16APY001363	Tree Planting	Bynum Run	02130704	697541.88	1485207.66	0.04
SH16APY001364	Tree Planting	Bynum Run	02130704	697374.95	1485252.18	0.06
SH14APY000842	Tree Planting	Broad Creek	02120205	736685.99	1509657.15	0.02
SH14APY000843	Tree Planting	Broad Creek	02120205	739363.91	1505088.10	0.06
SH14APY000844	Tree Planting	Broad Creek	02120205	741361.87	1501044.11	0.09
SH14APY000845	Tree Planting	Broad Creek	02120205	741275.95	1490038.52	0.36
SH14APY000846	Tree Planting	Broad Creek	02120205	733924.16	1484480.20	0.25
SH16APY001365	Tree Planting	Bynum Run	02130704	696281.12	1485343.03	0.19
SH14APY000847	Tree Planting	Broad Creek	02120205	745621.08	1495362.17	0.18
SH16APY001366	Tree Planting	Bynum Run	02130704	695890.11	1486729.01	0.55
SH14APY000848	Tree Planting	Lower Susquehanna River	02120201	695361.70	1546988.90	0.85
SH15APY001207	Tree Planting	Bynum Run	02130704	693231.55	1495301.21	0.46
SH15APY001208	Tree Planting	Deer Creek	02120202	696961.70	1498736.27	0.63
SH16APY001367	Tree Planting	Broad Creek	02120205	734716.67	1487370.52	0.43
SH14APY000849	Tree Planting	Broad Creek	02120205	738447.41	1507268.93	0.07
SH14APY000850	Tree Planting	Lower Susquehanna River	02120201	696193.13	1552497.85	0.30

Comprehensive List of Restoration Practices By Contract						
Table I-7: FMIS # AT0685382						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH14APY000851	Tree Planting	Broad Creek	02120205	734519.33	1486600.83	1.61
SH15APY001209	Tree Planting	Bynum Run	02130704	694030.34	1493333.79	0.21
SH15APY001210	Tree Planting	Atkisson Reservoir	02130703	671219.82	1498698.48	0.11
SH15APY001211	Tree Planting	Bush River	02130701	664224.59	1522978.65	0.08
SH14APY000852	Tree Planting	Broad Creek	02120205	739486.97	1504854.04	0.05
SH15APY001212	Tree Planting	Little Gunpowder Falls	02130804	685472.48	1458952.69	0.02
SH15APY001213	Tree Planting	Little Gunpowder Falls	02130804	678954.78	1470115.50	0.02
SH15APY001214	Tree Planting	Atkisson Reservoir	02130703	691357.11	1488926.55	0.05
SH15APY001215	Tree Planting	Atkisson Reservoir	02130703	677979.88	1472040.13	0.12
SH15APY001216	Tree Planting	Little Gunpowder Falls	02130804	682814.05	1463243.83	0.09
SH15APY001217	Tree Planting	Little Gunpowder Falls	02130804	683838.36	1461137.33	0.31
SH15APY001218	Tree Planting	Little Gunpowder Falls	02130804	680756.87	1466884.66	0.05
SH15APY001219	Tree Planting	Little Gunpowder Falls	02130804	680159.66	1467947.56	0.05
SH15APY001220	Tree Planting	Atkisson Reservoir	02130703	678216.39	1471565.20	0.12
SH16APY001368	Tree Planting	Atkisson Reservoir	02130703	695606.09	1475136.22	1.78
SH16APY001369	Tree Planting	Little Gunpowder Falls	02130804	681950.34	1464516.13	0.30
SH15APY001221	Tree Planting	Atkisson Reservoir	02130703	686954.66	1457191.18	0.05
SH15APY001222	Tree Planting	Atkisson Reservoir	02130703	684984.19	1459494.78	0.13
SH16APY001370	Tree Planting	Atkisson Reservoir	02130703	695512.03	1474634.55	0.51
SH15APY001223	Tree Planting	Atkisson Reservoir	02130703	690718.24	1453805.20	0.13
SH16APY001371	Tree Planting	Little Gunpowder Falls	02130804	682435.58	1463906.55	0.46
SH14APY000853	Tree Planting	Broad Creek	02120205	748642.63	1495573.49	0.22
SH14APY000854	Tree Planting	Broad Creek	02120205	748630.36	1495315.51	0.46
SH15APY001224	Tree Planting	Bynum Run	02130704	693555.08	1487379.14	0.16
SH16APY001372	Tree Planting	Atkisson Reservoir	02130703	695463.93	1478642.48	0.85
SH16APY001373	Tree Planting	Atkisson Reservoir	02130703	700032.75	1461184.91	1.75
SH16APY001374	Tree Planting	Atkisson Reservoir	02130703	695648.81	1473728.48	0.21
SH16APY001375	Tree Planting	Atkisson Reservoir	02130703	696725.58	1457772.94	0.70
SH16APY001376	Tree Planting	Deer Creek	02120202	732201.06	1469397.88	0.44
SH16APY001377	Tree Planting	Deer Creek	02120202	732688.63	1470115.37	0.35
SH16APY001378	Tree Planting	Atkisson Reservoir	02130703	685529.80	1483720.49	0.23
SH16APY001379	Tree Planting	Deer Creek	02120202	732504.83	1470026.49	0.02
SH16APY001380	Tree Planting	Deer Creek	02120202	732382.72	1469769.21	0.10
SH14APY000855	Tree Planting	Broad Creek	02120205	735451.19	1487925.50	0.61
SH15APY001226	Tree Planting	Bush River	02130701	662636.47	1525985.69	0.17
SH15APY001227	Tree Planting	Bush River	02130701	662201.37	1525651.12	0.53
SH15APY001228	Tree Planting	Bush River	02130701	661916.82	1525040.29	0.04
SH14APY000856	Tree Planting	Broad Creek	02120205	741229.95	1489781.47	0.05
SH15APY001229	Tree Planting	Atkisson Reservoir	02130703	670838.59	1499000.71	0.15
					Complete BMP Acreage Total	**32.99**

Comprehensive List of Restoration Practices By Contract Table I-8: FMIS # AT0685482						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH16APY001582	Tree Planting	Patapsco River L N Br	02130906	565812.78	1408738.65	0.46
SH16APY001583	Tree Planting	Baltimore Harbor	02130903	560820.76	1413661.97	0.22
SH16APY001584	Tree Planting	Baltimore Harbor	02130903	559422.57	1421463.20	0.04
SH16APY001257	Tree Planting	Patuxent River lower	02131101	389410.54	1427976.05	0.14
SH16APY001258	Tree Planting	South River	02131003	469048.83	1414029.46	0.15
SH16APY001259	Tree Planting	Patuxent River middle	02131102	416341.82	1397189.17	0.12
SH16APY001260	Tree Planting	Patuxent River middle	02131102	406084.56	1418766.19	0.09
SH16APY001261	Tree Planting	West River	02131004	446302.88	1435440.11	0.06
SH16APY001262	Tree Planting	South River	02131003	451422.26	1438832.19	0.23
SH16APY001263	Tree Planting	Patuxent River middle	02131102	407855.39	1414980.60	0.45
SH16APY001264	Tree Planting	Patuxent River middle	02131102	402480.92	1426615.06	0.16
SH16APY001265	Tree Planting	Patuxent River middle	02131102	408222.12	1428673.42	0.15
SH16APY001266	Tree Planting	West River	02131004	444371.62	1435021.11	0.12
SH16APY001267	Tree Planting	West Chesapeake Bay	02131005	417765.14	1425217.36	0.62
SH16APY001268	Tree Planting	Patuxent River middle	02131102	420117.60	1424520.58	0.09
SH16APY001563	Tree Planting	West Chesapeake Bay	02131005	395429.26	1428137.24	0.09
SH16APY001564	Tree Planting	Patuxent River middle	02131102	396571.12	1427887.70	0.27
SH16APY001269	Tree Planting	Patuxent River middle	02131102	407367.69	1415679.85	0.95
SH16APY001270	Tree Planting	Patuxent River middle	02131102	408501.91	1413417.61	0.33
SH16APY001271	Tree Planting	Patuxent River middle	02131102	405898.17	1419595.00	0.20
SH16APY001272	Tree Planting	West River	02131004	445988.94	1435268.39	0.24
SH16APY001273	Tree Planting	South River	02131003	451806.12	1438996.76	0.16
SH16APY001274	Tree Planting	Patuxent River middle	02131102	420351.98	1424383.67	0.09
SH16APY001275	Tree Planting	Patuxent River middle	02131102	413616.95	1426691.60	0.05
SH16APY001566	Tree Planting	Patuxent River middle	02131102	406004.40	1420846.57	0.12
SH16APY001553	Tree Planting	Patuxent River middle	02131102	406299.06	1417002.45	0.05
SH16APY001276	Tree Planting	West Chesapeake Bay	02131005	408297.18	1428897.18	0.16
SH16APY001277	Tree Planting	Patuxent River middle	02131102	405997.29	1419178.43	0.31
SH16APY001278	Tree Planting	Patuxent River lower	02131101	388006.67	1427369.91	0.38
SH16APY001279	Tree Planting	South River	02131003	470920.35	1411059.12	0.14
SH16APY001280	Tree Planting	Patuxent River middle	02131102	406067.86	1418889.94	0.08
SH16APY001281	Tree Planting	Patuxent River middle	02131102	419897.72	1424613.82	0.05
SH16APY001282	Tree Planting	Patuxent River middle	02131102	407633.70	1427356.10	0.21
SH16APY001283	Tree Planting	Patuxent River middle	02131102	411915.35	1426662.70	0.46
SH16APY001284	Tree Planting	Patuxent River middle	02131102	406230.32	1421418.29	0.52
SH16APY001285	Tree Planting	West Chesapeake Bay	02131005	418586.66	1424951.71	0.27
SH16APY001286	Tree Planting	Patuxent River middle	02131102	417063.90	1425451.38	0.09
SH16APY001287	Tree Planting	Patuxent River middle	02131102	405844.17	1420169.76	0.51
SH16APY001552	Tree Planting	Patuxent River middle	02131102	406256.86	1417175.68	0.12
SH16APY001288	Tree Planting	West Chesapeake Bay	02131005	422017.46	1422416.61	0.41
SH16APY001575	Tree Planting	South River	02131003	452342.53	1439250.47	0.02
SH16APY001289	Tree Planting	Patuxent River middle	02131102	411290.65	1426668.14	0.19
SH16APY001546	Tree Planting	South River	02131003	478709.67	1440213.23	0.30
SH16APY001545	Tree Planting	Patuxent River middle	02131102	407077.11	1423184.62	0.07
SH16APY001544	Tree Planting	Severn River	02131002	514807.27	1403932.72	0.57
SH16APY001543	Tree Planting	Severn River	02131002	514570.89	1404617.47	0.59
SH16APY001290	Tree Planting	Patuxent River middle	02131102	421504.21	1423025.86	0.04
SH16APY001291	Tree Planting	Patuxent River lower	02131101	386418.45	1426336.94	0.17
SH16APY001292	Tree Planting	Patuxent River middle	02131102	408030.48	1414588.61	0.19
SH16APY001293	Tree Planting	Severn River	02131002	490655.81	1456221.00	0.08
SH16APY001542	Tree Planting	Patuxent River middle	02131102	416199.59	1397324.37	0.24
SH16APY001541	Tree Planting	Severn River	02131002	495318.30	1467921.01	0.34
SH16APY001294	Tree Planting	Severn River	02131002	491455.05	1456407.62	0.18
SH16APY001295	Tree Planting	Severn River	02131002	490863.16	1457129.47	0.42
SH16APY001296	Tree Planting	Severn River	02131002	491373.43	1457019.82	0.14
SH16APY001297	Tree Planting	Severn River	02131002	490818.47	1456098.47	0.15
SH16APY001298	Tree Planting	Severn River	02131002	491418.54	1456197.32	0.23
SH16APY001299	Tree Planting	Severn River	02131002	494270.63	1462282.64	0.22
SH16APY001300	Tree Planting	Severn River	02131002	496134.74	1468586.27	0.12
SH16APY001572	Tree Planting	Severn River	02131002	495663.67	1467799.53	0.21
SH16APY001301	Tree Planting	Severn River	02131002	493827.29	1461066.99	0.16
SH16APY001302	Tree Planting	Severn River	02131002	490254.24	1457427.20	0.06
SH16APY001303	Tree Planting	Severn River	02131002	480191.79	1441658.73	0.13
SH16APY001570	Tree Planting	Severn River	02131002	508941.37	1413926.47	0.46
SH16APY001569	Tree Planting	Severn River	02131002	519227.47	1400965.87	0.36
SH16APY001577	Tree Planting	Severn River	02131002	522028.81	1399336.67	0.33
SH16APY001305	Tree Planting	South River	02131003	476147.60	1442758.17	0.11
SH16APY001306	Tree Planting	South River	02131003	475745.93	1443066.04	0.15
SH16APY001308	Tree Planting	West Chesapeake Bay	02131005	421784.00	1422786.98	0.30
SH16APY001309	Tree Planting	Patuxent River middle	02131102	421017.17	1423844.00	0.16
SH16APY001310	Tree Planting	Patuxent River middle	02131102	420856.41	1423954.34	0.06
SH16APY001311	Tree Planting	Patuxent River middle	02131102	420786.17	1424009.39	0.03
SH16APY001312	Tree Planting	Patuxent River middle	02131102	420660.81	1424111.42	0.12
SH16APY001567	Tree Planting	South River	02131003	452208.77	1439179.14	0.03
SH16APY001348	Tree Planting	Patuxent River lower	02131101	316308.36	1375466.67	0.49
SH16APY001571	Tree Planting	Zekiah Swamp	02140108	347107.25	1348062.92	0.19
SH16APY001349	Tree Planting	Mattawoman Creek	02140111	359902.56	1348346.91	0.16

Comprehensive List of Restoration Practices By Contract						
Table I-8: FMIS # AT0685482						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH16APY001573	Tree Planting	Patuxent River lower	02131101	318813.57	1372659.13	0.35
SH16APY001576	Tree Planting	Patuxent River lower	02131101	319403.33	1372284.07	0.10
SH16APY001350	Tree Planting	Patuxent River lower	02131101	314000.06	1376153.45	0.29
SH16APY001351	Tree Planting	Patuxent River lower	02131101	319340.24	1372039.61	0.19
SH16APY001352	Tree Planting	Mattawoman Creek	02140111	360456.04	1348226.80	0.19
SH16APY001578	Tree Planting	Gilbert Swamp	02140107	293814.24	1364861.18	0.20
SH16APY001353	Tree Planting	Zekiah Swamp	02140108	346248.32	1348117.45	0.35
SH16APY001579	Tree Planting	Gilbert Swamp	02140107	294275.72	1360869.16	0.32
SH16APY001568	Tree Planting	Nanjemoy Creek	02140110	299465.05	1246060.66	0.28
				Complete BMP Acreage Total		**19.36**

Comprehensive List of Restoration Practices By Contract Table I-9: FMIS # AT0685582						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH15APY001055	Tree Planting	Back Creek	02130604	678224.46	1646149.20	0.11
SH15APY001056	Tree Planting	Back Creek	02130604	678261.60	1645948.09	0.17
SH15APY001057	Tree Planting	Octoraro Creek	02120203	749772.22	1585012.18	0.47
SH15APY001058	Tree Planting	Octoraro Creek	02120203	747128.59	1580893.23	0.31
SH15APY001059	Tree Planting	Octoraro Creek	02120203	717147.81	1571821.99	0.07
SH15APY001060	Tree Planting	Little Elk Creek	02130605	727993.36	1634640.76	0.43
SH15APY001061	Tree Planting	Little Elk Creek	02130605	727288.83	1634794.04	0.23
SH15APY001062	Tree Planting	Little Elk Creek	02130605	743236.11	1626486.41	0.04
SH15APY001063	Tree Planting	Little Elk Creek	02130605	726929.55	1634989.81	0.12
SH15APY001064	Tree Planting	Northeast River	02130608	715495.09	1607688.68	0.03
SH15APY001065	Tree Planting	Northeast River	02130608	715421.04	1607714.60	0.04
SH15APY001066	Tree Planting	Octoraro Creek	02120203	747378.46	1581599.79	0.07
SH15APY001067	Tree Planting	Octoraro Creek	02120203	747244.50	1581662.75	0.13
SH15APY001068	Tree Planting	Little Elk Creek	02130605	725455.96	1636001.98	0.05
SH15APY001069	Tree Planting	Northeast River	02130608	731166.71	1605621.49	0.12
SH15APY001070	Tree Planting	Northeast River	02130608	731398.05	1605501.55	0.04
SH15APY001071	Tree Planting	Octoraro Creek	02120203	745104.61	1574495.64	0.24
SH15APY001072	Tree Planting	Octoraro Creek	02120203	746855.07	1580611.73	0.54
SH15APY001073	Tree Planting	Octoraro Creek	02120203	733076.98	1573141.74	0.10
SH15APY001074	Tree Planting	Octoraro Creek	02120203	740088.94	1567736.99	0.38
SH15APY001075	Tree Planting	Little Elk Creek	02130605	741429.26	1621901.58	0.34
SH15APY001076	Tree Planting	Little Elk Creek	02130605	726643.92	1635214.25	0.22
SH15APY001077	Tree Planting	Little Elk Creek	02130605	724979.32	1636164.28	0.13
SH15APY001078	Tree Planting	Little Elk Creek	02130605	710679.22	1636549.68	0.13
SH15APY001080	Tree Planting	Little Elk Creek	02130605	728649.33	1634590.73	0.06
SH15APY001081	Tree Planting	Northeast River	02130608	715050.80	1607799.47	0.21
SH15APY001082	Tree Planting	Octoraro Creek	02120203	717492.10	1572182.81	0.04
SH15APY001083	Tree Planting	Octoraro Creek	02120203	716638.79	1571310.44	0.09
SH15APY001084	Tree Planting	Octoraro Creek	02120203	745172.46	1575608.99	0.30
SH15APY001085	Tree Planting	Octoraro Creek	02120203	740437.79	1568139.94	0.06
SH15APY001086	Tree Planting	Octoraro Creek	02120203	749521.60	1584787.64	0.34
SH15APY001079	Tree Planting	Octoraro Creek	02120203	731320.62	1573055.29	0.16
SH15APY001087	Tree Planting	Northeast River	02130608	722056.79	1624285.73	0.31
SH15APY001088	Tree Planting	Northeast River	02130608	719588.92	1607422.47	2.86
				Complete BMP Acreage Total		**8.92**

Comprehensive List of Restoration Practices By Contract						
Table I-10: FMIS # AT0865182						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH16RST150021	Retrofit	Rock Creek	02140206	526599.21	1291010.18	3.61
SH16RST150023	Retrofit	Anacostia River	02140205	530812.72	1291753.49	7.46
SH16RST150026	Retrofit	Cabin John Creek	02140207	506302.10	1268867.05	2.47
SH16RST150029	Retrofit	Cabin John Creek	02140207	505812.90	1268327.78	1.11
SH16RST150342	Retrofit	Rock Creek	02140206	525354.20	1289986.04	2.77
SH16RST150343	Retrofit	Rock Creek	02140206	526011.38	1290942.56	2.49
SH16RST160101	Retrofit	Anacostia River	02140205	435834.56	1340561.16	5.68
SH16RST160170	Retrofit	Patuxent River upper	02131104	521281.40	1355421.37	0.13
SH16RST160171	Retrofit	Patuxent River upper	02131104	521464.11	1355574.52	0.07
SH16RST160189	Retrofit	Piscataway Creek	02140203	397714.20	1346623.29	0.50
SH16RST160190	Retrofit	Piscataway Creek	02140203	392907.94	1346761.02	0.21
SH16RST160210	Retrofit	Western Branch	02131103	466123.94	1357628.35	1.90
SH16RST160702	Retrofit	Anacostia River	02140205	483867.63	1340270.32	2.36
				Complete BMP Acreage Total		**30.74**

Comprehensive List of Restoration Practices By Contract						
Table I-11: FMIS # AT0875182						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH16RST020090	Retrofit	Severn River	02131002	510265.25	1412617.94	0.76
SH16RST020163	Retrofit	South River	02131003	490012.08	1422665.76	1.52
SH16RST020221	Retrofit	Severn River	02131002	504058.38	1418936.86	0.73
SH16RST020252	Retrofit	South River	02131003	480675.15	1439401.26	3.41
SH16RST020262	Retrofit	South River	02131003	479910.62	1440637.47	6.18
SH16RST020266	Retrofit	South River	02131003	479799.27	1440181.90	1.14
SH16RST020269	Retrofit	South River	02131003	480023.12	1438172.45	19.52
SH16RST020337	Retrofit	Patuxent River middle	02131102	413922.11	1400944.51	1.54
SH16RST020438	Retrofit	Severn River	02131002	508445.01	1414976.76	10.17
SH16RST020547	Retrofit	Baltimore Harbor	02130903	532307.33	1413802.78	18.70
					Complete BMP Acreage Total	**63.69**

Comprehensive List of Restoration Practices By Contract						
Table I-12: FMIS # AT0885182						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH16RST100300	Grass Swale	Upper Monocacy River	02140303	657949.21	1199262.14	0.73
SH16RST100305	Bioretention	Upper Monocacy River	02140303	661611.34	1200322.01	1.71
SH16RST100306	Grass Swale	Upper Monocacy River	02140303	663623.31	1200039.76	0.92
SH15RST130546	Swales	Little Patuxent River	02131105	539491.74	1362636.51	0.49
SH15RST130551	Swales	Little Patuxent River	02131105	536671.24	1364899.57	0.38
SH15RST130552	Swales	Little Patuxent River	02131105	534629.15	1367605.93	0.20
SH15RST130561	Swales	Middle Patuxent River	02131106	556353.97	1335461.83	0.54
SH15RST130563	Swales	Middle Patuxent River	02131106	556209.75	1335877.09	0.12
SH15RST130564	Swales	Middle Patuxent River	02131106	555119.85	1338415.14	0.70
SH15RST130566	Swales	Middle Patuxent River	02131106	553807.03	1340187.71	0.19
SH15RST130568	Swales	Little Patuxent River	02131105	548315.90	1355275.77	0.12
SH15RST130569	Swales	Little Patuxent River	02131105	548449.13	1355416.61	0.37
SH15RST130571	Swales	Little Patuxent River	02131105	550254.31	1351388.14	0.39
SH15RST130573	Swales	Little Patuxent River	02131105	548883.78	1354031.28	0.20
SH15RST130575	Swales	Little Patuxent River	02131105	548536.86	1354788.30	0.20
SH15RST130576	Swales	Little Patuxent River	02131105	549217.27	1353737.38	0.36
SH15RST130577	Swales	Little Patuxent River	02131105	549651.66	1352791.06	0.31
SH16RST130620	Grass Swale	Little Patuxent River	02131105	570266.87	1365271.02	0.31
SH16RST130627	Grass Swale	Patapsco River L N Br	02130906	558685.23	1377355.68	0.49
SH16RST130630	Grass Swale	Patapsco River L N Br	02130906	556062.21	1379739.30	0.49
SH16RST130631	Grass Swale	Patapsco River L N Br	02130906	552371.14	1384161.40	0.11
SH16RST130632	Grass Swale	Patapsco River L N Br	02130906	552113.50	1384542.60	0.29
SH16RST100311	Grass Swale	Upper Monocacy River	02140303	669749.71	1198839.63	0.40
SH16RST100316	Grass Swale	Upper Monocacy River	02140303	672862.96	1196805.71	0.45
SH16RST100319	Grass Swale	Lower Monocacy River	02140302	632546.83	1205265.47	0.24
SH16RST100320	Grass Swale	Lower Monocacy River	02140302	632003.33	1206547.91	0.32
SH16RST100322	Grass Swale	Lower Monocacy River	02140302	630440.47	1209737.48	0.31
SH16RST100323	Grass Swale	Lower Monocacy River	02140302	630323.28	1211368.38	0.62
SH16RST100325	Grass Swale	Lower Monocacy River	02140302	630341.19	1212673.95	0.36
SH16RST100328	Grass Swale	Lower Monocacy River	02140302	630218.13	1214332.84	0.59
SH16RST100330	Grass Swale	Lower Monocacy River	02140302	629949.49	1216061.38	0.68
SH16RST100331	Grass Swale	Lower Monocacy River	02140302	629725.18	1216918.43	0.65
SH16RST100332	Grass Swale	Lower Monocacy River	02140302	629471.97	1217732.24	0.53
SH16RST100335	Grass Swale	Lower Monocacy River	02140302	628798.18	1219842.48	0.81
SH15RST130544	Swales	Little Patuxent River	02131105	544809.97	1359485.80	0.31
SH15RST130549	Swales	Little Patuxent River	02131105	537209.06	1364223.72	0.95
SH15RST130555	Swales	Middle Patuxent River	02131106	552099.62	1347054.06	0.64
SH15RST130557	Swales	Middle Patuxent River	02131106	560789.66	1329566.44	0.29
SH15RST130559	Swales	Middle Patuxent River	02131106	560366.14	1330196.98	1.11
SH15RST130562	Swales	Middle Patuxent River	02131106	556232.52	1335811.67	0.05
SH15RST130570	Swales	Little Patuxent River	02131105	546871.22	1357508.05	0.30
SH16RST100299	Grass Swale	Upper Monocacy River	02140303	656845.01	1198930.90	0.72
SH16RST100301	Grass Swale	Upper Monocacy River	02140303	658764.92	1199654.88	0.87
SH16RST100302	Bioretention	Upper Monocacy River	02140303	659410.53	1199965.35	0.33
SH16RST100303	Bioretention	Upper Monocacy River	02140303	659478.70	1199989.27	0.49
SH16RST100304	Grass Swale	Upper Monocacy River	02140303	660027.26	1200169.32	0.80
SH16RST100309	Grass Swale	Upper Monocacy River	02140303	666353.85	1199950.91	0.32
SH16RST100310	Grass Swale	Upper Monocacy River	02140303	668369.20	1199574.57	1.54
SH16RST100312	Grass Swale	Upper Monocacy River	02140303	670685.17	1198230.61	0.44
SH16RST100313	Grass Swale	Upper Monocacy River	02140303	671231.79	1197869.72	0.40
SH16RST100314	Grass Swale	Upper Monocacy River	02140303	671784.22	1197509.61	0.42
SH16RST100315	Grass Swale	Upper Monocacy River	02140303	672343.93	1197145.24	0.33
SH16RST100321	Grass Swale	Lower Monocacy River	02140302	631673.54	1207318.48	0.27
SH16RST100324	Grass Swale	Lower Monocacy River	02140302	630332.50	1212132.12	0.33
SH16RST100326	Grass Swale	Lower Monocacy River	02140302	630343.88	1213038.65	0.68
SH16RST100327	Grass Swale	Lower Monocacy River	02140302	630296.21	1213748.16	0.41
SH16RST100329	Grass Swale	Lower Monocacy River	02140302	630095.26	1215166.89	0.58
SH16RST100333	Grass Swale	Lower Monocacy River	02140302	629255.99	1218400.68	0.71
SH16RST100334	Grass Swale	Lower Monocacy River	02140302	629037.59	1219104.45	0.46
SH15RST130572	Swales	Little Patuxent River	02131105	549070.29	1353636.63	0.44
SH15RST130574	Swales	Little Patuxent River	02131105	548742.54	1354334.69	0.20
SH16RST130619	Grass Swale	Little Patuxent River	02131105	573022.67	1364738.45	0.57
SH16RST130621	Grass Swale	Patapsco River L N Br	02130906	566432.66	1368404.78	0.47
SH16RST130622	Grass Swale	Patapsco River L N Br	02130906	566353.53	1368709.40	0.29
SH16RST130623	Grass Swale	Patapsco River L N Br	02130906	566076.20	1369661.99	0.39
SH16RST130624	Grass Swale	Patapsco River L N Br	02130906	561766.53	1371129.11	0.30
SH16RST130625	Grass Swale	Patapsco River L N Br	02130906	561366.95	1374330.16	0.16
SH16RST130628	Grass Swale	Patapsco River L N Br	02130906	558136.42	1377850.30	0.31
SH16RST130629	Grass Swale	Patapsco River L N Br	02130906	556810.21	1379061.28	0.47
				Complete BMP Acreage Total		**32.91**

Comprehensive List of Restoration Practices By Contract						
Table I-13: FMIS # AT0895182						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH16RST021244	Grass Swale	Severn River	02131002	492844.95	1455640.07	0.33
SH16RST080764	Grass Swale	Potomac River L tidal	02140101	277820.87	1320607.50	0.48
SH16RST080785	Grass Swale	Port Tobacco River	02140109	299476.11	1315883.95	0.37
SH16RST080786	Grass Swale	Port Tobacco River	02140109	299955.40	1315926.44	0.32
SH16RST080788	Grass Swale	Port Tobacco River	02140109	301129.29	1316040.97	0.37
SH16RST021222	Grass Swale	Magothy River	02131001	506302.66	1446837.26	0.79
SH16RST021223	Bioretention	Severn River	02131002	498527.35	1451983.35	0.58
SH16RST021225	Bioretention	Severn River	02131002	498171.51	1452212.25	0.56
SH16RST021232	Grass Swale	Magothy River	02131001	499895.69	1451102.12	0.28
SH16RST021237	Bioretention	Severn River	02131002	497557.70	1452607.43	0.29
SH16RST021238	Grass Swale	Severn River	02131002	497021.87	1452953.10	0.67
SH16RST021239	Grass Swale	Severn River	02131002	495994.68	1453614.65	0.46
SH16RST021240	Bioretention	Severn River	02131002	495224.27	1454108.51	0.46
SH16RST021241	Grass Swale	Severn River	02131002	493786.58	1455031.70	0.65
SH16RST080750	Grass Swale	Potomac River L tidal	02140101	279174.70	1319613.90	0.83
SH16RST080756	Grass Swale	Zekiah Swamp	02140108	282309.41	1317300.55	0.67
SH16RST080758	Grass Swale	Zekiah Swamp	02140108	283417.54	1316482.34	0.43
SH16RST080760	Grass Swale	Zekiah Swamp	02140108	284431.88	1315787.66	1.14
SH16RST080767	Grass Swale	Port Tobacco River	02140109	290858.28	1315064.56	0.26
SH16RST080772	Grass Swale	Port Tobacco River	02140109	292685.73	1315241.43	0.50
SH16RST080777	Grass Swale	Port Tobacco River	02140109	295237.40	1315486.28	0.82
SH16RST080780	Grass Swale	Port Tobacco River	02140109	297331.79	1315676.21	0.96
SH16RST080797	Grass Swale	Port Tobacco River	02140109	308341.87	1317310.13	0.44
SH16RST080796	Grass Swale	Port Tobacco River	02140109	307797.61	1317198.12	0.25
				Complete BMP Acreage Total		**12.91**

Comprehensive List of Restoration Practices By Contract						
Table I-14: FMIS # AT4285282						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH17APY001538	Impervious Surface Elimination (to Pervious)	S Branch Patapsco	02130908	648845.68	1295640.75	0.17
SH17APY001537	Impervious Surface Elimination (to Pervious)	Double Pipe Creek	02140304	725914.30	1342411.26	0.06
SH17APY001536	Impervious Surface Elimination (to Pervious)	Upper Monocacy River	02140303	730361.70	1267298.84	0.14
SH17APY001539	Impervious Surface Elimination (to Pervious)	Lower Monocacy River	02140302	630551.56	1209534.72	0.69
SH17APY001535	Impervious Surface Elimination (to Pervious)	Lower Monocacy River	02140302	633157.07	1188837.12	0.07
SH17APY001534	Impervious Surface Elimination (to Pervious)	Lower Monocacy River	02140302	636743.38	1189674.62	0.47
SH17APY001540	Impervious Surface Elimination (to Pervious)	Catoctin Creek	02140305	636153.58	1147957.05	0.11
SH17APY001533	Impervious Surface Elimination (to Pervious)	Little Patuxent River	02131105	548311.73	1372284.00	0.17
				Complete BMP Acreage Total		**1.88**

Comprehensive List of Restoration Practices By Contract						
Table I-15: FMIS # AT5025182						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH13APY000532	Tree Planting	Gwynns Falls	02130905	643730.81	1364286.78	0.24
SH12APY000377	Tree Planting	Gwynns Falls	02130905	622499.44	1382911.44	0.20
SH13APY000533	Tree Planting	Gwynns Falls	02130905	622795.63	1382826.49	0.33
SH13APY000534	Tree Planting	Gwynns Falls	02130905	623509.66	1382548.12	1.41
SH13APY000535	Tree Planting	Gwynns Falls	02130905	627337.84	1379984.08	0.59
SH13APY000536	Tree Planting	Gwynns Falls	02130905	632999.89	1377845.85	0.26
SH13APY000537	Tree Planting	Gwynns Falls	02130905	634577.21	1374148.85	0.30
SH13APY000538	Tree Planting	Gwynns Falls	02130905	634905.71	1373333.72	0.13
SH13APY000539	Tree Planting	Gwynns Falls	02130905	635692.93	1371878.01	0.50
SH13APY000540	Tree Planting	Gwynns Falls	02130905	636421.96	1370796.42	0.18
SH13APY000541	Tree Planting	Gwynns Falls	02130905	645973.72	1362861.07	0.19
SH13APY000542	Tree Planting	Gwynns Falls	02130905	646094.39	1362709.03	0.09
SH13APY000543	Tree Planting	Gwynns Falls	02130905	649420.34	1360563.23	0.27
SH13APY000544	Tree Planting	Gwynns Falls	02130905	635138.80	1371247.73	0.64
SH12APY000378	Tree Planting	Gwynns Falls	02130905	626780.32	1379879.05	2.95
SH12APY000379	Tree Planting	Gwynns Falls	02130905	625708.52	1380948.20	1.29
SH12APY000380	Tree Planting	Deer Creek	02120202	747758.55	1409434.11	0.43
SH12APY000381	Tree Planting	Loch Raven Reservoir	02130805	742449.77	1411815.49	0.35
SH12APY000382	Tree Planting	Loch Raven Reservoir	02130805	665436.86	1406460.82	0.22
SH12APY000383	Tree Planting	Jones Falls	02130904	645391.78	1415478.59	0.11
SH13APY000545	Tree Planting	Loch Raven Reservoir	02130805	666769.67	1405965.33	0.29
SH12APY000384	Tree Planting	Loch Raven Reservoir	02130805	685711.86	1406103.72	0.55
SH12APY000385	Tree Planting	Loch Raven Reservoir	02130805	705797.61	1408471.96	0.24
SH12APY000386	Tree Planting	Loch Raven Reservoir	02130805	709819.99	1407257.31	0.12
SH12APY000387	Tree Planting	Loch Raven Reservoir	02130805	714138.10	1405554.97	0.62
SH12APY000388	Tree Planting	Loch Raven Reservoir	02130805	723464.93	1407808.22	0.17
SH12APY000389	Tree Planting	Loch Raven Reservoir	02130805	727473.14	1411117.39	0.13
SH12APY000390	Tree Planting	Loch Raven Reservoir	02130805	730192.92	1411997.47	0.47
SH12APY000391	Tree Planting	Loch Raven Reservoir	02130805	730817.96	1412206.50	0.10
SH12APY000392	Tree Planting	Loch Raven Reservoir	02130805	731855.16	1412482.14	0.10
SH12APY000393	Tree Planting	Loch Raven Reservoir	02130805	734283.31	1412207.83	0.32
SH12APY000394	Tree Planting	Deer Creek	02120202	744495.85	1411585.40	0.49
SH12APY000395	Tree Planting	Loch Raven Reservoir	02130805	742288.28	1412533.31	0.93
SH12APY000396	Tree Planting	Deer Creek	02120202	747803.45	1410132.97	0.19
SH12APY000397	Tree Planting	Loch Raven Reservoir	02130805	677610.83	1408045.48	0.31
SH13APY000546	Tree Planting	Back River	02130901	602891.93	1457628.91	0.24
SH13APY000547	Tree Planting	Back River	02130901	593477.62	1452598.80	0.30
SH13APY000548	Tree Planting	Back River	02130901	593189.54	1452968.09	0.12
SH13APY000549	Tree Planting	Back River	02130901	591601.21	1453194.21	0.15
SH13APY000550	Tree Planting	Back River	02130901	591305.95	1453131.45	0.27
SH13APY000551	Tree Planting	Back River	02130901	590267.30	1454757.63	0.28
SH13APY000552	Tree Planting	Back River	02130901	590582.59	1454810.83	0.18
SH13APY000553	Tree Planting	Back River	02130901	590027.32	1455610.41	0.80
SH13APY000554	Tree Planting	Back River	02130901	589030.59	1456972.23	0.16
SH13APY000555	Tree Planting	Baltimore Harbor	02130903	586682.29	1461545.96	0.11
SH13APY000556	Tree Planting	Back River	02130901	587583.47	1461351.07	0.22
SH13APY000557	Tree Planting	Back River	02130901	586785.33	1461871.51	0.63
SH13APY000558	Tree Planting	Baltimore Harbor	02130903	584694.14	1463652.13	0.11
SH13APY000559	Tree Planting	Back River	02130901	582732.88	1464713.54	0.11
SH13APY000560	Tree Planting	Back River	02130901	583453.75	1464701.47	0.22
SH13APY000561	Tree Planting	Back River	02130901	579013.55	1466020.36	0.11
SH13APY000562	Tree Planting	Back River	02130901	578629.58	1465693.85	0.17
SH13APY000563	Tree Planting	Back River	02130901	575886.19	1466713.53	0.27
SH13APY000564	Tree Planting	Lower Gunpowder Falls	02130802	631847.59	1435233.02	0.19
SH13APY000565	Tree Planting	Back River	02130901	630364.70	1439600.40	0.72
SH13APY000566	Tree Planting	Loch Raven Reservoir	02130805	636086.25	1425486.16	0.28
SH13APY000567	Tree Planting	Back River	02130901	630642.89	1439394.12	0.42
SH13APY000568	Tree Planting	Jones Falls	02130904	638671.58	1413560.40	0.64
SH13APY000569	Tree Planting	Gwynns Falls	02130905	600013.96	1384705.93	0.25
SH13APY000570	Tree Planting	Back River	02130901	630149.33	1440456.81	0.11
SH13APY000571	Tree Planting	Back River	02130901	630401.47	1440198.06	0.24
SH13APY000572	Tree Planting	Gwynns Falls	02130905	599366.12	1384228.36	0.41
SH12APY000399	Tree Planting	Gwynns Falls	02130905	622383.23	1384022.61	0.38
SH12APY000401	Tree Planting	Jones Falls	02130904	629937.54	1399793.01	0.14
SH13APY000573	Tree Planting	Loch Raven Reservoir	02130805	636719.93	1421565.15	0.19
SH13APY000575	Tree Planting	Lower Gunpowder Falls	02130802	635318.56	1431174.52	0.24
SH13APY000576	Tree Planting	Back River	02130901	602175.36	1465595.59	0.11
SH13APY000577	Tree Planting	Back River	02130901	602344.28	1465864.82	0.14
SH13APY000578	Tree Planting	Back River	02130901	601608.54	1465809.04	0.73
SH13APY000579	Tree Planting	Back River	02130901	594583.82	1452855.40	0.30
SH13APY000580	Tree Planting	Back River	02130901	592814.51	1448436.59	0.36
SH13APY000581	Tree Planting	Back River	02130901	592798.14	1449475.31	0.26
SH13APY000582	Tree Planting	Back River	02130901	592647.51	1448895.49	0.19
SH13APY000583	Tree Planting	Back River	02130901	593028.67	1448997.94	0.31
SH13APY000584	Tree Planting	Back River	02130901	606797.96	1457183.43	0.11
SH13APY000585	Tree Planting	Back River	02130901	607519.61	1456990.24	0.16
SH13APY000586	Tree Planting	Back River	02130901	607302.36	1457209.58	0.31
SH12APY000402	Tree Planting	Gwynns Falls	02130905	625552.59	1387161.10	0.28
SH12APY000403	Tree Planting	Gwynns Falls	02130905	625355.74	1387334.27	0.28
SH13APY000587	Tree Planting	Back River	02130901	587235.68	1461820.18	0.12
SH13APY000588	Tree Planting	Back River	02130901	587286.59	1461214.03	0.29
SH12APY000404	Tree Planting	Loch Raven Reservoir	02130805	651576.31	1411656.07	0.15
SH13APY000589	Tree Planting	Back River	02130901	586174.13	1474764.03	0.83
SH12APY000405	Tree Planting	Loch Raven Reservoir	02130805	658328.33	1409320.15	0.10
SH13APY000590	Tree Planting	Gwynns Falls	02130905	597592.82	1384174.52	1.55
SH13APY000591	Tree Planting	Back River	02130901	586849.16	1461684.09	0.23

Comprehensive List of Restoration Practices By Contract						
Table I-15: FMIS # AT5025182						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH13APY000592	Tree Planting	Back River	02130901	587325.18	1461268.93	0.06
SH13APY000593	Tree Planting	Back River	02130901	583526.50	1464619.62	0.01
SH12APY000406	Tree Planting	Loch Raven Reservoir	02130805	658537.19	1409240.57	0.04
SH12APY000407	Tree Planting	Loch Raven Reservoir	02130805	655345.66	1408183.26	0.34
SH12APY000408	Tree Planting	Loch Raven Reservoir	02130805	657151.47	1408032.57	0.05
SH12APY000409	Tree Planting	Loch Raven Reservoir	02130805	656759.13	1407897.87	0.03
SH13APY000635	Tree Planting	Lower Winters Run	02130702	640311.86	1507317.30	0.25
SH13APY000636	Tree Planting	Gunpowder River	02130801	639625.43	1507331.04	0.07
SH13APY000637	Tree Planting	Atkisson Reservoir	02130703	676409.09	1489716.85	0.34
SH13APY000638	Tree Planting	Atkisson Reservoir	02130703	682264.78	1490437.63	0.40
SH13APY000639	Tree Planting	Bynum Run	02130704	687231.61	1490550.80	0.41
SH13APY000640	Tree Planting	Bynum Run	02130704	688066.22	1490753.15	0.26
SH13APY000641	Tree Planting	Bynum Run	02130704	688304.21	1490918.08	0.18
SH13APY000642	Tree Planting	Bynum Run	02130704	688662.71	1490973.54	0.52
SH13APY000643	Tree Planting	Bynum Run	02130704	689021.55	1491291.52	1.28
SH13APY000644	Tree Planting	Bynum Run	02130704	688818.01	1490835.08	0.29
SH13APY000645	Tree Planting	Conowingo Dam	02120204	723257.59	1537326.38	0.23
SH13APY000646	Tree Planting	Little Gunpowder Falls	02130804	668057.38	1481715.42	0.25
SH13APY000647	Tree Planting	Atkisson Reservoir	02130703	682807.29	1490195.97	0.39
SH13APY000648	Tree Planting	Lower Winters Run	02130702	639918.66	1507263.31	0.04
SH13APY001581	Tree Planting	Lower Winters Run	02130702	640760.13	1507248.66	0.40
					Complete BMP Acreage Total	**37.06**

Comprehensive List of Restoration Practices By Contract						
Table I-16: FMIS # AT5025282						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH13APY000595	Tree Planting	Double Pipe Creek	02140304	694886.2194	1308122.588	0.30
SH13APY000596	Tree Planting	Double Pipe Creek	02140304	689293.8228	1303126.017	0.23
SH13APY000597	Tree Planting	Double Pipe Creek	02140304	688414.4394	1300824.772	0.28
SH13APY000598	Tree Planting	Double Pipe Creek	02140304	683997.5657	1285496.784	0.26
SH13APY000599	Tree Planting	Double Pipe Creek	02140304	703986.3242	1299047.076	0.72
SH13APY000600	Tree Planting	Double Pipe Creek	02140304	705600.6931	1296427.095	0.90
SH13APY000601	Tree Planting	S Branch Patapsco	02130908	623851.2801	1271818.15	0.06
SH13APY000602	Tree Planting	S Branch Patapsco	02130908	620714.1322	1270940.032	0.20
SH13APY000603	Tree Planting	S Branch Patapsco	02130908	618645.4004	1268569.558	0.09
SH13APY000604	Tree Planting	S Branch Patapsco	02130908	618065.0272	1321924.079	0.16
SH13APY000605	Tree Planting	Double Pipe Creek	02140304	698698.7692	1309851.895	0.38
SH13APY000606	Tree Planting	Double Pipe Creek	02140304	696109.175	1309190.027	0.17
SH14APY000766	Tree Planting	Double Pipe Creek	02140304	693256.7401	1265654.775	0.19
SH14APY000767	Tree Planting	Double Pipe Creek	02140304	688476.4271	1276462.862	0.43
SH14APY000768	Tree Planting	Double Pipe Creek	02140304	684640.7907	1289098.047	0.17
SH14APY000769	Tree Planting	Double Pipe Creek	02140304	685316.1014	1293858.686	0.66
SH14APY000770	Tree Planting	S Branch Patapsco	02130908	625489.3638	1272170.427	0.40
SH14APY000771	Tree Planting	Double Pipe Creek	02140304	690595.8668	1304798.116	0.86
SH14APY000772	Tree Planting	Double Pipe Creek	02140304	692076.3937	1306095.987	0.45
SH14APY000773	Tree Planting	Double Pipe Creek	02140304	695445.5615	1308682.092	0.06
SH14APY000774	Tree Planting	S Branch Patapsco	02130908	626255.8163	1272421.159	0.17
SH14APY000775	Tree Planting	S Branch Patapsco	02130908	617348.9263	1270159.709	0.21
SH14APY000776	Tree Planting	Upper Monocacy River	02140303	728719.1868	1265928.913	1.04
SH14APY000777	Tree Planting	Upper Monocacy River	02140303	730544.3807	1267332.255	0.62
SH14APY000778	Tree Planting	Upper Monocacy River	02140303	744248.8307	1276859.109	0.12
SH14APY000779	Tree Planting	Double Pipe Creek	02140304	655446.2671	1290388.548	0.27
SH14APY000780	Tree Planting	Upper Monocacy River	02140303	737415.8948	1271591.269	0.30
SH14APY000781	Tree Planting	Upper Monocacy River	02140303	747115.1087	1277453.629	0.33
SH14APY000782	Tree Planting	S Branch Patapsco	02130908	650935.8696	1290979.674	0.18
SH14APY000783	Tree Planting	S Branch Patapsco	02130908	628780.8001	1272470.572	0.35
SH14APY000784	Tree Planting	Lower Monocacy River	02140302	654131.773	1280082.758	0.17
SH14APY000785	Tree Planting	S Branch Patapsco	02130908	649244.0066	1294705.499	0.16
SH14APY000786	Tree Planting	Double Pipe Creek	02140304	715141.9456	1282106.552	0.14
SH14APY001556	Tree Planting	Liberty Reservoir	02130907	709498.2364	1350799.227	3.81
SH14APY001557	Tree Planting	Liberty Reservoir	02130907	710637.6859	1350690.305	2.71
SH14APY001558	Tree Planting	Liberty Reservoir	02130907	713707.6667	1349319.928	0.76
SH14APY001559	Tree Planting	Liberty Reservoir	02130907	714846.0033	1349681.86	3.58
SH14APY001560	Tree Planting	Liberty Reservoir	02130907	716234.9051	1349746.515	0.91
SH14APY001561	Tree Planting	Liberty Reservoir	02130907	709466.1519	1349232.77	12.23
SH14APY001562	Tree Planting	Liberty Reservoir	02130907	712337.7301	1349434.714	10.32
SH14APY000787	Tree Planting	Upper Monocacy River	02140303	736939.7455	1271328.195	0.17
SH14APY000788	Tree Planting	S Branch Patapsco	02130908	626310.6289	1272250.302	0.39
SH14APY000789	Tree Planting	S Branch Patapsco	02130908	626986.4851	1272294.349	0.47
SH14APY000790	Tree Planting	Upper Monocacy River	02140303	727824.1486	1265192.071	0.19
SH13APY000607	Tree Planting	Double Pipe Creek	02140304	695230.866	1308493.223	0.05
SH13APY000608	Tree Planting	Double Pipe Creek	02140304	692933.2289	1306816.08	0.14
SH13APY000609	Tree Planting	Double Pipe Creek	02140304	694345.7582	1307700.116	0.18
SH13APY000610	Tree Planting	Double Pipe Creek	02140304	693649.5798	1307288.09	0.14
SH13APY000611	Tree Planting	Double Pipe Creek	02140304	688753.7048	1301748.391	0.01
SH13APY000612	Tree Planting	Double Pipe Creek	02140304	687435.7369	1299448.263	0.09
SH13APY000613	Tree Planting	Double Pipe Creek	02140304	688115.1493	1300291.609	0.11
SH13APY000614	Tree Planting	Double Pipe Creek	02140304	687722.4266	1299778.903	0.08
SH14APY000791	Tree Planting	Double Pipe Creek	02140304	691444.6712	1305485.531	0.39
SH13APY000622	Tree Planting	Lower Monocacy River	02140302	631083.0695	1194566.375	0.75
SH13APY000623	Tree Planting	Lower Monocacy River	02140302	632745.8299	1204349.045	2.17
SH13APY000624	Tree Planting	Lower Monocacy River	02140302	633357.0328	1212773.593	0.25
SH13APY000625	Tree Planting	Lower Monocacy River	02140302	678118.7933	1224282.551	0.28
SH13APY000626	Tree Planting	Lower Monocacy River	02140302	682624.3948	1223790.654	0.22
SH13APY000627	Tree Planting	Lower Monocacy River	02140302	646854.0172	1198172.232	0.17
SH13APY000628	Tree Planting	Lower Monocacy River	02140302	647735.524	1198731.122	0.43
SH13APY000629	Tree Planting	Lower Monocacy River	02140302	647127.5928	1198474.135	0.25
SH13APY000630	Tree Planting	Upper Monocacy River	02140303	706526.7827	1192231.158	0.20
SH13APY000631	Tree Planting	Upper Monocacy River	02140303	717520.6787	1197131.328	0.33
SH13APY000632	Tree Planting	Upper Monocacy River	02140303	741282.7218	1225080.631	0.04
SH13APY000633	Tree Planting	Upper Monocacy River	02140303	741642.3618	1224444.645	0.21
SH14APY000792	Tree Planting	Lower Monocacy River	02140302	637038.3905	1189176.997	0.39
SH14APY000793	Tree Planting	Catoctin Creek	02140305	655569.3709	1167898.657	0.23
SH14APY000794	Tree Planting	Catoctin Creek	02140305	644822.564	1157943.608	0.21
SH14APY000795	Tree Planting	Catoctin Creek	02140305	644151.102	1157095.86	0.20
SH14APY000796	Tree Planting	Catoctin Creek	02140305	635692.6977	1145840.636	0.14
SH14APY000797	Tree Planting	Lower Monocacy River	02140302	625508.5206	1230916.383	0.04
SH14APY000798	Tree Planting	Lower Monocacy River	02140302	624186.851	1234656.384	0.42
SH14APY000799	Tree Planting	Lower Monocacy River	02140302	620510.6539	1254221.588	0.12
SH14APY000800	Tree Planting	Lower Monocacy River	02140302	619690.5092	1255627.612	0.12
SH14APY000801	Tree Planting	Lower Monocacy River	02140302	619349.1395	1170527.032	0.59
SH14APY000802	Tree Planting	Lower Monocacy River	02140302	621001.1667	1172566.177	0.28
SH14APY000803	Tree Planting	Potomac River FR Cnty	02140301	610834.2477	1132512.019	0.02
SH14APY000804	Tree Planting	Lower Monocacy River	02140302	626347.721	1182993.733	0.13
SH14APY000805	Tree Planting	Lower Monocacy River	02140302	661337.6379	1251155.813	0.31
SH14APY000806	Tree Planting	Lower Monocacy River	02140302	661633.6383	1247216.632	0.08

Comprehensive List of Restoration Practices By Contract						
Table I-16: FMIS # AT5025282						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH14APY000807	Tree Planting	Lower Monocacy River	02140302	678558.6369	1224457.326	0.76
SH14APY000808	Tree Planting	Lower Monocacy River	02140302	616544.6228	1263999.22	0.36
SH14APY000809	Tree Planting	Lower Monocacy River	02140302	661552.1932	1247488.608	0.09
SH13APY000634	Tree Planting	Upper Monocacy River	02140303	717320.002	1196787.302	0.11
SH14APY000810	Tree Planting	Potomac River FR Cnty	02140301	611133.2061	1132882.346	0.06
SH14APY000811	Tree Planting	Catoctin Creek	02140305	655209.4333	1168086.108	0.15
SH14APY000812	Tree Planting	Catoctin Creek	02140305	645235.99	1158187.733	0.62
SH14APY000813	Tree Planting	Lower Monocacy River	02140302	661336.154	1250755.725	0.02
SH14APY000814	Tree Planting	Lower Monocacy River	02140302	679480.9133	1224566.47	0.16
SH13APY000649	Tree Planting	Patapsco River L N Br	02130906	561535.948	1372978.971	0.39
SH13APY000650	Tree Planting	Patapsco River L N Br	02130906	561497.5144	1373634.039	0.11
SH13APY000651	Tree Planting	Patapsco River L N Br	02130906	561530.0983	1374069.881	0.09
SH13APY000652	Tree Planting	Patapsco River L N Br	02130906	554124.7322	1381939.414	0.22
SH13APY000653	Tree Planting	Patapsco River L N Br	02130906	554676.7032	1381357.768	0.24
SH13APY000654	Tree Planting	Little Patuxent River	02131105	555678.6376	1365258.772	0.25
SH13APY000655	Tree Planting	Little Patuxent River	02131105	555294.0321	1365345.98	0.59
SH13APY000656	Tree Planting	Little Patuxent River	02131105	555023.2399	1365854.199	0.14
SH13APY000657	Tree Planting	Middle Patuxent River	02131106	585442.2523	1315892.288	0.49
SH13APY000658	Tree Planting	Middle Patuxent River	02131106	585291.931	1316143.977	0.21
SH13APY000659	Tree Planting	Little Patuxent River	02131105	536340.3971	1366018.459	0.71
SH13APY000660	Tree Planting	Little Patuxent River	02131105	536032.8688	1365144.062	0.79
SH13APY000661	Tree Planting	Little Patuxent River	02131105	535662.3912	1365655.385	0.61
SH13APY000662	Tree Planting	Little Patuxent River	02131105	572832.8697	1357994.033	0.49
SH13APY000663	Tree Planting	Little Patuxent River	02131105	568405.1656	1356488.12	0.05
SH13APY000664	Tree Planting	Little Patuxent River	02131105	568745.8575	1356610.455	0.15
SH13APY000665	Tree Planting	Little Patuxent River	02131105	568076.4271	1356461.757	0.08
SH13APY000666	Tree Planting	Little Patuxent River	02131105	555046.192	1349771.081	0.07
SH13APY000667	Tree Planting	Middle Patuxent River	02131106	551069.5523	1347375.378	0.23
SH13APY000668	Tree Planting	Middle Patuxent River	02131106	551784.6342	1347192.123	0.26
SH13APY000669	Tree Planting	Little Patuxent River	02131105	552223.1035	1348272.21	0.07
SH13APY000670	Tree Planting	Little Patuxent River	02131105	551226.7239	1348087.239	0.24
SH13APY000671	Tree Planting	Little Patuxent River	02131105	596491.2751	1336770.688	0.24
SH13APY000672	Tree Planting	Little Patuxent River	02131105	596642.6013	1336085.254	0.34
SH13APY000673	Tree Planting	Middle Patuxent River	02131106	597803.6242	1325455	0.79
SH13APY000674	Tree Planting	Middle Patuxent River	02131106	598367.0056	1324823.803	0.30
SH13APY000675	Tree Planting	Patapsco River L N Br	02130906	593749.0969	1361127.84	0.08
SH13APY000676	Tree Planting	Little Patuxent River	02131105	536247.7939	1348253.302	0.06
SH13APY000677	Tree Planting	Little Patuxent River	02131105	537722.3831	1345708.182	0.20
SH13APY000679	Tree Planting	Little Patuxent River	02131105	538294.8052	1343592.899	0.05
SH13APY000680	Tree Planting	Little Patuxent River	02131105	538225.913	1343789.623	0.01
SH13APY000681	Tree Planting	Patapsco River L N Br	02130906	554471.1672	1390902.568	0.77
SH14APY000857	Tree Planting	Middle Patuxent River	02131106	552836.0717	1342052.768	0.21
SH14APY000858	Tree Planting	Middle Patuxent River	02131106	543458.1476	1343398.008	0.26
SH14APY000859	Tree Planting	Middle Patuxent River	02131106	552528.5143	1345710.727	0.06
SH14APY000860	Tree Planting	Middle Patuxent River	02131106	552893.2248	1341272.062	0.31
SH14APY000861	Tree Planting	Patapsco River L N Br	02130906	563628.0551	1370354.456	0.20
SH14APY000862	Tree Planting	Little Patuxent River	02131105	536326.6323	1364928.794	0.43
SH14APY000863	Tree Planting	Middle Patuxent River	02131106	553173.2669	1340678.766	0.48
SH14APY000864	Tree Planting	Little Patuxent River	02131105	551564.5851	1347388.842	0.68
SH14APY000865	Tree Planting	Middle Patuxent River	02131106	554663.676	1338651.846	0.57
SH14APY000909	Tree Planting	Patapsco River L N Br	02130906	563091.5142	1369699.63	0.54
SH14APY000910	Tree Planting	Patapsco River L N Br	02130906	562537.9208	1369377.867	0.71
SH14APY000911	Tree Planting	Little Patuxent River	02131105	551363.5796	1347473.311	0.14
SH14APY000912	Tree Planting	Little Patuxent River	02131105	551700.2387	1347567.181	0.25
SH10APY000198	Tree Planting	Middle Patuxent River	02131106	542796.247	1343910.627	0.32
SH10APY000201	Tree Planting	Brighton Dam	02131108	609373.6854	1291957.339	0.32
SH13APY000682	Tree Planting	Middle Patuxent River	02131106	586969.5625	1317133.243	0.61
SH13APY000683	Tree Planting	Middle Patuxent River	02131106	588426.3867	1319279.02	0.87
SH14APY000914	Tree Planting	Patapsco River L N Br	02130906	562606.5673	1369838.831	0.56
SH13APY000684	Tree Planting	Patapsco River L N Br	02130906	554569.026	1390645.579	0.61
SH14APY000915	Tree Planting	Little Patuxent River	02131105	535727.8743	1365148.897	0.12
SH14APY000916	Tree Planting	Middle Patuxent River	02131106	552568.0339	1341376.814	0.10
SH14APY000917	Tree Planting	Middle Patuxent River	02131106	554153.0783	1339533.013	0.13
SH14APY000918	Tree Planting	Middle Patuxent River	02131106	552554.1009	1345281.351	0.09
					Complete BMP Acreage Total	**76.51**

Comprehensive List of Restoration Practices By Contract						
Table I-17: FMIS # AT5025382						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH13APY000515	Tree Planting	Severn River	02131002	522266.16	1398848.06	0.37
SH13APY000516	Tree Planting	Patapsco River L N Br	02130906	547816.86	1389145.33	1.07
SH13APY000517	Tree Planting	Baltimore Harbor	02130903	540581.70	1402585.94	0.19
SH13APY000518	Tree Planting	Baltimore Harbor	02130903	542322.57	1412444.84	0.82
SH13APY000519	Tree Planting	Baltimore Harbor	02130903	541771.95	1412517.48	1.68
SH13APY000520	Tree Planting	Baltimore Harbor	02130903	541661.42	1413154.93	0.65
SH13APY000521	Tree Planting	Baltimore Harbor	02130903	540913.19	1413289.47	1.03
SH13APY000522	Tree Planting	Baltimore Harbor	02130903	540456.70	1413181.95	0.90
SH13APY000523	Tree Planting	Severn River	02131002	519218.28	1418114.60	1.47
SH13APY000524	Tree Planting	Severn River	02131002	520572.15	1418375.71	0.37
SH13APY000525	Tree Planting	Baltimore Harbor	02130903	547495.06	1414168.70	0.59
SH13APY000526	Tree Planting	Baltimore Harbor	02130903	550692.61	1415702.56	0.08
SH13APY000527	Tree Planting	Baltimore Harbor	02130903	550400.47	1415504.09	0.32
SH13APY000528	Tree Planting	Baltimore Harbor	02130903	541636.60	1407286.18	0.39
SH13APY000529	Tree Planting	Baltimore Harbor	02130903	541781.26	1407901.23	3.01
SH13APY000530	Tree Planting	Patapsco River L N Br	02130906	540549.39	1399133.39	1.23
SH13APY000615	Tree Planting	Patuxent River lower	02131101	315137.51	1375850.35	0.32
SH13APY000616	Tree Planting	Patuxent River lower	02131101	315226.55	1376209.80	0.15
SH13APY000617	Tree Planting	Patuxent River lower	02131101	314689.81	1376319.94	0.14
SH13APY000618	Tree Planting	Patuxent River lower	02131101	315664.64	1376081.76	0.08
SH13APY000619	Tree Planting	Patuxent River lower	02131101	318510.41	1373369.97	0.15
SH13APY000620	Tree Planting	Patuxent River lower	02131101	316475.40	1375554.30	0.51
SH13APY000621	Tree Planting	Patuxent River lower	02131101	317116.41	1374559.80	0.17
SH13APY000685	Tree Planting	Lower Monocacy River	02140302	587282.86	1220769.29	0.47
SH13APY000686	Tree Planting	Anacostia River	02140205	491640.04	1308051.25	0.21
SH13APY000687	Tree Planting	Anacostia River	02140205	491135.91	1307813.51	0.14
SH13APY000688	Tree Planting	Anacostia River	02140205	491249.56	1307349.92	0.07
SH13APY000689	Tree Planting	Anacostia River	02140205	491631.20	1307429.41	0.18
SH13APY000690	Tree Planting	Anacostia River	02140205	491031.96	1310715.87	0.09
SH13APY000691	Tree Planting	Anacostia River	02140205	491429.18	1310497.02	0.13
SH13APY000692	Tree Planting	Seneca Creek	02140208	562035.48	1260595.62	0.36
SH13APY000693	Tree Planting	Seneca Creek	02140208	562689.15	1261004.85	0.34
SH13APY000694	Tree Planting	Seneca Creek	02140208	563103.22	1261362.43	0.13
SH13APY000695	Tree Planting	Seneca Creek	02140208	562969.87	1260678.26	0.31
SH13APY000696	Tree Planting	Seneca Creek	02140208	562132.48	1260059.52	0.17
SH13APY000697	Tree Planting	Western Branch	02131103	456128.88	1354626.52	0.51
SH13APY000698	Tree Planting	Western Branch	02131103	446885.83	1355479.59	0.58
SH13APY000699	Tree Planting	Western Branch	02131103	447105.99	1355781.65	0.21
SH13APY000700	Tree Planting	Potomac River U tidal	02140201	420389.36	1334711.73	0.21
SH13APY000701	Tree Planting	Potomac River U tidal	02140201	420240.07	1334842.16	0.33
SH13APY000702	Tree Planting	Potomac River U tidal	02140201	420517.49	1335143.87	0.46
SH13APY000703	Tree Planting	Potomac River U tidal	02140201	420432.07	1335313.02	0.37
SH13APY000704	Tree Planting	Piscataway Creek	02140203	386541.26	1320018.04	1.54
SH13APY000705	Tree Planting	Piscataway Creek	02140203	388939.67	1321215.01	0.15
SH13APY000706	Tree Planting	Potomac River U tidal	02140201	412841.44	1312955.54	0.70
SH13APY000707	Tree Planting	Anacostia River	02140205	456314.66	1354524.14	0.09
				Complete BMP Acreage Total		**23.42**

Comprehensive List of Restoration Practices By Contract

Table I-18: FMIS # AT5025482

Unique BMP #	BMP Type	8-Digit Watershed Name	8-Digit Watershed Code	Northing	Easting	Impervious Treated (acres)
SH13APY000708	Tree Planting	Conococheague Creek	02140504	723658.47	1072509.60	1.04
SH13APY000709	Tree Planting	Conococheague Creek	02140504	723221.64	1074015.76	0.55
SH13APY000710	Tree Planting	Conococheague Creek	02140504	721713.62	1077019.12	0.49
SH13APY000711	Tree Planting	Conococheague Creek	02140504	710895.17	1090882.04	0.58
SH13APY000712	Tree Planting	Conococheague Creek	02140504	711161.86	1091413.00	0.70
SH13APY000713	Tree Planting	Conococheague Creek	02140504	711421.33	1091695.87	0.35
SH13APY000714	Tree Planting	Marsh Run	02140503	707143.97	1099272.78	0.53
SH13APY000715	Tree Planting	Antietam Creek	02140502	705243.05	1120085.47	0.65
SH13APY000716	Tree Planting	Antietam Creek	02140502	704610.64	1120408.82	0.79
SH13APY000717	Tree Planting	Antietam Creek	02140502	684443.07	1140984.11	0.52
SH13APY000718	Tree Planting	Conococheague Creek	02140504	724021.54	1066268.26	1.30
SH13APY000719	Tree Planting	Conococheague Creek	02140504	723748.70	1068707.88	0.84
SH13APY000720	Tree Planting	Little Conococheague	02140505	724036.45	1063047.06	0.43
SH13APY000721	Tree Planting	Conococheague Creek	02140504	724014.56	1064093.97	0.18
SH13APY000722	Tree Planting	Little Conococheague	02140505	724680.78	1054405.60	0.88
SH13APY000723	Tree Planting	Little Conococheague	02140505	724084.84	1062391.50	0.44
SH13APY000724	Tree Planting	Little Conococheague	02140505	723693.70	1052796.97	0.27
SH13APY000725	Tree Planting	Potomac River WA Cnty	02140501	722601.22	1048834.32	0.54
SH13APY000726	Tree Planting	Potomac River WA Cnty	02140501	721113.55	1046074.24	1.37
SH13APY000727	Tree Planting	Little Conococheague	02140505	723813.46	1052006.52	1.78
SH13APY000728	Tree Planting	Potomac River WA Cnty	02140501	718906.54	1043173.61	0.33
SH13APY000729	Tree Planting	Potomac River WA Cnty	02140501	737516.86	1000540.97	0.95
SH13APY000730	Tree Planting	Potomac River WA Cnty	02140501	745344.35	979574.25	0.19
SH13APY000731	Tree Planting	Potomac River WA Cnty	02140501	745262.84	979281.42	0.31
SH13APY000732	Tree Planting	Little Tonoloway Creek	02140509	745019.85	978823.74	0.54
SH13APY000733	Tree Planting	Potomac River WA Cnty	02140501	739639.95	992670.02	0.44
SH13APY000734	Tree Planting	Little Tonoloway Creek	02140509	747032.93	978353.52	0.70
SH13APY000735	Tree Planting	Little Tonoloway Creek	02140509	747663.24	977343.26	0.73
SH13APY000736	Tree Planting	Little Tonoloway Creek	02140509	745822.10	979015.13	0.37
SH13APY000737	Tree Planting	Little Tonoloway Creek	02140509	745454.88	978897.11	0.33
SH13APY000738	Tree Planting	Little Tonoloway Creek	02140509	748539.34	978138.84	0.85
SH13APY000739	Tree Planting	Little Tonoloway Creek	02140509	748016.10	977759.70	0.48
SH13APY000740	Tree Planting	Little Tonoloway Creek	02140509	748190.91	952177.36	0.91
SH13APY000741	Tree Planting	Little Tonoloway Creek	02140509	742141.56	961255.58	0.27
SH13APY000742	Tree Planting	Little Tonoloway Creek	02140509	742116.85	961696.52	0.25
SH13APY000743	Tree Planting	Little Tonoloway Creek	02140509	747703.80	966262.36	0.25
SH13APY000744	Tree Planting	Little Tonoloway Creek	02140509	747759.44	966646.94	0.12
SH13APY000745	Tree Planting	Conococheague Creek	02140504	724620.22	1101668.22	0.56
SH13APY000746	Tree Planting	Conococheague Creek	02140504	741712.89	1103932.88	0.37
SH13APY000747	Tree Planting	Conococheague Creek	02140504	741218.01	1104211.98	1.15
SH13APY000748	Tree Planting	Conococheague Creek	02140504	741452.21	1104570.74	0.45
SH13APY000749	Tree Planting	Antietam Creek	02140502	706543.04	1107083.07	0.80
SH13APY000750	Tree Planting	Antietam Creek	02140502	707459.48	1107151.94	0.91
SH13APY000751	Tree Planting	Little Conococheague	02140505	724238.91	1057963.06	0.93
SH13APY000752	Tree Planting	Marsh Run	02140503	707473.66	1098492.68	0.53
SH13APY000753	Tree Planting	Conococheague Creek	02140504	724547.94	1102214.45	0.19
SH13APY000754	Tree Planting	Antietam Creek	02140502	706596.60	1106664.12	0.56
SH13APY000755	Tree Planting	Conococheague Creek	02140504	725787.57	1087345.70	0.63
SH13APY000756	Tree Planting	Potomac River WA Cnty	02140501	745221.96	979407.25	0.16
SH13APY000757	Tree Planting	Conococheague Creek	02140504	723990.32	1063971.73	0.09
SH13APY000758	Tree Planting	Little Conococheague	02140505	722843.92	1049386.12	0.07
SH13APY000759	Tree Planting	Conococheague Creek	02140504	707466.50	1094926.14	0.37
SH13APY000760	Tree Planting	Marsh Run	02140503	707015.44	1099416.15	0.28
SH13APY000761	Tree Planting	Potomac River WA Cnty	02140501	718773.47	1042861.93	0.28
SH13APY000762	Tree Planting	Antietam Creek	02140502	705184.52	1120627.99	0.40
SH13APY000763	Tree Planting	Marsh Run	02140503	707439.32	1095858.15	0.39
					Complete BMP Acreage Total	**31.38**

Comprehensive List of Restoration Practices By Contract						
Table I-19: FMIS # AT7995382						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH15RST021282	Swales	South River	02131003	472560.05	1415460.29	0.67
SH15RST021298	Swales	Patuxent River upper	02131104	469711.49	1403223.01	0.32
SH14RST021338	Swales	Patuxent River middle	02131102	401099.36	1409923.39	0.29
SH14RST021341	Swales	Patuxent River middle	02131102	408797.80	1407482.26	0.64
SH14RST021343	Swales	Patuxent River middle	02131102	409240.16	1407250.96	0.42
SH14RST021349	Swales	Patuxent River middle	02131102	412735.40	1402764.55	0.06
SH14RST021354	Swales	Patuxent River middle	02131102	412896.32	1402537.29	0.31
SH14RST021359	Swales	Patuxent River middle	02131102	413160.59	1402158.97	0.18
SH14RST021364	Swales	Patuxent River middle	02131102	413430.11	1401787.06	0.35
SH14RST021374	Swales	Patuxent River middle	02131102	416777.78	1395883.26	0.68
SH15RST021451	Swales	Little Patuxent River	02131105	485178.52	1397362.07	0.23
SH14RST080519	Swales	Zekiah Swamp	02140108	271698.93	1324979.83	0.80
SH13RST080520	Swales	Zekiah Swamp	02140108	273712.44	1323634.75	0.26
SH13RST080524	Swales	Zekiah Swamp	02140108	276729.73	1321410.28	0.23
SH14RST082122	Swales	Patuxent River lower	02131101	306683.57	1376774.84	0.45
SH14RST082123	Swales	Patuxent River lower	02131101	306937.74	1376779.00	0.27
SH14RST082124	Swales	Patuxent River lower	02131101	307295.65	1376784.58	0.17
SH14RST082125	Swales	Patuxent River lower	02131101	307858.96	1376795.08	0.26
SH14RST082128	Swales	Patuxent River lower	02131101	309100.92	1376809.91	0.75
SH14RST082133	Swales	Zekiah Swamp	02140108	321994.01	1364234.35	0.65
SH14RST082134	Swales	Zekiah Swamp	02140108	322019.66	1363853.18	0.62
SH13RST082136	Swales	Zekiah Swamp	02140108	322984.29	1358998.07	0.52
SH13RST082138	Swales	Zekiah Swamp	02140108	327819.03	1352047.72	0.25
SH13RST082139	Swales	Zekiah Swamp	02140108	328826.70	1351975.94	0.43
SH13RST082141	Swales	Zekiah Swamp	02140108	340499.29	1348774.80	0.98
SH14RST082126	Swales	Patuxent River lower	02131101	308213.10	1376800.00	0.26
SH14RST082127	Swales	Patuxent River lower	02131101	308716.11	1376805.97	0.44
SH14RST082135	Swales	Zekiah Swamp	02140108	322125.21	1362540.65	0.43
SH13RST082140	Swales	Zekiah Swamp	02140108	340145.48	1348894.87	0.16
SH14RST080516	Swales	Wicomico River	02140106	267715.67	1325853.71	0.28
SH14RST080517	Micro-Bioretention	Wicomico River	02140106	267807.14	1325854.37	0.44
SH14RST080518	Micro-Bioretention	Zekiah Swamp	02140108	271599.82	1325028.85	0.19
SH13RST080521	Swales	Zekiah Swamp	02140108	274070.06	1323373.90	0.45
SH13RST080522	Swales	Zekiah Swamp	02140108	276215.98	1321794.37	0.31
SH13RST080523	Swales	Zekiah Swamp	02140108	276644.89	1321474.23	0.21
SH13RST080525	Swales	Potomac River L tidal	02140101	277093.44	1321149.16	0.43
SH15RST021449	Swales	Little Patuxent River	02131105	484147.69	1397152.19	1.00
SH15RST021450	Swales	Little Patuxent River	02131105	484794.67	1397285.39	0.37
SH14RST021348	Swales	Patuxent River middle	02131102	412620.66	1402931.87	0.49
SH14RST021351	Swales	Patuxent River middle	02131102	412811.44	1402660.06	0.05
SH14RST021369	Swales	Patuxent River middle	02131102	414626.53	1400222.13	0.32
SH14RST021370	Swales	Patuxent River middle	02131102	415884.34	1398454.45	0.34
SH14RST021371	Swales	Patuxent River middle	02131102	416425.35	1397273.65	0.50
SH15RST021283	Swales	South River	02131003	471785.87	1411806.10	0.31
SH15RST021295	Swales	South River	02131003	472202.53	1413878.01	0.33
SH15RST021299	Swales	Patuxent River upper	02131104	469879.01	1404699.85	0.41
SH15RST021302	Swales	South River	02131003	476597.41	1420974.72	0.35
				Complete BMP Acreage Total		**18.86**

Comprehensive List of Restoration Practices By Contract Table I-20: FMIS # AW0465182						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH17APY001644	Tree Planting	Potomac River U tidal	02140201	424967.19	1329070.54	0.07
SH17APY001645	Tree Planting	Western Branch	02131103	438052.60	1357632.23	1.35
SH17APY001646	Tree Planting	Western Branch	02131103	463436.84	1353743.52	1.28
SH17APY001647	Tree Planting	Anacostia River	02140205	435694.31	1341384.69	0.08
SH17APY001648	Tree Planting	Western Branch	02131103	463610.98	1353512.78	0.04
SH17APY001649	Tree Planting	Potomac River U tidal	02140201	416400.74	1321904.74	0.19
SH17APY001650	Tree Planting	Anacostia River	02140205	481710.49	1338985.15	0.28
SH17APY001651	Tree Planting	Western Branch	02131103	466621.11	1356772.32	0.26
SH17APY001639	Tree Planting	Patuxent River upper	02131104	448316.46	1393820.57	0.07
SH17APY001642	Tree Planting	Anacostia River	02140205	487339.25	1342659.32	0.16
SH17APY001643	Tree Planting	Anacostia River	02140205	481883.42	1344977.36	0.27
SH17APY001640	Tree Planting	Anacostia River	02140205	487046.47	1342465.85	0.16
SH17APY001641	Tree Planting	Potomac River U tidal	02140201	419829.97	1342485.77	0.12
				Complete BMP Acreage Total		**4.33**

Comprehensive List of Restoration Practices By Contract						
Table I-21: FMIS # AW0825282						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH15APY001017	Tree Planting	Double Pipe Creek	02140304	693924.96	1264650.13	0.08
SH15APY001018	Tree Planting	Double Pipe Creek	02140304	693176.80	1265982.57	0.18
SH15APY001019	Tree Planting	Double Pipe Creek	02140304	693377.12	1265750.75	0.05
SH15APY001020	Tree Planting	Double Pipe Creek	02140304	693124.20	1267809.28	0.82
SH15APY001021	Tree Planting	Double Pipe Creek	02140304	692105.77	1269719.67	0.31
SH15APY001022	Tree Planting	Upper Monocacy River	02140303	732457.79	1268660.68	0.15
SH15APY001023	Tree Planting	Upper Monocacy River	02140303	733160.87	1269137.32	0.18
SH15APY001024	Tree Planting	Upper Monocacy River	02140303	737822.05	1271785.65	0.13
SH15APY001025	Tree Planting	Upper Monocacy River	02140303	741761.87	1276403.81	0.14
SH15APY001026	Tree Planting	S Branch Patapsco	02130908	616196.01	1264842.39	0.45
SH15APY001027	Tree Planting	S Branch Patapsco	02130908	616916.48	1265809.02	0.46
SH15APY001028	Tree Planting	S Branch Patapsco	02130908	619040.26	1269686.73	0.14
SH15APY001029	Tree Planting	S Branch Patapsco	02130908	628058.78	1272379.08	0.08
SH15APY001030	Tree Planting	S Branch Patapsco	02130908	647707.10	1298013.51	0.18
SH15APY001031	Tree Planting	S Branch Patapsco	02130908	651101.45	1290504.05	0.11
SH15APY001032	Tree Planting	Double Pipe Creek	02140304	684369.33	1287811.56	0.54
SH15APY001033	Tree Planting	Double Pipe Creek	02140304	693520.20	1265149.11	0.05
SH15APY001034	Tree Planting	Double Pipe Creek	02140304	693318.07	1266594.05	0.11
SH15APY001035	Tree Planting	Upper Monocacy River	02140303	732137.32	1268469.77	0.15
SH15APY001036	Tree Planting	S Branch Patapsco	02130908	620036.78	1270779.97	0.13
SH15APY001037	Tree Planting	S Branch Patapsco	02130908	623279.27	1271629.15	0.38
SH15APY001038	Tree Planting	S Branch Patapsco	02130908	626717.12	1272434.96	0.23
SH15APY001039	Tree Planting	Lower Monocacy River	02140302	653047.25	1285984.53	0.28
SH15APY001040	Tree Planting	S Branch Patapsco	02130908	650727.57	1291576.81	0.13
SH15APY001041	Tree Planting	Double Pipe Creek	02140304	684833.18	1289553.88	0.30
SH15APY001042	Tree Planting	Double Pipe Creek	02140304	684008.74	1285329.38	0.08
SH15APY001043	Tree Planting	S Branch Patapsco	02130908	623829.13	1321176.72	0.12
SH15APY001044	Tree Planting	S Branch Patapsco	02130908	622197.28	1322230.07	0.04
SH15APY001045	Tree Planting	Upper Monocacy River	02140303	739648.26	1273544.53	0.05
SH15APY001046	Tree Planting	Upper Monocacy River	02140303	739920.14	1273976.32	0.28
SH15APY001048	Tree Planting	Upper Monocacy River	02140303	733444.30	1269313.08	0.07
SH15APY001049	Tree Planting	Upper Monocacy River	02140303	734500.86	1269931.78	0.46
SH15APY001050	Tree Planting	Upper Monocacy River	02140303	741223.35	1276004.70	0.02
SH15APY001051	Tree Planting	Upper Monocacy River	02140303	745655.60	1277060.60	0.25
SH15APY001052	Tree Planting	Upper Monocacy River	02140303	738417.29	1272184.17	0.19
SH15APY001053	Tree Planting	Upper Monocacy River	02140303	739102.26	1272860.91	0.66
SH15APY001054	Tree Planting	Upper Monocacy River	02140303	735960.96	1270769.60	0.64
SH15APY001089	Tree Planting	Catoctin Creek	02140305	616196.41	1156195.65	0.26
SH15APY001090	Tree Planting	Catoctin Creek	02140305	616643.32	1161084.23	0.31
SH15APY001091	Tree Planting	Lower Monocacy River	02140302	636877.20	1189592.01	0.41
SH15APY001092	Tree Planting	Lower Monocacy River	02140302	637415.49	1189274.43	0.13
SH15APY001093	Tree Planting	Lower Monocacy River	02140302	648559.56	1198666.76	0.27
SH15APY001094	Tree Planting	Catoctin Creek	02140305	660266.33	1164888.94	0.03
SH15APY001095	Tree Planting	Lower Monocacy River	02140302	637555.45	1177594.76	0.15
SH15APY001096	Tree Planting	Lower Monocacy River	02140302	603848.00	1211246.23	0.26
SH15APY001097	Tree Planting	Lower Monocacy River	02140302	632648.24	1183764.20	0.06
SH15APY001098	Tree Planting	Catoctin Creek	02140305	664082.43	1154858.25	0.22
SH15APY001099	Tree Planting	Catoctin Creek	02140305	668870.12	1149897.44	0.33
SH15APY001100	Tree Planting	Lower Monocacy River	02140302	633418.78	1180564.57	0.49
SH15APY001101	Tree Planting	Catoctin Creek	02140305	616705.92	1159176.03	0.51
SH15APY001102	Tree Planting	Catoctin Creek	02140305	617801.49	1163397.38	0.31
SH15APY001103	Tree Planting	Lower Monocacy River	02140302	636481.80	1189422.56	0.13
SH15APY001104	Tree Planting	Lower Monocacy River	02140302	637674.87	1189430.10	0.07
SH15APY001105	Tree Planting	Potomac River FR Cnty	02140301	612592.05	1169294.54	0.53
SH15APY001106	Tree Planting	Catoctin Creek	02140305	660726.47	1164640.62	0.08
SH15APY001107	Tree Planting	Lower Monocacy River	02140302	603342.66	1211436.03	0.20
SH15APY001108	Tree Planting	Catoctin Creek	02140305	616862.74	1162065.33	0.11
SH15APY001109	Tree Planting	Upper Monocacy River	02140303	709352.75	1193858.54	0.14
SH15APY001110	Tree Planting	Upper Monocacy River	02140303	736365.85	1218736.31	0.22
SH15APY001111	Tree Planting	Upper Monocacy River	02140303	740546.78	1223707.85	0.03
SH15APY001112	Tree Planting	Lower Monocacy River	02140302	604360.41	1209276.68	0.15
SH15APY001113	Tree Planting	Lower Monocacy River	02140302	627442.02	1223981.12	0.11
SH15APY001114	Tree Planting	Lower Monocacy River	02140302	632260.78	1198609.51	0.12
SH15APY001115	Tree Planting	Catoctin Creek	02140305	657005.35	1164400.92	0.54
SH15APY001116	Tree Planting	Catoctin Creek	02140305	668950.96	1149437.33	0.15
SH15APY001117	Tree Planting	Upper Monocacy River	02140303	747235.55	1225822.75	0.06
SH15APY001118	Tree Planting	Upper Monocacy River	02140303	747161.96	1225599.06	0.16
SH15APY001119	Tree Planting	Upper Monocacy River	02140303	742853.07	1224115.69	0.12
SH15APY001120	Tree Planting	Upper Monocacy River	02140303	726297.69	1206729.57	0.27
SH15APY001121	Tree Planting	Upper Monocacy River	02140303	717344.14	1197227.59	0.44
SH15APY001122	Tree Planting	Upper Monocacy River	02140303	718100.24	1198254.72	0.11
SH15APY001123	Tree Planting	Lower Monocacy River	02140302	637726.12	1189762.12	0.17
SH15APY001124	Tree Planting	Lower Monocacy River	02140302	642073.81	1194176.32	0.39
SH15APY001125	Tree Planting	Upper Monocacy River	02140303	669466.54	1199147.70	0.06
SH15APY001126	Tree Planting	Upper Monocacy River	02140303	688691.24	1190859.40	0.09
SH15APY001127	Tree Planting	Upper Monocacy River	02140303	655620.44	1209717.46	0.23
SH15APY001128	Tree Planting	Upper Monocacy River	02140303	658551.87	1211169.85	0.42
SH15APY001129	Tree Planting	Catoctin Creek	02140305	615909.50	1147460.80	0.05
SH15APY001130	Tree Planting	Catoctin Creek	02140305	615419.01	1142710.12	0.08
SH15APY001131	Tree Planting	Catoctin Creek	02140305	615971.47	1153628.89	0.20

Comprehensive List of Restoration Practices By Contract						
Table I-21: FMIS # AW0825282						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH15APY001132	Tree Planting	Lower Monocacy River	02140302	621696.53	1174570.78	0.29
SH15APY001133	Tree Planting	Lower Monocacy River	02140302	642305.01	1194460.44	0.22
SH15APY001134	Tree Planting	Upper Monocacy River	02140303	666437.97	1200069.52	0.13
SH15APY001135	Tree Planting	Upper Monocacy River	02140303	691491.14	1190632.26	0.35
SH15APY001136	Tree Planting	Upper Monocacy River	02140303	662400.48	1215505.57	0.15
SH15APY001137	Tree Planting	Potomac River FR Cnty	02140301	612417.15	1134510.17	0.02
SH15APY001138	Tree Planting	Lower Monocacy River	02140302	624439.47	1239005.17	0.22
SH15APY001139	Tree Planting	Potomac River FR Cnty	02140301	598452.18	1166602.00	0.33
SH15APY001140	Tree Planting	Lower Monocacy River	02140302	613150.74	1201677.68	0.27
SH15APY001141	Tree Planting	Lower Monocacy River	02140302	628601.89	1220950.64	0.41
SH15APY001142	Tree Planting	Potomac River FR Cnty	02140301	613946.18	1137597.92	0.05
SH15APY001143	Tree Planting	Catoctin Creek	02140305	616788.20	1161795.22	0.08
SH15APY001144	Tree Planting	Upper Monocacy River	02140303	712764.75	1194461.59	0.09
SH15APY001145	Tree Planting	Upper Monocacy River	02140303	709921.41	1194205.09	0.08
SH15APY001146	Tree Planting	Lower Monocacy River	02140302	681277.64	1224223.90	0.16
SH15APY001147	Tree Planting	Lower Monocacy River	02140302	636936.42	1189865.04	0.05
SH15APY001148	Tree Planting	Lower Monocacy River	02140302	626347.93	1227374.64	0.32
SH15APY001149	Tree Planting	Lower Monocacy River	02140302	632634.96	1185333.72	0.42
SH15APY001150	Tree Planting	Catoctin Creek	02140305	657594.29	1163356.30	0.52
SH15APY001151	Tree Planting	Upper Monocacy River	02140303	744655.83	1224761.79	0.16
SH15APY001152	Tree Planting	Upper Monocacy River	02140303	708700.19	1193573.37	0.31
SH15APY001153	Tree Planting	Upper Monocacy River	02140303	741339.07	1224003.92	0.05
SH15APY001154	Tree Planting	Upper Monocacy River	02140303	741457.70	1224312.58	0.88
SH15APY001155	Tree Planting	Upper Monocacy River	02140303	722539.66	1203167.90	0.28
SH15APY001156	Tree Planting	Catoctin Creek	02140305	617039.45	1161741.31	0.24
SH15APY001157	Tree Planting	Lower Monocacy River	02140302	626331.16	1182542.06	0.40
SH15APY001158	Tree Planting	Catoctin Creek	02140305	617140.37	1162055.75	0.06
SH15APY001159	Tree Planting	Lower Monocacy River	02140302	620031.21	1170933.88	0.22
SH15APY001160	Tree Planting	Lower Monocacy River	02140302	625828.28	1181731.36	0.36
SH15APY001161	Tree Planting	Lower Monocacy River	02140302	625315.19	1180914.50	0.12
SH15APY001162	Tree Planting	Lower Monocacy River	02140302	630961.60	1187922.26	0.73
SH15APY001163	Tree Planting	Lower Monocacy River	02140302	632025.44	1187194.54	0.50
SH15APY001164	Tree Planting	Catoctin Creek	02140305	617853.46	1164442.06	0.42
SH15APY001165	Tree Planting	Lower Monocacy River	02140302	631109.04	1187387.19	0.61
SH15APY001166	Tree Planting	Lower Monocacy River	02140302	625476.01	1181174.47	0.12
SH15APY001167	Tree Planting	Lower Monocacy River	02140302	630406.42	1188421.38	1.49
SH15APY001168	Tree Planting	Lower Monocacy River	02140302	606202.46	1207042.30	0.33
SH15APY001169	Tree Planting	Lower Monocacy River	02140302	604903.74	1208265.27	0.21
SH15APY001547	Tree Planting	Lower Monocacy River	02140302	630568.72	1187497.82	0.47
SH15APY001170	Tree Planting	Upper Monocacy River	02140303	690164.53	1190517.50	0.22
SH15APY001171	Tree Planting	Upper Monocacy River	02140303	689961.84	1190843.03	0.04
SH15APY001172	Tree Planting	Lower Monocacy River	02140302	633015.73	1181516.40	0.28
SH15APY001173	Tree Planting	Lower Monocacy River	02140302	632805.30	1182627.98	0.28
SH15APY001174	Tree Planting	Upper Monocacy River	02140303	746261.96	1225211.92	0.12
SH15APY001175	Tree Planting	Upper Monocacy River	02140303	745542.96	1224888.56	0.11
SH15APY001176	Tree Planting	Catoctin Creek	02140305	615571.83	1148259.74	0.06
SH15APY001177	Tree Planting	Catoctin Creek	02140305	660516.82	1164653.87	0.16
SH15APY001178	Tree Planting	Catoctin Creek	02140305	655804.10	1165324.90	0.42
SH15APY001179	Tree Planting	Catoctin Creek	02140305	655318.74	1165851.93	0.11
SH15APY001180	Tree Planting	Catoctin Creek	02140305	656753.71	1164287.44	0.53
SH14APY001608	Tree Planting	Catoctin Creek	02140305	660871.68	1164357.55	0.32
SH14APY001609	Tree Planting	Catoctin Creek	02140305	617496.67	1162835.67	0.02
SH14APY001611	Tree Planting	Potomac River FR Cnty	02140301	613329.12	1135834.83	0.03
SH14APY001610	Tree Planting	Potomac River FR Cnty	02140301	613683.02	1136592.02	0.03
SH14APY001565	Tree Planting	Potomac River FR Cnty	02140301	612997.17	1135281.29	0.09
SH14APY001614	Tree Planting	Upper Monocacy River	02140303	669227.83	1199311.54	0.04
SH14APY001615	Tree Planting	Upper Monocacy River	02140303	670074.81	1198766.01	0.24
SH14APY001616	Tree Planting	Lower Monocacy River	02140302	604095.41	1210135.93	0.07
SH14APY001621	Tree Planting	Upper Monocacy River	02140303	661766.56	1214979.07	0.59
SH14APY001622	Tree Planting	Catoctin Creek	02140305	656158.63	1165328.87	0.86
SH14APY000866	Tree Planting	Middle Patuxent River	02131106	558981.53	1331926.27	0.30
SH14APY000867	Tree Planting	Little Patuxent River	02131105	567234.07	1356529.50	0.09
SH14APY000868	Tree Planting	Patapsco River L N Br	02130906	587211.95	1363221.65	0.40
SH14APY000869	Tree Planting	Little Patuxent River	02131105	575301.83	1364028.01	0.23
SH14APY000870	Tree Planting	Little Patuxent River	02131105	575087.14	1363921.12	0.19
SH14APY000871	Tree Planting	Little Patuxent River	02131105	575645.04	1364310.72	0.23
SH14APY000872	Tree Planting	Patapsco River L N Br	02130906	562337.62	1370635.41	0.12
SH14APY000873	Tree Planting	Patuxent River upper	02131104	531734.07	1351023.05	0.16
SH14APY000874	Tree Planting	Patapsco River L N Br	02130906	561772.53	1371552.51	0.11
SH14APY000875	Tree Planting	Little Patuxent River	02131105	573736.94	1364815.94	0.09
SH14APY000876	Tree Planting	Patapsco River L N Br	02130906	556978.28	1378494.82	0.75
SH14APY000877	Tree Planting	Little Patuxent River	02131105	556563.52	1364872.30	0.10
SH14APY000878	Tree Planting	Patapsco River L N Br	02130906	562729.81	1370309.10	0.09
SH14APY000879	Tree Planting	Patapsco River L N Br	02130906	586213.56	1362740.06	0.28
SH14APY000880	Tree Planting	Middle Patuxent River	02131106	560892.25	1329153.58	0.31
SH14APY000881	Tree Planting	Middle Patuxent River	02131106	556083.53	1335890.70	0.09
SH14APY000882	Tree Planting	Little Patuxent River	02131105	541057.02	1361910.43	0.11
SH14APY000883	Tree Planting	Little Patuxent River	02131105	532593.82	1369326.26	0.11
SH14APY000884	Tree Planting	Little Patuxent River	02131105	533554.67	1369147.13	0.15
SH14APY000885	Tree Planting	Little Patuxent River	02131105	535969.99	1366330.76	0.57

Comprehensive List of Restoration Practices By Contract						
Table I-21: FMIS # AW0825282						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH14APY000886	Tree Planting	Little Patuxent River	02131105	547196.81	1357379.14	0.37
SH14APY000887	Tree Planting	Middle Patuxent River	02131106	557439.17	1333584.24	0.17
SH14APY000888	Tree Planting	Middle Patuxent River	02131106	560177.26	1330638.48	0.34
SH14APY000889	Tree Planting	Patapsco River L N Br	02130906	587268.08	1363993.86	0.11
SH14APY000890	Tree Planting	Little Patuxent River	02131105	575820.63	1363718.04	1.16
SH14APY000891	Tree Planting	Little Patuxent River	02131105	576151.37	1364054.06	0.73
SH14APY000892	Tree Planting	Little Patuxent River	02131105	552301.62	1370532.17	0.70
SH14APY000893	Tree Planting	Little Patuxent River	02131105	538738.59	1341758.18	1.94
SH14APY000894	Tree Planting	Little Patuxent River	02131105	532269.21	1370783.48	0.40
SH14APY000895	Tree Planting	Patapsco River L N Br	02130906	557469.72	1377936.15	0.40
SH14APY000896	Tree Planting	Little Patuxent River	02131105	553956.27	1348880.83	0.04
SH14APY000897	Tree Planting	Little Patuxent River	02131105	557201.28	1364133.43	0.50
SH14APY000898	Tree Planting	Middle Patuxent River	02131106	551199.59	1347403.54	0.15
SH14APY000899	Tree Planting	Patuxent River upper	02131104	531664.09	1352331.78	0.07
SH14APY000900	Tree Planting	Patapsco River L N Br	02130906	561631.72	1373600.73	0.17
SH14APY000901	Tree Planting	Patapsco River L N Br	02130906	556499.18	1379562.50	0.15
SH14APY000902	Tree Planting	Patapsco River L N Br	02130906	560640.28	1375384.03	0.23
SH14APY000903	Tree Planting	Middle Patuxent River	02131106	585666.25	1316513.77	0.25
SH14APY000904	Tree Planting	Middle Patuxent River	02131106	558214.86	1332404.19	0.06
SH14APY000905	Tree Planting	Little Patuxent River	02131105	542714.47	1360621.85	0.12
SH14APY000906	Tree Planting	Little Patuxent River	02131105	531888.18	1370774.06	0.74
SH14APY000907	Tree Planting	Little Patuxent River	02131105	534616.16	1367876.76	0.31
SH14APY000908	Tree Planting	Middle Patuxent River	02131106	557148.62	1333974.33	0.13
SH14APY000913	Tree Planting	Little Patuxent River	02131105	557830.58	1364106.10	0.15
SH14APY001594	Tree Planting	Little Patuxent River	02131105	553679.40	1348738.71	0.08
SH14APY001596	Tree Planting	Little Patuxent River	02131105	567118.35	1355971.40	0.10
SH14APY001598	Tree Planting	Little Patuxent River	02131105	566894.93	1355786.17	0.12
SH14APY001599	Tree Planting	Little Patuxent River	02131105	532926.53	1369201.95	0.85
SH14APY001600	Tree Planting	Little Patuxent River	02131105	533737.71	1368356.65	0.64
SH14APY001601	Tree Planting	Little Patuxent River	02131105	543151.21	1360829.14	0.27
SH14APY001554	Tree Planting	Middle Patuxent River	02131106	551887.12	1347046.32	0.28
SH14APY001555	Tree Planting	Little Patuxent River	02131105	556117.92	1365381.16	0.85
SH14APY001605	Tree Planting	Patuxent River upper	02131104	531698.61	1351887.85	1.14
SH14APY001607	Tree Planting	Little Patuxent River	02131105	531609.24	1371291.29	0.11
SH14APY001635	Tree Planting	Little Patuxent River	02131105	535134.20	1367296.38	0.14
SH14APY001636	Tree Planting	Little Patuxent River	02131105	576772.17	1362169.06	0.53
				Complete BMP Acreage Total		**53.55**

Comprehensive List of Restoration Practices By Contract						
Table I-22: FMIS # AX2645182						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH13RST030570	Swales	Loch Raven Reservoir	02130805	739954.13	1413320.53	0.12
SH13RST030571	Swales	Loch Raven Reservoir	02130805	739336.71	1413156.72	0.23
SH13RST030574	Swales	Loch Raven Reservoir	02130805	736552.20	1412419.91	0.39
SH13RST030577	Swales	Loch Raven Reservoir	02130805	733262.71	1412394.35	0.77
SH13RST030582	Swales	Loch Raven Reservoir	02130805	728052.19	1411182.02	0.19
SH13RST030583	Swales	Loch Raven Reservoir	02130805	726956.62	1410826.25	0.22
SH13RST030585	Swales	Loch Raven Reservoir	02130805	725567.15	1410311.42	1.24
SH13RST030587	Swales	Loch Raven Reservoir	02130805	730895.42	1412115.29	0.70
SH13RST070046	Swales	Lower Susquehanna River	02120201	695189.88	1575770.57	0.44
SH13RST070052	Swales	Lower Susquehanna River	02120201	695843.10	1576863.41	0.45
SH13RST070053	Micro-Bioretention	Lower Susquehanna River	02120201	696342.83	1577774.70	1.23
SH13RST070072	Swales	Lower Susquehanna River	02120201	696901.10	1579176.04	1.45
SH13RST070073	Swales	Furnace Bay	02130609	697593.19	1581682.43	0.53
SH13RST070074	Swales	Furnace Bay	02130609	697744.60	1582259.30	0.51
SH13RST070076	Swales	Furnace Bay	02130609	698048.18	1583412.81	0.56
SH13RST070077	Swales	Furnace Bay	02130609	698411.17	1584798.54	1.15
SH13RST070083	Swales	Furnace Bay	02130609	699002.21	1587029.83	0.37
SH13RST070087	Swales	Furnace Bay	02130609	700235.97	1591241.96	0.27
SH12RST120311	Swales	Atkisson Reservoir	02130703	665487.15	1502376.62	0.28
SH12RST120313	Swales	Atkisson Reservoir	02130703	666145.22	1502070.85	0.37
SH12RST120314	Swales	Atkisson Reservoir	02130703	666988.50	1501662.19	0.24
SH12RST120315	Swales	Atkisson Reservoir	02130703	668543.22	1500831.05	0.47
SH12RST120317	Swales	Atkisson Reservoir	02130703	668852.21	1500628.10	0.28
SH12RST120318	Swales	Atkisson Reservoir	02130703	669892.20	1499725.25	0.11
SH12RST120323	Swales	Atkisson Reservoir	02130703	678717.21	1493501.31	0.14
SH12RST120324	Swales	Atkisson Reservoir	02130703	680092.27	1491955.09	0.21
SH13RST120335	Swales	Lower Winters Run	02130702	662430.66	1503838.04	0.30
SH13RST120337	Swales	Lower Winters Run	02130702	663593.19	1503283.35	0.24
SH13RST120343	Swales	Atkisson Reservoir	02130703	673508.63	1497857.44	0.23
SH14RST030567	Swales	Loch Raven Reservoir	02130805	742148.81	1413043.63	0.97
SH14RST030568	Swales	Loch Raven Reservoir	02130805	740855.28	1413413.71	1.30
SH14RST030569	Swales	Loch Raven Reservoir	02130805	740068.30	1413351.34	0.25
SH13RST030572	Swales	Loch Raven Reservoir	02130805	737140.98	1412562.53	0.25
SH13RST030573	Swales	Loch Raven Reservoir	02130805	736705.58	1412454.69	0.07
SH13RST030575	Swales	Loch Raven Reservoir	02130805	735556.96	1412282.21	1.04
SH13RST030576	Swales	Loch Raven Reservoir	02130805	734022.19	1412344.62	0.23
SH13RST030578	Swales	Loch Raven Reservoir	02130805	732267.43	1412392.94	1.08
SH13RST030580	Swales	Loch Raven Reservoir	02130805	729999.98	1411816.14	0.16
SH13RST030581	Swales	Loch Raven Reservoir	02130805	729047.72	1411505.05	0.20
SH13RST030584	Swales	Loch Raven Reservoir	02130805	726215.31	1410585.33	0.21
SH13RST070051	Swales	Lower Susquehanna River	02120201	695465.34	1576219.22	0.44
SH13RST070071	Swales	Lower Susquehanna River	02120201	696654.41	1578498.75	0.21
SH13RST070075	Swales	Furnace Bay	02130609	697890.40	1582840.27	0.64
SH13RST070081	Micro-Bioretention	Furnace Bay	02130609	698599.62	1585505.85	0.55
SH13RST070082	Swales	Furnace Bay	02130609	698739.02	1586032.88	0.82
SH13RST070084	Swales	Furnace Bay	02130609	699168.22	1587645.09	0.74
SH13RST070085	Swales	Furnace Bay	02130609	699557.43	1589116.93	0.92
SH13RST070086	Swales	Furnace Bay	02130609	700053.91	1590795.70	0.69
SH13RST070088	Micro-Bioretention	Furnace Bay	02130609	700416.58	1591643.01	0.67
SH12RST120310	Swales	Lower Winters Run	02130702	660868.10	1504460.54	0.55
SH12RST120312	Swales	Atkisson Reservoir	02130703	665734.92	1502271.50	0.15
SH12RST120319	Micro-Bioretention	Atkisson Reservoir	02130703	670517.10	1499156.94	0.15
SH12RST120320	Micro-Bioretention	Atkisson Reservoir	02130703	670589.60	1499091.69	0.94
SH12RST120321	Swales	Atkisson Reservoir	02130703	672843.44	1498022.86	0.29
SH12RST120328	Swales	Atkisson Reservoir	02130703	675653.57	1497203.17	0.41
SH13RST120333	Swales	Lower Winters Run	02130702	660509.44	1504558.67	0.31
SH13RST120341	Swales	Atkisson Reservoir	02130703	671823.69	1498279.45	0.85
SH13RST120349	Swales	Atkisson Reservoir	02130703	679362.49	1492766.63	0.35
SH13RST120345	Swales	Atkisson Reservoir	02130703	676471.61	1496434.64	0.73
SH13RST120347	Swales	Atkisson Reservoir	02130703	676867.15	1495875.09	0.62
					Complete BMP Acreage Total	**30.48**

Comprehensive List of Restoration Practices By Contract						
Table I-23: FMIS # AX2645282						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH13RST150449	Swales	Potomac River MO Cnty	02140202	531181.45	1246092.78	0.23
SH13RST150450	Swales	Potomac River MO Cnty	02140202	530399.14	1247085.53	0.22
SH13RST150456	Swales	Seneca Creek	02140208	535779.74	1239266.94	0.21
SH13RST150457	Swales	Seneca Creek	02140208	533955.00	1243378.09	0.58
SH13RST150444	Swales	Seneca Creek	02140208	537066.68	1235644.31	0.16
SH13RST150445	Swales	Seneca Creek	02140208	535928.36	1236925.15	0.14
SH13RST150446	Swales	Seneca Creek	02140208	535984.43	1236753.96	0.23
SH13RST150447	Swales	Seneca Creek	02140208	533611.40	1243883.37	0.20
SH13RST150448	Swales	Seneca Creek	02140208	533471.24	1244030.03	0.17
SH13RST150451	Swales	Potomac River MO Cnty	02140202	528943.43	1248873.26	0.29
SH13RST150452	Swales	Potomac River MO Cnty	02140202	525116.50	1252264.65	0.16
SH13RST150459	Swales	Potomac River MO Cnty	02140202	531416.72	1245872.84	0.40
SH13RST150460	Swales	Potomac River MO Cnty	02140202	530244.74	1247366.40	0.22
SH15RST160827	Swales	Anacostia River	02140205	465774.36	1351407.50	0.71
SH15RST160830	Micro-Bioretention	Anacostia River	02140205	471414.64	1350635.98	0.73
SH15RST160319	Swales	Western Branch	02131103	455167.27	1355119.89	0.74
SH15RST160831	Micro-Bioretention	Anacostia River	02140205	471576.68	1350393.03	0.63
					Complete BMP Acreage Total	**6.01**

Comprehensive List of Restoration Practices By Contract						
Table I-24: FMIS # AX2645382						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH16RST080500	Bioretention	Potomac River L tidal	02140101	255025.24	1322281.21	0.46
SH12RST080501	Swales	Potomac River L tidal	02140101	255240.37	1322594.66	0.25
SH12RST080504	Swales	Wicomico River	02140106	256379.84	1323686.20	0.44
SH12RST080505	Swales	Wicomico River	02140106	256938.04	1324010.08	0.33
SH14RST080507	Swales	Wicomico River	02140106	260900.66	1324867.86	0.48
SH12RST080502	Swales	Potomac River L tidal	02140101	255516.39	1322924.36	0.28
SH12RST080503	Swales	Potomac River L tidal	02140101	255958.12	1323359.26	0.31
SH12RST080506	Micro-Bioretention	Wicomico River	02140106	257532.79	1324266.15	0.62
SH14RST080512	Swales	Wicomico River	02140106	264292.55	1325383.50	0.36
SH14RST080513	Swales	Wicomico River	02140106	264871.78	1325475.83	0.44
SH14RST080508	Swales	Wicomico River	02140106	261866.54	1325016.25	0.50
SH16RST080510	Grass Swale	Wicomico River	02140106	262796.88	1325157.88	0.35
SH14RST080515	Swales	Wicomico River	02140106	267170.56	1325815.59	0.29
				Complete BMP Acreage Total		**5.11**

Comprehensive List of Restoration Practices By Contract						
Table I-25: FMIS # AX2645482						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH16RST100462	Bioretention	Upper Monocacy River	02140303	674884.15	1195488.39	0.44
SH16RST100463	Grass Swale	Upper Monocacy River	02140303	675679.42	1194967.89	0.09
SH16RST100470	Grass Swale	Upper Monocacy River	02140303	685192.07	1191871.53	0.77
SH16RST100474	Grass Swale	Upper Monocacy River	02140303	688530.18	1190970.32	0.67
SH16RST100476	Grass Swale	Upper Monocacy River	02140303	690897.77	1190850.41	0.80
SH16RST100477	Bioretention	Upper Monocacy River	02140303	691767.02	1190701.69	0.96
SH16RST100479	Grass Swale	Upper Monocacy River	02140303	692527.03	1190564.97	0.26
SH16RST100480	Grass Swale	Upper Monocacy River	02140303	693060.23	1190465.79	0.74
SH16RST100481	Grass Swale	Upper Monocacy River	02140303	694112.65	1190279.94	0.48
SH13RST130521	Swales	Little Patuxent River	02131105	594794.81	1338359.95	0.42
SH13RST130522	Swales	Little Patuxent River	02131105	593986.15	1339273.04	0.73
SH13RST130526	Swales	Little Patuxent River	02131105	592227.52	1341850.73	0.35
SH13RST130527	Swales	Little Patuxent River	02131105	591891.34	1342405.45	0.51
SH13RST130530	Swales	Little Patuxent River	02131105	590173.10	1345255.28	0.42
SH16RST130531	Grass Swale	Little Patuxent River	02131105	591125.13	1343665.49	0.27
SH16RST210194	Grass Swale	Conococheague Creek	02140504	724389.82	1102198.39	0.30
SH16RST210196	Grass Swale	Conococheague Creek	02140504	724391.04	1101781.36	0.17
SH16RST210197	Grass Swale	Conococheague Creek	02140504	724393.50	1100131.43	0.32
SH16RST100461	Grass Swale	Upper Monocacy River	02140303	673285.01	1196533.56	0.19
SH16RST100464	Grass Swale	Upper Monocacy River	02140303	677284.24	1193919.04	0.60
SH16RST100465	Grass Swale	Upper Monocacy River	02140303	677761.80	1193614.87	0.39
SH16RST100466	Grass Swale	Upper Monocacy River	02140303	678994.08	1193087.41	0.56
SH16RST100467	Grass Swale	Upper Monocacy River	02140303	679665.54	1192931.57	0.75
SH16RST100468	Grass Swale	Upper Monocacy River	02140303	681454.97	1192658.28	0.33
SH16RST100469	Grass Swale	Upper Monocacy River	02140303	682410.74	1192508.90	1.20
SH16RST100471	Bioretention	Upper Monocacy River	02140303	685632.19	1191712.15	0.48
SH16RST100472	Bioretention	Upper Monocacy River	02140303	686838.09	1191274.03	0.18
SH16RST100473	Bioretention	Upper Monocacy River	02140303	687712.31	1191054.44	0.94
SH16RST100475	Grass Swale	Upper Monocacy River	02140303	689536.94	1190947.49	0.71
SH13RST130520	Swales	Little Patuxent River	02131105	595387.16	1337694.83	0.27
SH13RST130524	Swales	Little Patuxent River	02131105	592936.84	1340679.86	0.48
SH13RST130525	Swales	Little Patuxent River	02131105	592657.97	1341143.35	0.41
SH13RST130528	Swales	Little Patuxent River	02131105	591514.63	1343023.07	0.54
SH13RST130529	Swales	Little Patuxent River	02131105	591399.67	1343215.82	0.45
SH13RST130532	Micro-Bioretention	Little Patuxent River	02131105	589881.23	1345711.81	0.46
SH12RST130533	Swales	Little Patuxent River	02131105	589747.31	1345933.33	0.54
SH13RST130534	Swales	Little Patuxent River	02131106	589154.67	1346897.27	0.94
SH12RST130536	Swales	Little Patuxent River	02131105	588812.44	1347398.55	0.37
SH13RST130539	Swales	Little Patuxent River	02131105	593045.11	1340511.56	0.42
SH16RST210193	Grass Swale	Conococheague Creek	02140504	724390.81	1101950.42	0.17
SH16RST210195	Grass Swale	Conococheague Creek	02140504	724391.43	1101888.05	0.07
SH16RST210198	Grass Swale	Conococheague Creek	02140504	724393.79	1100028.08	0.13
SH14RST210202	Swales	Conococheague Creek	02140504	724396.22	1099370.34	0.19
SH14RST210203	Swales	Conococheague Creek	02140504	724400.22	1098562.07	0.69
SH14RST210209	Swales	Antietam Creek	02140502	723833.26	1104220.59	0.30
SH16RST210210	Grass Swale	Antietam Creek	02140502	723898.36	1104420.23	0.07
SH16RST210211	Grass Swale	Antietam Creek	02140502	723982.08	1104244.45	0.19
SH14RST210216	Swales	Conococheague Creek	02140504	724310.13	1103284.28	0.28
SH14RST210199	Swales	Conococheague Creek	02140504	724394.35	1100538.19	0.29
SH14RST210201	Swales	Conococheague Creek	02140504	724403.24	1099538.19	0.43
SH14RST210204	Swales	Conococheague Creek	02140504	724417.06	1099055.22	0.17
SH14RST210205	Swales	Conococheague Creek	02140504	724373.65	1099019.32	0.09
SH16RST210206	Grass Swale	Conococheague Creek	02140504	724149.90	1094411.07	0.19
SH16RST210207	Grass Swale	Conococheague Creek	02140504	724113.84	1094325.83	0.19
SH14RST210208	Swales	Antietam Creek	02140502	723750.36	1104369.94	0.04
				Complete BMP Acreage Total		**23.40**

Comprehensive List of Restoration Practices By Contract						
Table I-26: FMIS # AX3765360						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH12ALN000013	Stream Restoration	Anacostia River	02140205	522508.99	1301934.44	60.11
				Complete BMP Acreage Total		**60.11**

Comprehensive List of Restoration Practices By Contract						
Table I-27: FMIS # AX3765560						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH14ALN000010	Stream Restoration	Rock Creek	02140206	532881.05	1285588.21	29.07
SH16ALN000011	Stream Restoration	Rock Creek	02140206	525751.90	1285106.12	60.03
					Complete BMP Acreage Total	**89.10**

Comprehensive List of Restoration Practices By Contract						
Table I-28: FMIS # AX3765D60						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH15ALN000008	Stream Restoration	Anacostia River	02140205	488114.80	1331149.47	64.50
					Complete BMP Acreage Total	**64.50**

Comprehensive List of Restoration Practices By Contract Table I-29: FMIS # AX3765E60						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH13ALN000003	Stream Restoration	Anacostia River	02140205	523679.43	1318992.21	20.26
SH13ALN000005	Stream Restoration	Anacostia River	02140205	525649.67	1316576.34	5.46
SH13ALN000007	Stream Restoration	Anacostia River	02140205	521754.47	1317227.16	27.89
				Complete BMP Acreage Total		**53.61**

Comprehensive List of Restoration Practices By Contract						
Table I-30: FMIS # AX3765F60						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH15ALN000004	Stream Restoration	Anacostia River	02140205	520991.44	1314568.17	7.12
SH15ALN000006	Stream Restoration	Anacostia River	02140205	519141.74	1314484.94	20.14
					Complete BMP Acreage Total	**27.26**

Comprehensive List of Restoration Practices By Contract						
Table I-31: FMIS # AX3765K60						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH15ALN000009	Stream Restoration	Anacostia River	02140205	496998.09	1339985.57	12.09
				Complete BMP Acreage Total		12.09

Comprehensive List of Restoration Practices By Contract						
Table I-32: FMIS # AX3765L60						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH16ALN000012	Stream Restoration	Anacostia River	02140205	517436.50	1306372.94	51.71
				Complete BMP Acreage Total		**51.71**

Comprehensive List of Restoration Practices By Contract						
Table I-33: FMIS # AX3765N60						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH13ALN000032	Stream Restoration	Seneca Creek	02140208	561514.76	1259876.91	39.91
					Complete BMP Acreage Total	**39.91**

Comprehensive List of Restoration Practices By Contract						
Table I-34: FMIS # AX3765U60						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH13ALN000014	Stream Restoration	Rock Creek	02140206	534657.30	1269961.01	48.54
					Complete BMP Acreage Total	**48.54**

Comprehensive List of Restoration Practices By Contract						
Table I-35: FMIS # AX3785R60						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH17ALN000046	Stream Restoration	Anacostia River	02140205	506981.30	1317663.41	32.00
SH17ALN000045	Stream Restoration	Anacostia River	02140205	508468.54	1316104.78	32.00
					Complete BMP Acreage Total	**64.00**

Comprehensive List of Restoration Practices By Contract						
Table I-36: FMIS # AX7665182						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH17RST030737	Bio-Swale	Loch Raven Reservoir	02130805	657700.00	1408550.00	0.44
SH17RST120055	Retrofit	Deer Creek	02120202	690266.70	1523890.33	1.44
SH17RST120094	Retrofit	Lower Winters Run	02130702	645674.79	1497852.06	2.91
					Complete BMP Acreage Total	**4.78**

Comprehensive List of Restoration Practices By Contract						
Table I-37: FMIS # AX9295182						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH14RST160390	Swales	Western Branch	02131103	450257.37	1383657.30	0.46
SH14RST160391	Swales	Western Branch	02131103	450391.06	1384437.95	0.50
SH14RST160397	Swales	Western Branch	02131103	449620.98	1387280.56	0.58
SH14RST160399	Swales	Western Branch	02131103	449539.16	1387985.22	0.60
SH14RST160400	Swales	Western Branch	02131103	449440.08	1388866.45	0.91
SH14RST160394	Swales	Western Branch	02131103	450232.53	1385757.92	0.65
SH14RST160396	Swales	Western Branch	02131103	449817.14	1386597.03	0.48
SH14RST160398	Swales	Western Branch	02131103	449568.62	1387718.42	0.27
SH14RST160411	Swales	Western Branch	02131103	449278.20	1390190.30	0.73
SH14RST160412	Swales	Patuxent River upper	02131104	449045.36	1391281.17	0.73
SH14RST160415	Swales	Patuxent River upper	02131104	448855.47	1392049.12	0.38
SH14RST160416	Swales	Patuxent River upper	02131104	448568.92	1393205.32	0.63
SH16RST161120	Grass Swale	Western Branch	02131103	419327.93	1358040.95	1.63
SH15RST160886	Swales	Western Branch	02131103	446923.88	1361081.69	0.99
SH14RST160410	Swales	Western Branch	02131103	449358.68	1389593.28	0.46
SH14RST160418	Swales	Patuxent River upper	02131104	448483.78	1393552.53	0.75
SH16RST161121	Grass Swale	Western Branch	02131103	419112.65	1358754.80	0.51
					Complete BMP Acreage Total	**11.26**

Comprehensive List of Restoration Practices By Contract						
Table I-38: FMIS # DNR - Million Tree						
Unique BMP #	BMP Type	8-Digit Watershed Name	8-Digit Watershed Code	Northing	Easting	Impervious Treated (acres)
SH12APY000511	Tree Planting	Patuxent River middle	02131102	387009.92	1393048.26	2.64
SH12APY000505	Tree Planting	Patuxent River lower	02131101	352777.64	1399383.59	1.41
SH10APY000205	Tree Planting	Seneca Creek	02140208	519948.30	1217536.28	3.42
SH12APY000359	Tree Planting	Gunpowder River	02130801	617527.67	1493177.30	7.64
SH12APY000430	Tree Planting	Port Tobacco River	02140109	284193.69	1299872.17	0.32
SH09APY001588	Tree Planting	S Branch Patapsco	02130908	614362.42	1345815.91	0.17
SH09APY001589	Tree Planting	S Branch Patapsco	02130908	614710.42	1345453.84	0.04
SH12APY000357	Tree Planting	Severn River	02131002	511597.89	1425002.69	0.63
SH13APY001580	Tree Planting	Severn River	02131002	511260.79	1425975.04	0.32
SH12APY000358	Tree Planting	Lower Gunpowder Falls	02130802	639702.36	1474510.96	17.15
SH10APY000135	Tree Planting	Loch Raven Reservoir	02130805	704935.20	1394702.33	5.28
SH10APY000136	Tree Planting	Little Gunpowder Falls	02130804	660780.14	1473901.09	2.19
SH10APY000137	Tree Planting	Little Gunpowder Falls	02130804	637365.00	1487769.47	3.06
SH10APY000149	Tree Planting	Lower Gunpowder Falls	02130802	640961.38	1453410.12	0.34
SH10APY000150	Tree Planting	Loch Raven Reservoir	02130805	706318.80	1395661.51	5.02
SH10APY000151	Tree Planting	Loch Raven Reservoir	02130805	708621.12	1398050.78	2.61
SH10APY000152	Tree Planting	Loch Raven Reservoir	02130805	705649.08	1394678.77	1.24
SH10APY000154	Tree Planting	S Branch Patapsco	02130908	614984.33	1344824.25	0.21
SH10APY000155	Tree Planting	S Branch Patapsco	02130908	614806.78	1345593.57	0.36
SH10APY000156	Tree Planting	S Branch Patapsco	02130908	614497.23	1345724.51	0.37
SH12APY000414	Tree Planting	Big Elk Creek	02130606	748324.29	1638468.28	1.13
SH12APY000415	Tree Planting	Big Elk Creek	02130606	745256.91	1635514.28	1.32
SH10APY000159	Tree Planting	Big Elk Creek	02130606	748614.91	1635687.51	1.22
SH10APY000160	Tree Planting	Big Elk Creek	02130606	747834.17	1637107.95	0.86
SH10APY000161	Tree Planting	Christina River	02130607	746468.78	1648196.18	0.64
SH10APY000162	Tree Planting	Christina River	02130607	745066.46	1648314.75	2.09
SH10APY000163	Tree Planting	Christina River	02130607	746227.21	1648243.55	0.09
SH10APY000164	Tree Planting	Christina River	02130607	745955.33	1648201.69	1.09
SH10APY000165	Tree Planting	Christina River	02130607	744696.12	1647268.19	0.87
SH10APY000166	Tree Planting	Christina River	02130607	743627.32	1648079.61	11.10
SH10APY000167	Tree Planting	Big Elk Creek	02130606	750321.40	1631810.25	1.76
SH10APY000168	Tree Planting	Big Elk Creek	02130606	750166.22	1630543.69	1.50
SH10APY000169	Tree Planting	Christina River	02130607	744134.73	1647233.45	1.61
SH12APY000416	Tree Planting	Potomac River M tidal	02140102	288607.59	1236533.42	1.34
SH12APY000417	Tree Planting	Mattawoman Creek	02140111	331504.16	1267863.34	8.85
SH12APY000418	Tree Planting	Potomac River M tidal	02140102	347446.58	1279272.18	2.16
SH12APY000419	Tree Planting	Mattawoman Creek	02140111	328364.57	1287933.78	0.35
SH12APY000426	Tree Planting	Potomac River L tidal	02140101	280694.22	1296476.21	1.66
SH12APY000427	Tree Planting	Nanjemoy Creek	02140110	284541.79	1290298.93	1.23
SH12APY000428	Tree Planting	Port Tobacco River	02140109	284951.60	1298178.83	0.04
SH12APY000429	Tree Planting	Port Tobacco River	02140109	283083.49	1298421.45	1.67
SH12APY000431	Tree Planting	Potomac River M tidal	02140102	346718.86	1278140.65	2.71
SH12APY000432	Tree Planting	Mattawoman Creek	02140111	326247.51	1288522.39	0.25
SH12APY000433	Tree Planting	Mattawoman Creek	02140111	326025.50	1288840.63	0.15
SH12APY000434	Tree Planting	Mattawoman Creek	02140111	325692.36	1288622.69	0.05
SH12APY000435	Tree Planting	Mattawoman Creek	02140111	324574.38	1288638.89	0.46
SH12APY000436	Tree Planting	Mattawoman Creek	02140111	322507.16	1288617.67	0.32
SH12APY000437	Tree Planting	Mattawoman Creek	02140111	321514.06	1288334.82	0.08
SH12APY000438	Tree Planting	Mattawoman Creek	02140111	321415.50	1288484.30	0.02
SH12APY000439	Tree Planting	Potomac River L tidal	02140101	279722.87	1292753.78	2.72
SH12APY000440	Tree Planting	Potomac River L tidal	02140101	281916.27	1298167.02	0.95
SH12APY000441	Tree Planting	Potomac River L tidal	02140101	278075.03	1291573.37	0.81
SH12APY000442	Tree Planting	Potomac River L tidal	02140101	278083.04	1293622.61	0.84
SH12APY000443	Tree Planting	Potomac River L tidal	02140101	279332.91	1294870.24	1.03
SH12APY000444	Tree Planting	Potomac River L tidal	02140101	278282.65	1292464.11	0.48
SH12APY000445	Tree Planting	Potomac River L tidal	02140101	282629.39	1299235.46	0.64
SH12APY000446	Tree Planting	Potomac River L tidal	02140101	279142.75	1293551.45	0.39
SH12APY000447	Tree Planting	Potomac River L tidal	02140101	276937.67	1292563.98	0.32
SH12APY000448	Tree Planting	Potomac River L tidal	02140101	277936.29	1291970.22	0.37
SH12APY000449	Tree Planting	Potomac River L tidal	02140101	279183.76	1292318.05	0.24
SH12APY000450	Tree Planting	Potomac River L tidal	02140101	279479.76	1293532.26	0.10
SH12APY000451	Tree Planting	Potomac River L tidal	02140101	279794.88	1293144.23	0.19
SH12APY000452	Tree Planting	Potomac River L tidal	02140101	281329.65	1297479.29	0.13
SH12APY000453	Tree Planting	Potomac River L tidal	02140101	277530.74	1291392.04	0.04
SH12APY000454	Tree Planting	Potomac River L tidal	02140101	280998.39	1297106.49	0.09
SH12APY000455	Tree Planting	Nanjemoy Creek	02140110	283270.59	1288896.90	1.01
SH12APY000456	Tree Planting	Nanjemoy Creek	02140110	283340.44	1289500.70	0.56
SH12APY000457	Tree Planting	Nanjemoy Creek	02140110	283662.10	1288561.76	0.21
SH12APY000458	Tree Planting	Nanjemoy Creek	02140110	283778.04	1289325.67	0.12
SH12APY000459	Tree Planting	Port Tobacco River	02140109	283470.07	1297319.91	1.05
SH12APY000460	Tree Planting	Port Tobacco River	02140109	283327.55	1291798.73	0.27
SH12APY000461	Tree Planting	Port Tobacco River	02140109	283494.15	1290177.83	0.18
SH12APY000462	Tree Planting	Mattawoman Creek	02140111	323703.06	1288687.88	0.24
SH10APY000176	Tree Planting	Potomac River FR Cnty	02140301	572775.82	1183787.13	4.08
SH10APY000177	Tree Planting	Lower Monocacy River	02140302	575970.44	1184119.19	4.01
SH10APY000180	Tree Planting	Potomac River FR Cnty	02140301	573814.44	1183409.21	1.68
SH10APY000181	Tree Planting	Lower Monocacy River	02140302	574031.14	1183617.25	3.49

Comprehensive List of Restoration Practices By Contract						
Table I-38: FMIS # DNR - Million Tree						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH10APY000182	Tree Planting	Lower Monocacy River	02140302	573423.53	1184201.67	5.47
SH11APY000248	Tree Planting	Lower Susquehanna River	02120201	704619.92	1556322.71	1.23
SH11APY000249	Tree Planting	Lower Susquehanna River	02120201	704366.31	1556274.41	1.19
SH11APY000250	Tree Planting	Lower Susquehanna River	02120201	704586.62	1556995.41	1.16
SH11APY000251	Tree Planting	Lower Susquehanna River	02120201	703416.87	1555557.55	1.81
SH11APY000252	Tree Planting	Lower Susquehanna River	02120201	702822.12	1555062.51	3.65
SH11APY000253	Tree Planting	Lower Susquehanna River	02120201	705144.85	1552839.05	2.80
SH11APY000254	Tree Planting	Lower Susquehanna River	02120201	704745.80	1552570.91	2.84
SH11APY000255	Tree Planting	Lower Susquehanna River	02120201	704791.67	1553308.05	1.91
SH11APY000256	Tree Planting	Lower Susquehanna River	02120201	704399.54	1553543.32	5.74
SH11APY000257	Tree Planting	Lower Susquehanna River	02120201	704329.53	1552456.34	2.88
SH12APY000463	Tree Planting	Deer Creek	02120202	713190.21	1517710.12	2.81
SH12APY000464	Tree Planting	Deer Creek	02120202	713696.60	1516818.98	4.94
SH11APY000260	Tree Planting	Lower Susquehanna River	02120201	704447.77	1555478.06	2.81
SH10APY000200	Tree Planting	Patapsco River L N Br	02130906	609885.82	1344070.90	4.55
SH11APY000299	Tree Planting	Patapsco River L N Br	02130906	566291.12	1385258.29	2.82
SH12APY000486	Tree Planting	Potomac River MO Cnty	02140202	515626.63	1206967.73	0.81
SH12APY000487	Tree Planting	Potomac River MO Cnty	02140202	514962.49	1206656.90	2.15
SH12APY000488	Tree Planting	Potomac River MO Cnty	02140202	514297.86	1206128.23	1.16
SH12APY000489	Tree Planting	Potomac River MO Cnty	02140202	514879.29	1205043.19	0.39
SH12APY000490	Tree Planting	Potomac River MO Cnty	02140202	513052.88	1204042.74	2.09
SH12APY000491	Tree Planting	Potomac River MO Cnty	02140202	511443.60	1201691.92	1.28
SH12APY000492	Tree Planting	Potomac River MO Cnty	02140202	511933.92	1201842.18	1.68
SH12APY000493	Tree Planting	Potomac River MO Cnty	02140202	512850.91	1202039.92	2.38
SH12APY000494	Tree Planting	Potomac River MO Cnty	02140202	513802.88	1200636.02	1.77
SH12APY000495	Tree Planting	Potomac River MO Cnty	02140202	514162.78	1201848.91	1.35
SH12APY000496	Tree Planting	Potomac River MO Cnty	02140202	513342.97	1198463.02	0.33
SH12APY000497	Tree Planting	Potomac River MO Cnty	02140202	513168.20	1198213.52	0.22
SH12APY000501	Tree Planting	Potomac River MO Cnty	02140202	513413.64	1193762.08	0.73
SH12APY000502	Tree Planting	Potomac River MO Cnty	02140202	513223.58	1193555.55	0.57
SH12APY000503	Tree Planting	Potomac River MO Cnty	02140202	512158.33	1202113.31	0.37
SH12APY000504	Tree Planting	Patuxent River middle	02131102	391085.70	1395987.00	0.49
SH12APY000506	Tree Planting	Patuxent River lower	02131101	351976.49	1400034.08	0.73
SH12APY000507	Tree Planting	Patuxent River lower	02131101	350288.08	1399354.35	1.08
SH12APY000508	Tree Planting	Patuxent River lower	02131101	351034.44	1397997.20	0.50
SH12APY000509	Tree Planting	Patuxent River middle	02131102	391184.81	1395163.25	0.27
SH12APY000510	Tree Planting	Patuxent River middle	02131102	388261.33	1394369.46	1.00
SH12APY000512	Tree Planting	Little Conococheague	02140505	739608.82	1044026.32	1.62
SH12APY000513	Tree Planting	Sideling Hill Creek	02140510	729386.99	934363.16	1.18
SH11APY000258	Tree Planting	Little Gunpowder Falls	02130804	636868.28	1491056.20	1.13
SH11APY000259	Tree Planting	Little Gunpowder Falls	02130804	636432.16	1491107.39	1.01
SH12APY000514	Tree Planting	Little Conococheague	02140505	739742.42	1045260.25	0.58
					Complete BMP Acreage Total	**202.78**

Comprehensive List of Restoration Practices By Contract						
Table I-39: FMIS # HA4075182						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH15ALN000015	Stream Restoration	Atkisson Reservoir	02130703	671619.72	1498492.67	21.00
					Complete BMP Acreage Total	**21.00**

Comprehensive List of Restoration Practices By Contract						
Table I-40: FMIS # HA4095182SBR						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH13ALN000017	Stream Restoration	Deer Creek	02120202	726476.17	1446856.98	11.60
				Complete BMP Acreage Total		**11.60**

Comprehensive List of Restoration Practices By Contract						
Table I-41: FMIS # HO1695182						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH16ALN000044	Stream Restoration	Patapsco River L N Br	02130906	563711.14	1396012.83	3.00
					Complete BMP Acreage Total	**3.00**

Comprehensive List of Restoration Practices By Contract						
Table I-42: FMIS # HO2065182						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH15ALN000016	Stream Restoration	Little Patuxent River	02131105	581541.75	1354631.25	45.00
					Complete BMP Acreage Total	**45.00**

Comprehensive List of Restoration Practices By Contract						
Table I-43: FMIS # HO3255124						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH12ALN000018	Stream Restoration	Little Patuxent River	02131105	539038.06	1373209.43	19.73
				Complete BMP Acreage Total		19.73

Comprehensive List of Restoration Practices By Contract						
Table I-44: FMIS # HO4085174						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH12ALN000029	Stream Restoration	Little Patuxent River	02131105	571640.33	1365244.12	4.17
					Complete BMP Acreage Total	**4.17**

Comprehensive List of Restoration Practices By Contract						
Table I-45: FMIS # PG0735182						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH17ALN000043	Outfall Stabilization	Potomac River U tidal	02140201	393907.68	1314612.33	0.50
SH17ALN000039	Outfall Stabilization	Piscataway Creek	02140203	366528.73	1309746.07	2.00
SH17ALN000036	Outfall Stabilization	Piscataway Creek	02140203	369455.20	1312178.08	3.00
SH17ALN000038	Outfall Stabilization	Piscataway Creek	02140203	378472.01	1315547.96	2.00
SH17ALN000037	Outfall Stabilization	Piscataway Creek	02140203	379461.15	1315141.60	2.00
SH17ALN000041	Outfall Stabilization	Potomac River U tidal	02140201	393115.36	1314480.70	1.25
				Complete BMP Acreage Total		**10.75**

Comprehensive List of Restoration Practices By Contract						
Table I-46: FMIS # WA2445182						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH16RST210525	Bio-Swale	Little Tonoloway Creek	02140509	749495.78	978344.01	0.43
SH16RST210526	Bio-Swale	Little Tonoloway Creek	02140509	749265.59	978245.09	0.14
SH16RST210529	Bio-Swale	Little Tonoloway Creek	02140509	747988.86	978172.42	0.40
SH16RST210530	Bio-Swale	Little Tonoloway Creek	02140509	746067.64	979007.98	0.39
SH16RST210533	Bio-Swale	Potomac River WA Cnty	02140501	745297.00	979735.57	0.22
SH16RST210548	Bio-Swale	Potomac River WA Cnty	02140501	740537.99	989726.14	0.56
SH16RST210549	Bio-Swale	Potomac River WA Cnty	02140501	740372.27	990122.04	0.20
SH16RST210550	Bio-Swale	Potomac River WA Cnty	02140501	740082.28	990901.14	0.51
SH16RST210554	Bio-Swale	Potomac River WA Cnty	02140501	738825.29	994823.08	0.25
SH16RST210555	Bio-Swale	Potomac River WA Cnty	02140501	738606.07	995268.78	0.25
SH16RST210558	Bio-Swale	Potomac River WA Cnty	02140501	738165.49	997176.71	0.25
SH16RST210569	Bio-Swale	Potomac River WA Cnty	02140501	722534.18	1019492.12	0.09
SH16RST210573	Bio-Swale	Potomac River WA Cnty	02140501	718236.95	1023945.98	1.23
SH16RST210574	Bio-Swale	Potomac River WA Cnty	02140501	717332.29	1024623.02	0.09
SH16RST210576	Bio-Swale	Potomac River WA Cnty	02140501	737831.07	998490.98	0.77
SH16RST210578	Bio-Swale	Potomac River WA Cnty	02140501	736697.15	1002522.80	0.58
SH16RST210579	Bio-Swale	Potomac River WA Cnty	02140501	736390.95	1002982.38	0.57
SH16RST210582	Bio-Swale	Potomac River WA Cnty	02140501	734699.22	1004926.93	0.39
SH16RST210590	Bio-Swale	Potomac River WA Cnty	02140501	726466.46	1015702.00	0.43
SH16RST210592	Bio-Swale	Little Conococheague	02140505	723645.47	1052910.66	0.43
SH16RST210602	Bio-Swale	Marsh Run	02140503	707330.74	1100931.33	0.50
SH16RST210604	Bio-Swale	Marsh Run	02140503	707175.52	1101923.62	0.62
SH16RST210605	Bio-Swale	Marsh Run	02140503	706977.03	1103225.39	0.48
SH16RST210612	Bio-Swale	Antietam Creek	02140502	704995.11	1122085.81	1.17
SH16RST210613	Bio-Swale	Antietam Creek	02140502	705047.97	1122896.21	0.27
SH16RST210617	Bio-Swale	Antietam Creek	02140502	701939.54	1128828.22	1.07
SH16RST210619	Bio-Swale	Antietam Creek	02140502	696234.80	1135573.35	0.85
SH16RST210523	Bio-Swale	Little Tonoloway Creek	02140509	750542.92	978870.16	0.87
SH16RST210524	Bio-Swale	Little Tonoloway Creek	02140509	749976.29	978586.63	0.21
SH16RST210545	Bio-Swale	Tonoloway Creek	02140507	743122.60	986637.95	0.29
SH16RST210551	Bio-Swale	Potomac River WA Cnty	02140501	740013.55	991123.15	0.21
SH16RST210552	Bio-Swale	Potomac River WA Cnty	02140501	739795.70	991837.12	0.26
SH16RST210553	Bio-Swale	Potomac River WA Cnty	02140501	739652.36	992399.46	0.23
SH16RST210556	Bio-Swale	Potomac River WA Cnty	02140501	738403.58	995921.79	0.22
SH16RST210559	Bio-Swale	Potomac River WA Cnty	02140501	738133.33	997138.43	0.34
SH16RST210560	Bio-Swale	Potomac River WA Cnty	02140501	716072.49	1025853.17	0.34
SH16RST210562	Micro-Bioretention	Potomac River WA Cnty	02140501	720072.12	1022543.95	0.29
SH16RST210565	Bio-Swale	Licking Creek	02140506	725200.98	1017218.34	0.48
SH16RST210566	Bio-Swale	Potomac River WA Cnty	02140501	723284.48	1018850.23	0.13
SH16RST210567	Bio-Swale	Potomac River WA Cnty	02140501	723185.07	1018932.38	0.13
SH16RST210568	Bio-Swale	Potomac River WA Cnty	02140501	722711.78	1019315.65	0.37
SH16RST210571	Bio-Swale	Potomac River WA Cnty	02140501	721276.90	1021067.87	0.05
SH16RST210572	Bio-Swale	Potomac River WA Cnty	02140501	720245.18	1022363.18	0.83
SH16RST210575	Bio-Swale	Potomac River WA Cnty	02140501	719164.74	1023303.37	0.86
SH16RST210577	Bio-Swale	Potomac River WA Cnty	02140501	737340.19	1000660.43	0.67
SH16RST210580	Bio-Swale	Potomac River WA Cnty	02140501	735342.26	1004188.35	0.79
SH16RST210581	Bio-Swale	Potomac River WA Cnty	02140501	735141.51	1004416.92	0.80
SH16RST210584	Bio-Swale	Potomac River WA Cnty	02140501	728041.03	1013839.02	0.38
SH16RST210585	Bio-Swale	Potomac River WA Cnty	02140501	727661.50	1014212.87	0.36
SH16RST210586	Bio-Swale	Potomac River WA Cnty	02140501	727564.26	1014309.29	0.17
SH16RST210587	Bio-Swale	Potomac River WA Cnty	02140501	727300.61	1014605.75	0.17
SH16RST210588	Bio-Swale	Potomac River WA Cnty	02140501	727232.14	1014678.94	0.63
SH16RST210589	Bio-Swale	Potomac River WA Cnty	02140501	726593.49	1015518.47	0.63
SH16RST210591	Bio-Swale	Little Conococheague	02140505	723674.31	1052766.46	0.32
SH16RST210593	Bio-Swale	Little Conococheague	02140505	723922.83	1051600.85	1.48
SH16RST210594	Bio-Swale	Little Conococheague	02140505	723991.30	1051769.78	0.25
SH16RST210595	Bio-Swale	Conococheague Creek	02140504	714296.60	1087615.90	0.52
SH16RST210596	Bio-Swale	Conococheague Creek	02140504	713878.33	1088394.12	0.70
SH16RST210598	Bio-Swale	Marsh Run	02140503	707350.62	1097695.02	0.45
SH16RST210599	Bio-Swale	Marsh Run	02140503	707361.71	1098217.95	0.38
SH16RST210600	Bio-Swale	Marsh Run	02140503	707381.20	1099417.22	0.29
SH16RST210601	Bio-Swale	Marsh Run	02140503	707392.84	1100110.76	0.56
SH16RST210603	Bio-Swale	Marsh Run	02140503	707197.40	1101796.12	0.17
SH16RST210606	Bio-Swale	Antietam Creek	02140502	706909.31	1103812.72	0.37
SH16RST210609	Bio-Swale	Antietam Creek	02140502	704716.47	1120320.82	0.36
SH16RST210610	Bio-Swale	Antietam Creek	02140502	704612.53	1120458.82	0.30
SH16RST210614	Bio-Swale	Antietam Creek	02140502	705047.18	1123013.08	0.45
SH16RST210615	Bio-Swale	Antietam Creek	02140502	704974.18	1123871.47	0.57
SH16RST210616	Bio-Swale	Antietam Creek	02140502	703237.01	1127239.54	0.46
SH16RST210618	Bio-Swale	Antietam Creek	02140502	696819.57	1135136.44	0.50
					Complete BMP Acreage Total	**31.97**

Comprehensive List of Restoration Practices By Contract						
Table I-47: FMIS # WA2775182						
Unique BMP #	**BMP Type**	**8-Digit Watershed Name**	**8-Digit Watershed Code**	**Northing**	**Easting**	**Impervious Treated (acres)**
SH17APY001548	Tree Planting	Potomac River WA Cnty	02140501	664162.42	1100982.02	5.33
SH17APY001549	Tree Planting	Antietam Creek	02140502	661480.14	1102716.96	1.62
SH17APY001551	Tree Planting	Antietam Creek	02140502	662567.54	1102721.75	1.56
SH17APY001550	Tree Planting	Potomac River WA Cnty	02140501	660706.75	1100397.64	0.80
				Complete BMP Acreage Total		**9.31**

Appendix J

Little Catoctin Creek Watershed Monitoring Implementation Document

Appendix J

Appendix J

Little Catoctin Creek Watershed
Monitoring Implementation Document

Note:

The final design plans for the Little Catoctin Creek Stream Restoration project are included within the digital submission of the MDOT SHA 2017 Annual Report as “Appendix J.1”.

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Little Catoctin Creek Watershed Monitoring Implementation Document

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October 2017

Table of Contents

1 Introduction 2
2 Chemical Monitoring 2
2.1 Surface Water Stage/Discharge/Velocity 4
2.2 Continuous Water Quality 5
2.3 Discrete Water Quality 5
2.4 Floodplain Monitoring and Assessment (optional) 6
3 Biological Monitoring 6
3.1 Methods 7
3.2 Summary of Pre-Restoration Biological and Physical Habitat Conditions 8
3.3 Photo Log of Sampling Locations 1
3.4 Next Steps 8
4 Physical Monitoring 8
5 References 13

Attachments

Attachment A – Monitoring Locations

Attachment B – Geomorphic Data

1 Introduction

The stream restoration of Little Catoctin Creek (LCC) is currently under design by the Maryland Department of Transportation State Highway Administration (MDOT SHA) Water Programs Division (WPD). The restoration extents originate at MDOT SHA bridge structure number 10081 along MD 180 (Jefferson Pike) and continues downstream approximately 3,100 LF of the existing channel. MDOT SHA is in the process of monitoring the physical, chemical and biological features of the project stream for five years: This report documents the findings from the first year of monitoring per the NPDES/MS4 Assessment of Controls for Stream Restoration of Little Catoctin Creek at U.S. 340.

The following sections of this yearly report include activities for chemical, biological, and physical monitoring for the pre-restoration baseline between July 2016 and June 2017.

2 Chemical Monitoring

Per the NPDES/MS4 Assessment of Controls monitoring plan, chemical monitoring of the Little Catoctin Creek was performed as specified in the chemical monitoring methodology. The monitoring efforts herein fall under phase CHEM 1 to establish pre-restoration conditions. Data for stage, discharge, velocity, continuous water quality measurements, and discrete water quality measurements were recorded and reported on the U.S. Geological Survey's National Water Information Service (NWIS). The chemical monitoring locations referenced in the following sections of the report can be found in Figure 1.

Figure 1. Chemical Monitoring Locations

2.1 Surface Water Stage/Discharge/Velocity

In September 2016, U.S. Geological Survey Site 01636845 (Little Catoctin Creek Near Rosemont, MD; upstream) was established (see Figure 2), which included a radar stage sensor and acoustic doppler velocity meter (ADVM) for velocity. Since the installation of the equipment, 29 discharge measurements have been made. The combination of discharge and stage measurements (at different flows) has led to the development of the stage-discharge relationship for this site, which has been approved. In December 2016, U.S. Geological Survey Site 01636846 (Little Catoctin Creek at Rosemont, MD; downstream) was established (Figure 3) and instrumented with an ADVM to measure stream velocity.

Figure 2. U.S. Geological Survey Site 01636845 (Little Catoctin Creek Near Rosemont, MD; upstream)

Figure 3. U.S. Geological Survey Site 01636846 (Little Catoctin Creek at Rosemont, MD; downstream)

2.2 Continuous Water Quality

In November 2016, a YSI EXO-2 Multiparameter Water Quality was installed at site 01636845. In December 2016, a YSI EXO-2 Multiparameter Water Quality was installed at site 01636846 (see Figures 3 and 4). Both sondes were programed to measure Temperature, Specific Conductivity, pH, and Turbidity on a 5-minute interval. Both sites have been operational since installation and data are available in near-real time on NWISweb. Final QA/QC of the continuous data is currently underway.

Figure 4. U.S. Geological Survey Site 01636846 (Little Catoctin Creek at Rosemont, MD; downstream) Continuous water quality measurements

2.3 Discrete Water Quality

During storm events, rise, peak, and fall stages of the hydrograph are targeted for sample collection at both the upstream (01636845) and downstream (01636846) locations. From the period 01/24/2017 through 07/06/2017, a total of 8 complete sets of storm samples have been collected. If possible, depth-weighted equal width interval samples are collected at each site, however if the stream is not safe to wade,

autosamplers are engaged to collect samples. In addition to storm samples, one baseflow sample was collected on 02/23/2017. Both the upstream site (01636845) and the downstream site (01636846) have 2 ISCO Autosamplers, which were installed on 03/30/2017. Samples have been analyzed for nutrients, metals, VOC's, bacteria and 5-day biological oxygen demand. Upon completion of analyses, results are loaded into the U.S. Geological Survey's NWIS and are available online. A variety of field and equipment blanks have also been performed over this period for quality assurance.

2.4 Floodplain Monitoring and Assessment (optional)

In December 2016, 125 floodplain tiles were installed at 7 floodplain-monitoring transects to quantify floodplain sediment accretion throughout the study reach. No overbank deposition has been detected to date.

3 Biological Monitoring

This report summarizes biological monitoring data collected from April 2016 to June 2017 by the MDNR Resource Assessment Service. This report provides a preliminary synopsis of the baseline biological conditions present within Little Catoctin Creek. It was compiled to support MDOT SHA's MS4 reporting requirements (FY2017) for this restoration project. A more thorough synopsis of baseline, pre-restoration conditions will be completed in 2018 once Year 2 monitoring has concluded (fall 2017).

MDOT SHA and MDNR identified three stream reaches on Little Catoctin Creek to monitor over the course of the study to assess changes in biological condition and stream physical habitat quality associated with the restoration. The study reaches included:

1. Control reach located west of MD 180 (upstream of the planned restoration);
2. Restoration reach extending approximately 3,100 linear feet east of MD 180; and
3. Downstream reach located east (downstream) of the restoration reach.

Two sites were allocated to each of these study reaches (Fig. 1). When possible, biological monitoring sites were co-located at proposed geomorphological transects (MDOT SHA) and chemical monitoring stations (USGS) to improve interpretation of all monitoring data over the course of the study. We also monitored a seventh site located on a small tributary entering the Control reach just west of MD 180 to assess its potential influence on conditions in the Little Catoctin Creek main stem. Only benthic macroinvertebrates were sampled at this site. Fish and physical habitat were not assessed at this site.

To provide an understanding of natural variability in stream biological conditions, MDNR monitors 29 reference streams known as the MBSS Sentinel Site network (Becker et al. 2011). Although monitoring of these Sentinel sites is not related to nor funded under this project, we will use data from these nearby reference sites to better interpret pre- and post-restoration biological conditions in Little Catoctin Creek. Specifically, annual data collected from Sentinel sites during this project will allow us to differentiate natural changes in stream conditions occurring within the region from changes associated with the restoration. Two of these Sentinel sites, Fifteen Mile Creek in Washington County, and Jones Falls in Baltimore County, are of similar size to Little Catoctin Creek. We present data from these reference sites in this baseline report.

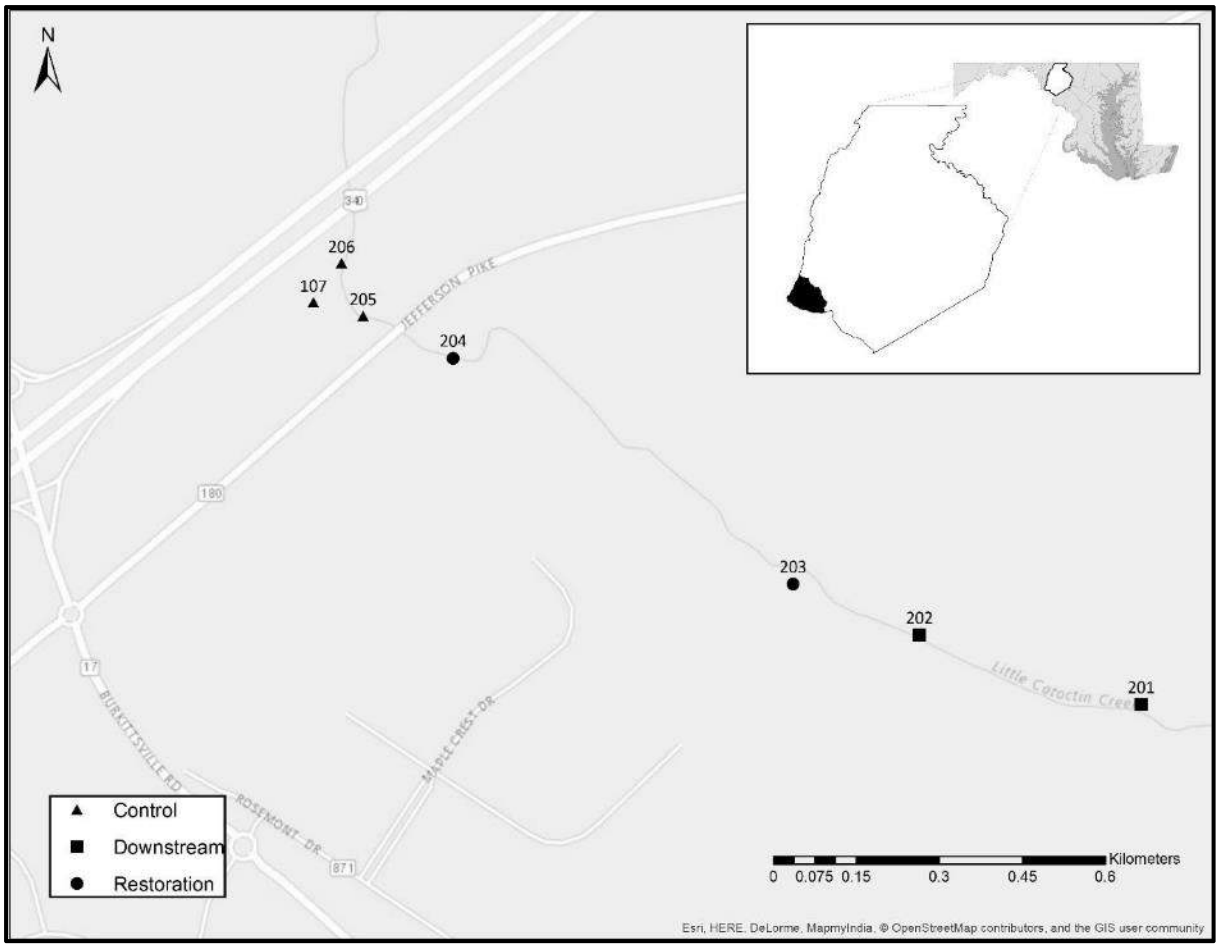


Figure 5. Locations of the seven biological monitoring sites in Little Catoctin Creek in Frederick County, Maryland

3.1 Methods

Biological and physical habitat assessments at all sites summarized in this report were conducted following Maryland Biological Stream Survey (MBSS) sampling protocols. Detailed descriptions of these protocols are provided by Stranko et al. (2014). However, a brief description of sampling protocols used for this project are as follows:

Benthic Macroinvertebrates: Benthic macroinvertebrates were collected during the MBSS spring index period (March 1 – April 30) using a 540 µm mesh D-shaped net. Twenty 0.09 m^2 sub-samples were collected from optimal benthic habitats in each site. The 20 sub-samples were allocated in proportion to the abundance of each optimal habitat type (e.g., riffle, woody debris) present and all sub-samples were combined into one composite sample. Each composite sample was processed at MDNR's benthic laboratory. A random sub-sample of at least 100 organisms were identified to genus or the lowest practical taxonomic level. A benthic index of biotic integrity (BIBI) was calculated following methods described in Southerland et al. (2008).

Fish: Fishes were collected during the MBSS summer index period (June 1 – September 30) using two-pass backpack electrofishing in a 75-meter section of stream closed at the upstream and downstream ends with 6 mm mesh block nets. All fishes collected were weighed in aggregate, identified to species, counted, and released. A fish index of biotic integrity (FIBI) was calculated following methods described in Southerland et al. (2008).

Physical Habitat: Several metrics representing various aspects of stream habitat quality were measured at each site. Instream habitat, epifaunal substrate, velocity/depth diversity, pool/glide/eddy quality, riffle/run quality were scored on a 0-20 scale following protocols similar to the EPA rapid bioassessment protocols (Barbour et al. 1999) and described in Stranko et al. (2014). These five metrics as well as embeddedness, stream bank erosion area, and bar formation/deposition were scored during the MBSS summer index period. Riparian buffer width was characterized during the MBSS spring index period. These data were used to calculate a physical habitat index (PHI) following methods described by Paul et al. (2002).

3.2 Summary of Pre-Restoration Biological and Physical Habitat Conditions

Biological and physical habitat data collected at all seven sites in 2016 and from March – June 30 of 2017 are summarized below. This report summarizes data that had undergone quality control and assurance review and were considered finalized as of June 30, 2017. At the time that this report was drafted, benthic data from the two reference sites had not undergone QA/QC review, and are not reported here. Below we compare conditions documented in the three study reaches and present data collected during the same period from the two reference sites (MBSS Sentinel sites).

Biological Conditions:

A total of 42 benthic taxa were collected in Little Catoctin Creek. Taxa richness at each site ranged from 14 to 22, with taxa richness generally decreasing in an upstream direction throughout the study reaches. For comparison, taxa richness observed in 2016 at the reference sites was 19 and 28 for Fifteen Mile Creek and Jones Falls, respectively. Benthic macroinvertebrate index scores ranged from Very Poor to Poor condition in the three study reaches (Table 1). BIBI scores observed during the same time period at the reference sites ranged from Fair to Good (Table 2). The highest BIBI score (2.25) was observed in the Downstream reach of Little Catoctin Creek in 2016. The lowest BIBI score was observed in the Control reach in 2017. BIBI scores were variable at all sites between years, but this variation was well within what would be considered normal for benthic macroinvertebrate communities. Similar variation has been documented at MBSS Sentinel sites and is attributed to biotic response to natural variation in precipitation and other factors. For example, annual BIBI scores at the Fifteen Mile Creek Sentinel site varied as much as 0.75 from 2000-2016.

Table 1. Benthic and fish index of biotic integrity scores from the three study reaches in Little Catoctin Creek.

Reach	Downstream				Restoration				Control					
Site	201		202		203		204		205		206		107	
Year	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
BIBI	2.00	1.75	2.25	1.50	2.00	1.75	1.75	1.75	1.50	1.75	1.50	1.25	2.00	1.50
FIBI	4.33	*	3.33	*	3.33	*	3.33	*	3.00	*	3.33	*	NM	NM

NM = Not measured (Only benthic macroinvertebrates sampled at this site); * Fish sampling at these sites occurred after reporting period.

Table 2. Benthic and fish index of biotic integrity scores from representative MBSS Sentinel sites.

	Reference Sites			
Site	Fifteen Mile Creek		Jones Falls	
Year	2016	2017	2016	2017
BIBI	3.00	**	4.00	**
FIBI	4.33	*	3.67	*

* Fish sampling at these sites occurred after reporting period. ** Benthic data not finalized at time of reporting.

A total of 21 fish species representing seven families were collected from Little Catoctin Creek in 2016. Fish species richness at each site ranged from 13 to 18. As observed in benthic taxa richness, fish species

richness in Little Catoctin Creek generally decreased in an upstream direction – with the highest richness observed at both sites in the Downstream reach. Species richness at the reference sites during the same year was 11 and eight for Fifteen Mile Creek and Jones Falls, respectively. Fish biological integrity scores ranged from Fair to Good in Little Catoctin Creek, with the highest score (4.33) observed in the Downstream reach (Table 1). As observed in the BIBI scores, the lowest FIBI score was observed in the Control reach. Fish assemblage integrity in Little Catoctin Creek is comparable to that of the two reference sites (Table 2).

As reflected in the BIBI and FIBI scores, benthic macroinvertebrate communities appear to be in poorer condition than the fish communities present in each of the three study reaches of Little Catoctin Creek. Discrepancies in biological indicators as observed in this study are not uncommon. Benthic macroinvertebrate and fish communities may in some cases respond differently to stressors. Although all the factors affecting benthic macroinvertebrate communities in the study area are not understood at this time, the presence of heavy deposits of fine silt and sand within Little Catoctin Creek has likely contributed to the lower integrity scores documented here.

Physical Habitat Conditions:

As described previously, Little Catoctin Creek within the study area flows through predominately agricultural lands consisting of crops and active and inactive pasture. The riparian areas adjacent to the biological monitoring sites had, in most cases, minimal coverage of trees and other woody vegetation. Riparian buffer widths measured at these sites varied from zero (no vegetated buffer) to at least 50 meters (Table 4). As a result, much of the streambed within the study reaches was open with minimal shading of stream substrates and aquatic habitats. Percent of the stream channel shaded by riparian vegetation was highest in the Downstream reach and decreased upstream.

Eroded stream bank area measurements were the highest within the Restoration reach below MD 180. Fine sediments eroding from stream banks and other sources are found throughout the depositional areas within the study area – especially within the Restoration and Control reaches. Depositional bar formation ranged from Severe (Downstream reach) to Minimal (Control reach).

Physical habitat index scores for each site showed a downstream to upstream pattern of decreasing habitat quality with highest index scores measured in the Downstream reach and lowest scores measured in the Control reach. Instream habitat quality, a qualitative measure of habitat available for stream fishes, ranged from Sub-optimal to Optimal within the study area. Fish habitat was generally of higher quality in the Downstream reach, where the highest FIBI scores were documented. In comparison to reference conditions, fish habitat quality within Little Catoctin Creek is similar to that observed during the same time period in Jones Falls and of higher quality than observed in Fifteen Mile Creek.

Epifaunal substrate quality, a qualitative measure of habitat available to benthic macroinvertebrates, ranged from Sub-optimal to Optimal within the study area. The highest quality habitat was again observed in the Downstream reach and lowest quality benthic habitat was observed in the Control reach. In comparison to reference conditions, benthic macroinvertebrate habitat quality within Little Catoctin Creek is similar to that observed during the same time period in Jones Falls and of higher quality than observed in Fifteen Mile Creek.

Table 3. Physical habitat metrics and physical habitat index scores measured at each site within the three study reaches of Little Catoctin Creek.

Metric	Downstream		Restoration		Control	
	201	202	203	204	205	206
Instream Habitat Quality (0-20	15	18	16	13	15	12
Epifaunal Substrate Quality (0-20 scale)	15	17	15	16	12	11
Velocity/Depth Diversity (0-20 scale)	14	14	14	13	13	12
Pool/Glide/Eddy Quality (0-20 scale)	15	17	16	12	13	11
Riffle/Run Quality (0-20 scale)	16	16	16	17	16	11
Bar Formation (severity score)	Severe	Moderate	Moderate	Minimal	Minimal	Minimal
Embeddedness (%)	40	25	25	15	30	40
Shading (%)	60	40	20	20	10	15
Minimum Riparian Buffer Width (m)	30	7	50	0	4	5
Bank Erosion (total area m^2)	118	35	137	91	69	51
Physical Habitat Index (0-100)	69	68	76	44	35	40

Table 4. Physical habitat metrics and physical habitat index scores measured at representative MBSS Sentinel sites.

Metric	Fifteen Mile Creek	Jones Falls
Instream Habitat Quality (0-20 scale)	9	16
Epifaunal Substrate Quality (0-20 scale)	10	17
Velocity/Depth Diversity (0-20 scale)	8	14
Pool/Glide/Eddy Quality (0-20 scale)	8	15
Riffle/Run Quality (0-20 scale)	8	15
Bar Formation (severity score)	Severe	Moderate
Embeddedness (%)	0	25
Shading (%)	40	60
Minimum Riparian Buffer Width (m)	33	50
Bank Erosion (total area m^2)	120	36
Physical Habitat Index (0-100)	51	80

3.3 Photo Log of Sampling Locations

PRFR-107-X-2016 midpoint looking downstream

PRFR-107-X-2016 midpoint looking upstream

PRFR-201-X-2016 midpoint downstream

PRFR-201-X-2016 midpoint upstream

PRFR-202-X-2016 Midpoint looking downstream

PRFR-202-X-2016 midpoint looking upstream

PRFR-203-X-2016 Midpoint looking downstream

PRFR-203-X-2016 Midpoint looking upstream

PRFR-204-X-2016 midpoint downstream

PRFR-204-X-2016 midpoint upstream

PRFR-205-X-2016 midpoint downstream

PRFR-205-X-2016 midpoint upstream

PRFR-205-X-2016 Trib confluence @ 37 m mark

PRFR-206-X-2016 Midpoint looking downstream

PRFR-206-X-2016 Midpoint looking upstream

3.4 Next Steps

This report summarizes only those data collected and finalized from April 2016 –June 2017, and as such, is only a preliminary assessment of baseline, pre-restoration conditions. A more thorough assessment of pre-restoration conditions of Little Catoctin Creek, summarizing two full years of baseline monitoring, will be completed in 2018.

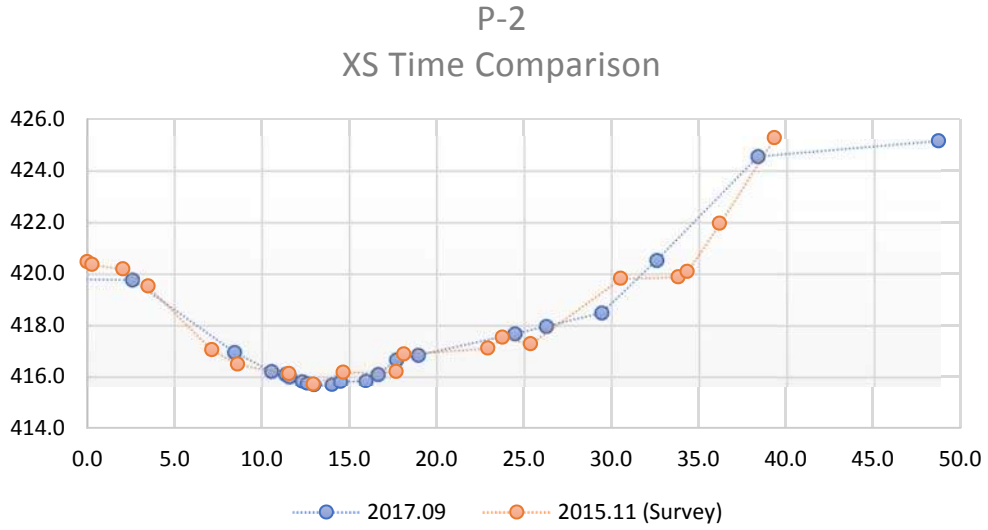
4 Physical Monitoring

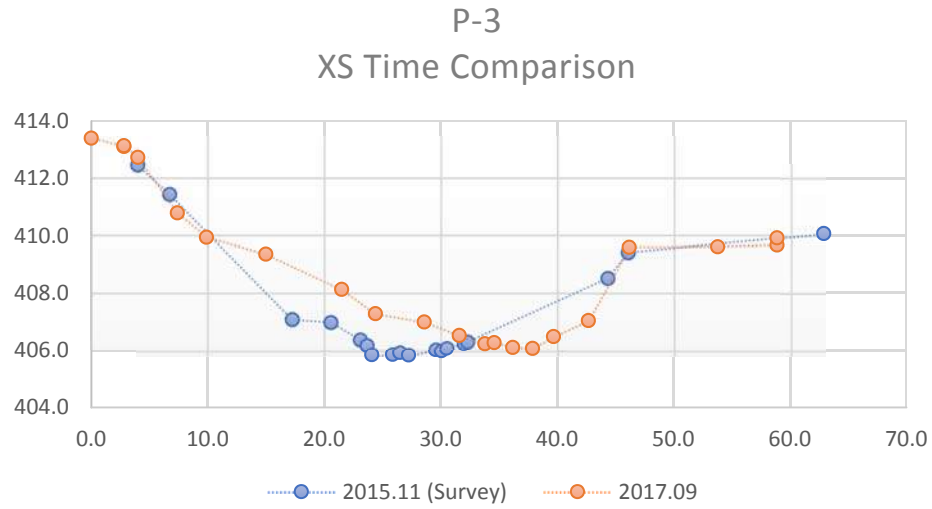
A geomorphic assessment was performed on September 19th, 2017 to establish a baseline for the pre-restoration project area. The assessment was performed at 5 cross-sections throughout the project reach as well as upstream and downstream of the project limits. The cross-sections were monumented for future reference and comparison. The sixth location at the very downstream limit will be surveyed in the fall once leaf fall has occurred. The cross-section locations are shown in the plan sheets at the end of this appendix.

It was anticipated that the cross-section locations that were identified during previous field visits could be recovered and used in the data comparison. However, it was discovered that many of the temporary monuments that had marked the cross-sections were not recoverable due to bank erosion, animals grazing in the area, and/or lack of depth on monument stakes. To avoid further loss of the monuments, the new cross-section locations were established using a 4-foot length of rebar driven into the ground with a monument cap. Since the previous section locations could not be located, the cross section and profile data from previous field visits were discarded from further comparison. An additional survey will be performed at each location prior to construction of the restoration reach to ensure that a baseline is established at each location.

The cross-section data that was collected in 2017 was compared to cross sections taken from the topographical survey performed in 2015. This comparison shows some bank erosion and channel

aggradation at Sections 2, 3 and 4 within the project reach. It was noted that section 4, which is characterized by steep, bare earth on the right bank, has noticeably eroded. This observation coincides with the preliminary findings. See Figure 6.





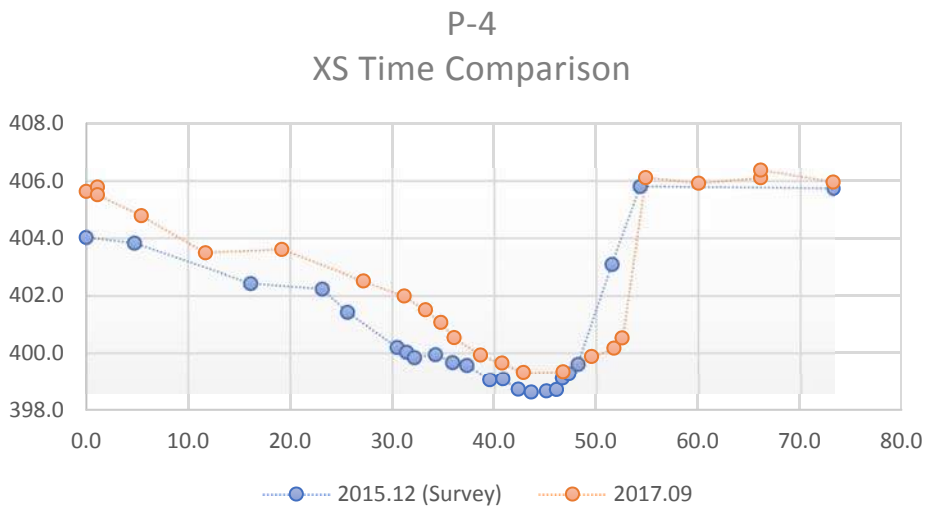


Figure 6. Preliminary cross section comparisons using topographic survey data and field collection data

The geomorphic data that was gathered for each cross section is compiled at the end of this appendix. A photo for each cross section can be found in Figure 7 through Figure 9. The data was collected on a clear day with baseflow conditions in the channel. The channel was classified using the Rosgen classification technique as type 'F' channel due to its low gradient, incised channel (see Figure 8), and entrenched ratio. The channel slope ranged from 0.57% to 1.23% as measured from top of riffle to top of riffle. The D50 ranges from 9.1 mm to 13.6 mm.

Geomorphic results demonstrate that the restoration reach is degrading with tall, unconsolidated banks and significant bank recession from 2015 to 2017 (especially at site P-4). All sites classify generally as Rosgen Classification Type F. These results validate this reach as an excellent candidate for restoration. Preliminary chemical and biological results corroborate well with the geomorphic results.

Figure 7. P-5 looking downstream from left bank

Figure 8. P-4 looking downstream from left bank

Figure 9. P-3 Looking towards channel from left bank

5 References

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Becker, A.J., S.A. Stranko, R.J. Klauda, A.P. Prochaska, J.D. Schuster, and M.T. Kashiwagi. 2010. Maryland Biological Stream Survey's sentinel site network: A multi-purpose monitoring program. Maryland Department of Natural Resources, Annapolis, Maryland.

Paul, M.J., J.B. Stribling, R.J. Klauda, and P.F. Kazyak. 2002. A physical habitat index for freshwater wadeable streams in Maryland. Final report prepared for the Maryland Department of Natural Resources, Monitoring and Non-Tidal Assessment, Annapolis, Maryland.

State Highway Administration (SHA), Maryland Department of Transportation. 2016. NPDES/MS4 assessment of controls for stream restoration of Little Catoctin Creek at U.S. 340 in Frederick County, Maryland. Baltimore, Maryland.

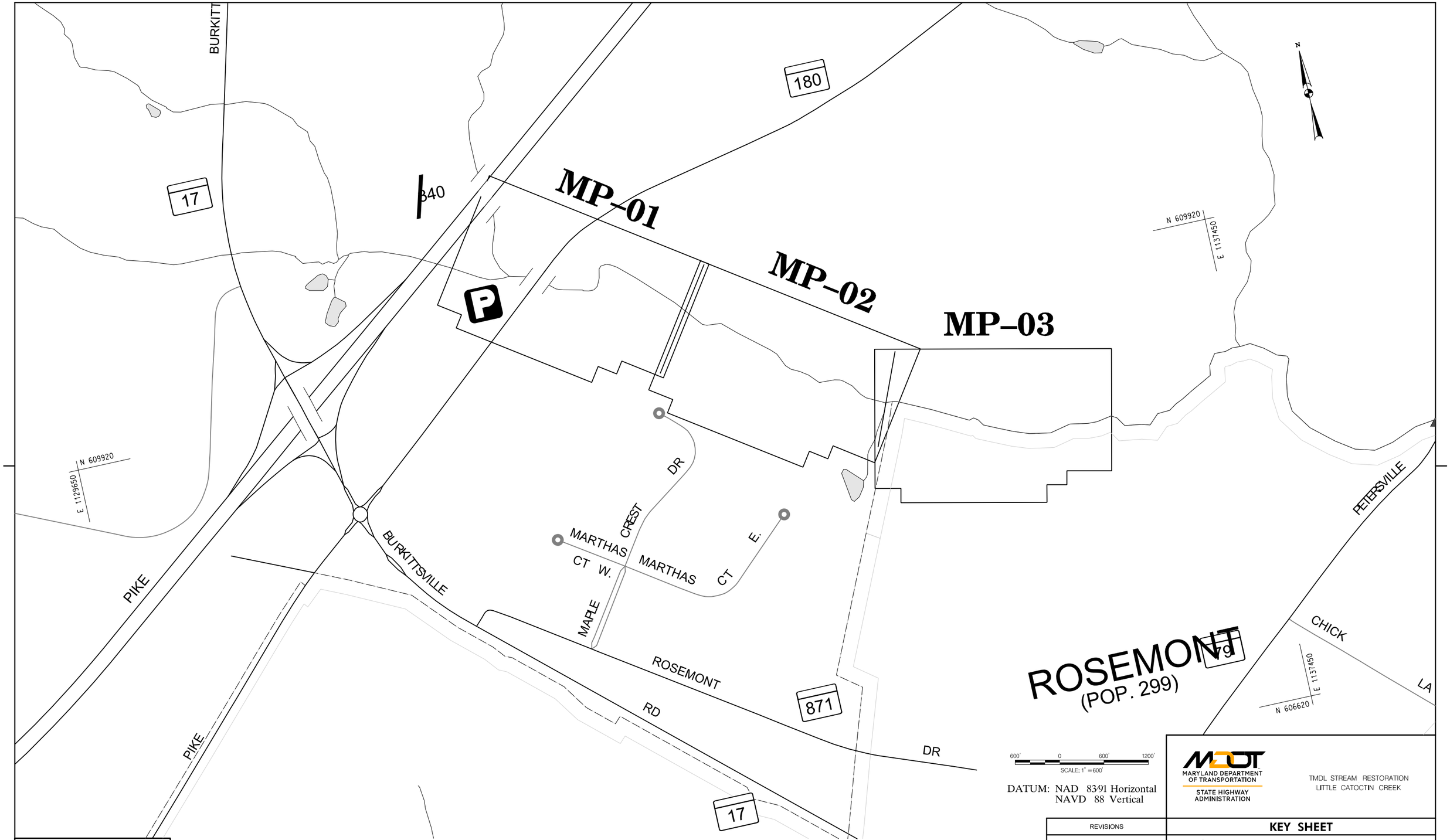
Stranko, S.A., D.M. Boward, J.V. Kilian, A.J. Becker, M. Ashton, M. Southerland, B. Franks, W. Harbold, and J. Cessna. 2014. Maryland Biological Stream Survey: Round four field sampling manual. Maryland Department of Natural Resources, Annapolis, Maryland.

Attachment A

Monitoring Locations

MARYLAND DEPARTMENT OF TRANSPORTATION

STATE HIGHWAY ADMINISTRATION



600' 0 600' 1200'
SCALE: 1" = 600'

DATUM: NAD 83-91 Horizontal
NAVD 88 Vertical

MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

TMDL STREAM RESTORATION
LITTLE CATOCTIN CREEK

REVISIONS

KEY SHEET

SCALE 1" = 600' ADVERTISED DATE OCTOBER 2017 CONTRACT NO. AT62813

DESIGNED BY
DRAWN BY
CHECKED BY
MDE/PRD

COUNTY FREDERICK
LOGMILE

DRAWING NO. KY-01 OF 01

SHEET NO. 1 OF 4

RK&K
Rummel, Klepper & Kahl, LLP
700 EAST PRATT STREET | BALTIMORE, MD 21202
SUITE 500 PH: (410) 728-2900
Engineers | Construction Managers | Planners | Scientists
www.rkk.com

BY: dblack -

PLOTTED: Tuesday, October 03, 2017 AT 03:39 PM
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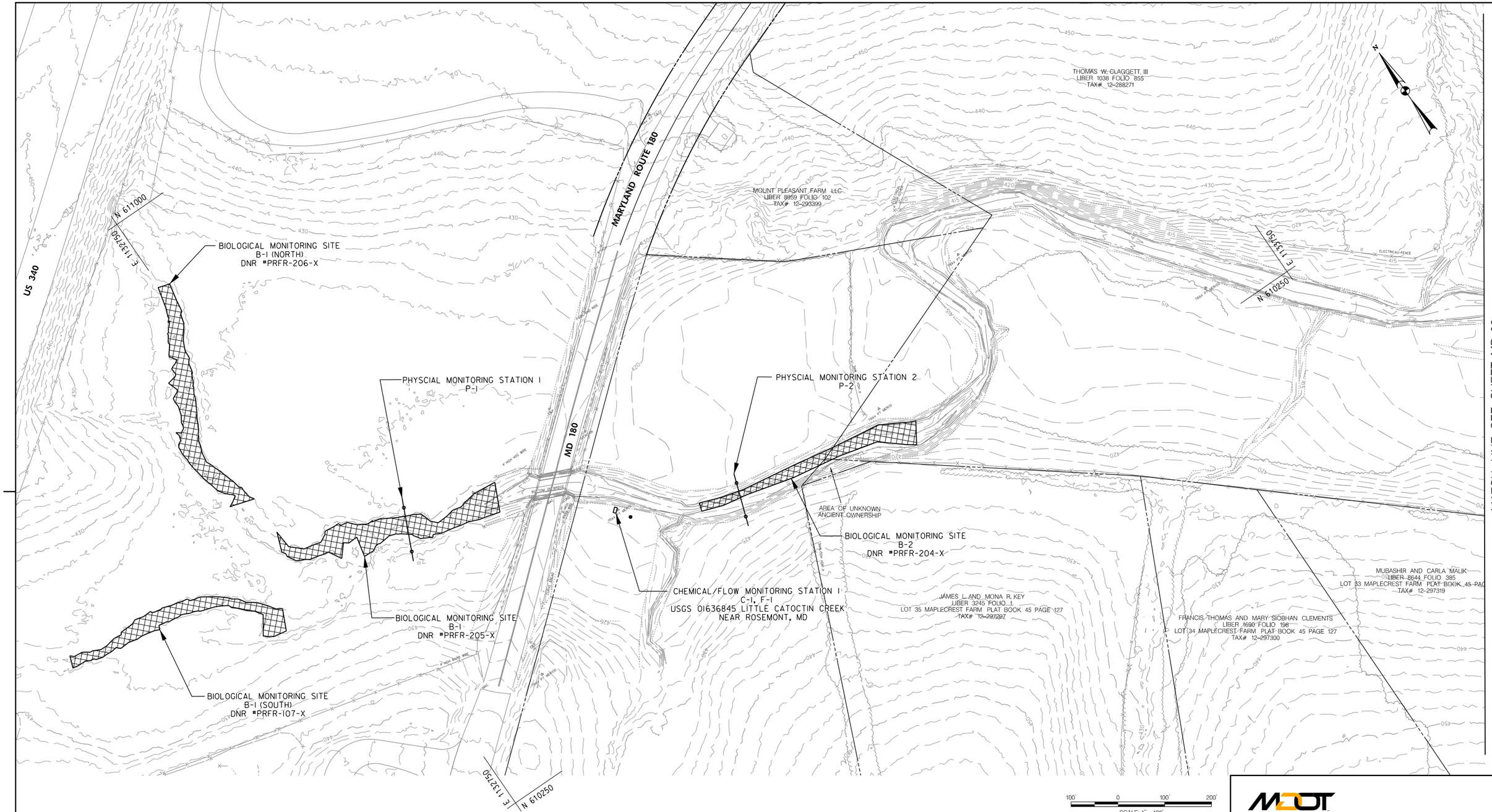

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SCALE: 1" = 100'

DATUM: NAD 83'91 Horizontal
NAVD 88 Vertical

MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

TMDL STREAM RESTORATION
LITTLE CATOCTIN CREEK

REVISIONS

MONITORING LOCATION PLAN

SCALE 1" = 100' ADVERTISED DATE OCTOBER 2017 CONTRACT NO. AT62813

DESIGNED BY
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LOGMILE

DRAWING NO. MP-01 OF 03

SHEET NO. 2 OF 4

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MATCH LINE SEE SHEET MP-01

MATCH LINE SHEET MP-03

MATCH LINE SHEET 2

N 610000

E 1134500

THOMAS W. CLAGGETT, III
LIBER 1038 FOLIO 855
TAX# 12-268271

PHYSCIAL MONITORING STATION 3
P-3

PHYSCIAL MONITORING STATION 4
P-4

BIOLOGICAL MONITORING SITE
B-3
DNR #PRFR-203-X

ROBERT K. McMONAGLE, JR. AND TABETHA M. McMONAGLE
LIBER 9548 FOLIO 217
LOT 32 MAPLECREST FARM PLAT BOOK 45 PAGE 126
TAX# 12-297238

CHARLES E. AND SHAWN L. ANDREWS
LIBER 2009 FOLIO 641
LOT 31 MAPLECREST FARM PLAT BOOK 45 PAGE 126
TAX# 12-297211

GARY A. AND BONNIE J. TEAGUE
LIBER 2644 FOLIO 700
LOT 30 MAPLECREST FARM PLAT BOOK 45 PAGE 126
TAX# 12-297203

MICHAEL THOMPSON
LIBER 2850 FOLIO 1265
LOT 19 MAPLECREST FARM PLAT BOOK 39 PAGE 22
TAX# 12-297835

MICHAEL D. AND LAURA L. PRITCHARD
LIBER 7003 FOLIO 136
LOT 18 MAPLECREST FARM PLAT BOOK 39 PAGE 22
TAX# 12-296827

AREA OF UNKNOWN ANCIENT OWNERSHIP

E 1134500

N 609250

E 1134000

N 609250

100' 0 100' 200'
SCALE: 1" = 100'

DATUM: NAD 83/91 Horizontal
NAVD 88 Vertical

MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

TMDL STREAM RESTORATION
LITTLE CATOCTIN CREEK

REVISIONS

MONITORING PLAN LOCATION

SCALE 1" = 100' ADVERTISED DATE OCTOBER 2017 CONTRACT NO. AT62813

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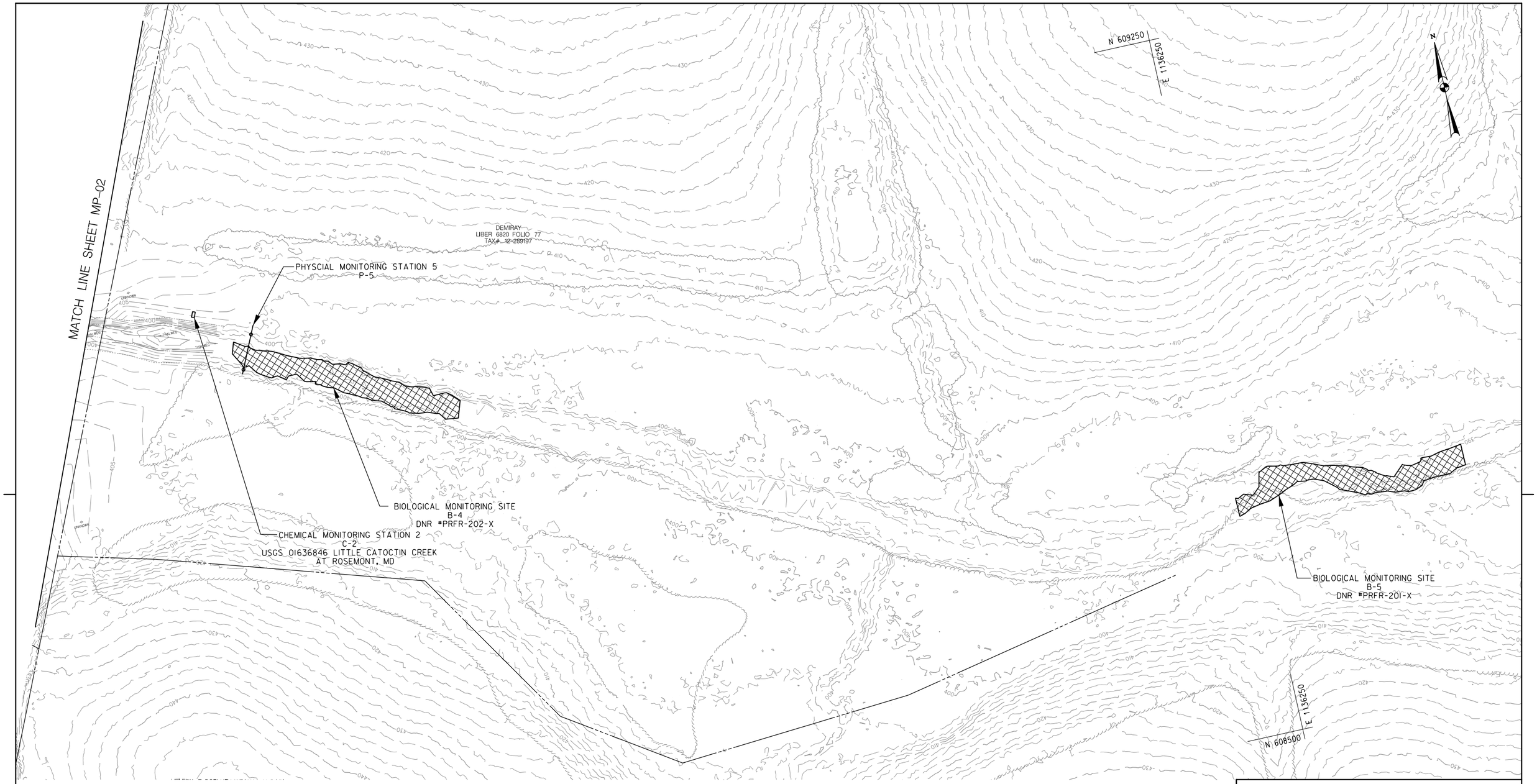
BY: dblack -



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NAVD 88 Vertical

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TMDL STREAM RESTORATION
LITTLE CATOCTIN CREEK

REVISIONS

MONITORING PLAN LOCATIONS

SCALE 1" = 100' ADVERTISED DATE OCTOBER 2017 CONTRACT NO. AT62813

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MDE/PRD

COUNTY FREDERICK

LOGMILE

DRAWING NO. MP-03 OF 03

SHEET NO. 4 OF 4

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BY: dblack -

Attachment B

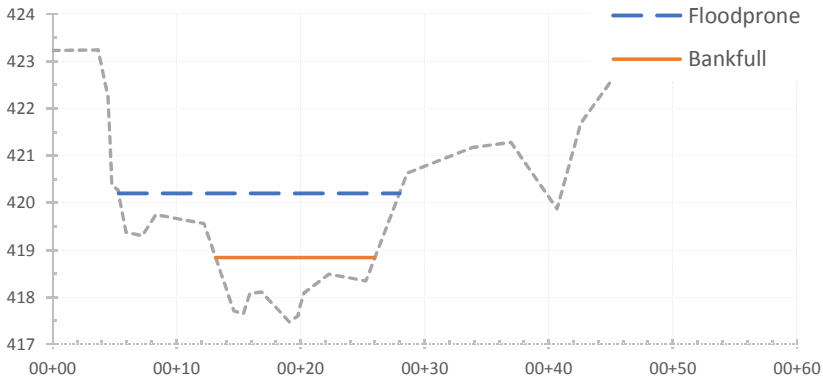
Geomorphic Data

MARYLAND DEPARTMENT OF TRANSPORTATION

STATE HIGHWAY ADMINISTRATION

Project: Little Catoctin Creek
Project Number: 11102.48
Site Name/Number: P-1
Date: September 28, 2017

Cross Section



		Rogen Classification
ver. 1.0		
BF Width:	12.83 ft	
BF Max Depth:	1.36 ft	
BF Area:	9.17 ft²	
BF R_h:	0.66 ft	
BF WP:	13.88 ft	
BF W/D Ratio:	9.44	*A, E, G*
FP Width:	22.64 ft	
Entrenchment:	1.76	*B*
Slope:	0.76%	*D, C, E, F*
Sinuosity:	1.35	*B, C, F, G*
Manning's n:	0.030	
BF Discharge:	30.08 ft³/s	
BF Velocity:	3.28 ft/s	
BF Boundary Shear Stress:	0.313 lbs/ft²	
Critical Shear Stress:	0.132 lbs/ft²	
Most Probable Classification →		F

Is Benchmark in XS Data?	Yes	
↓Use This ↓		
Benchmark Elev:	423.23	
Station for Benchmark:	00+00.0	
RH at Benchmark:	5.01	6.20
Bankfull RH/Elevation:	9.40	418.84
Floodprone RH/Elevation:		420.20

Pnt Num	*Station (ft)*	*Rod Height (ft)*	*Notes*	*Adj. Elev (ft)*	*BF Wetted Perimeter (ft)*	*BF Area (ft²)*	*BF Top Width (ft)*	*FP Top Width (ft)*
					13.88	9.17	12.83	23.85
1	00+00.0	5.01	LPIN	423.23	0.00	0.00	0.00	0.00
2	00+03.7	5.00		423.24	0.00	0.00	0.00	0.00
3	00+04.5	6.00		422.24	0.00	0.00	0.00	0.00
4	00+04.8	7.87		420.37	0.00	0.00	0.00	0.00
5	00+05.3	7.97		420.27	0.00	0.00	0.00	0.00
6	00+05.9	8.86		419.38	0.00	0.00	0.00	0.58
7	00+07.2	8.94		419.30	0.00	0.00	0.00	1.31
8	00+08.3	8.49		419.75	0.00	0.00	0.00	1.08
9	00+12.2	8.68		419.56	0.00	0.00	0.00	3.90
10	00+14.6	10.53		417.71	1.86	0.83	1.47	2.41
11	00+15.4	10.59		417.65	0.77	0.89	0.77	0.77
12	00+15.9	10.16		418.08	0.67	0.50	0.51	0.51
13	00+16.9	10.13		418.11	0.95	0.71	0.95	0.95
14	00+18.6	10.63		417.61	1.85	1.74	1.78	1.78
15	00+19.1	10.76		417.48	0.47	0.58	0.45	0.45
16	00+19.8	10.63		417.61	0.72	0.92	0.71	0.71

Pnt Num	Station (ft)	Rod Height (ft)	Notes	Adj. Elev (ft)	BF Wetted Perimeter (ft)	BF Area (ft^2)	BF Top Width (ft)	FP Top Width (ft)
17	00+19.9	10.49		417.75	0.16	0.09	0.08	0.08
18	00+20.3	10.15		418.09	0.52	0.36	0.39	0.39
19	00+22.3	9.75		418.49	2.07	1.12	2.03	2.03
20	00+25.3	9.89		418.35	2.97	1.25	2.97	2.97
21	00+28.6	7.61		420.63	0.87	0.18	0.72	2.72
22	00+33.9	7.07		421.17	0.00	0.00	0.00	0.00
23	00+37.0	6.96		421.28	0.00	0.00	0.00	0.00
24	00+40.7	8.37		419.87	0.00	0.00	0.00	0.87
25	00+42.6	6.56		421.68	0.00	0.00	0.00	0.34
26	00+46.2	5.25		422.99	0.00	0.00	0.00	0.00
27	00+49.6	5.29	RPIN	422.95	0.00	0.00	0.00	0.00
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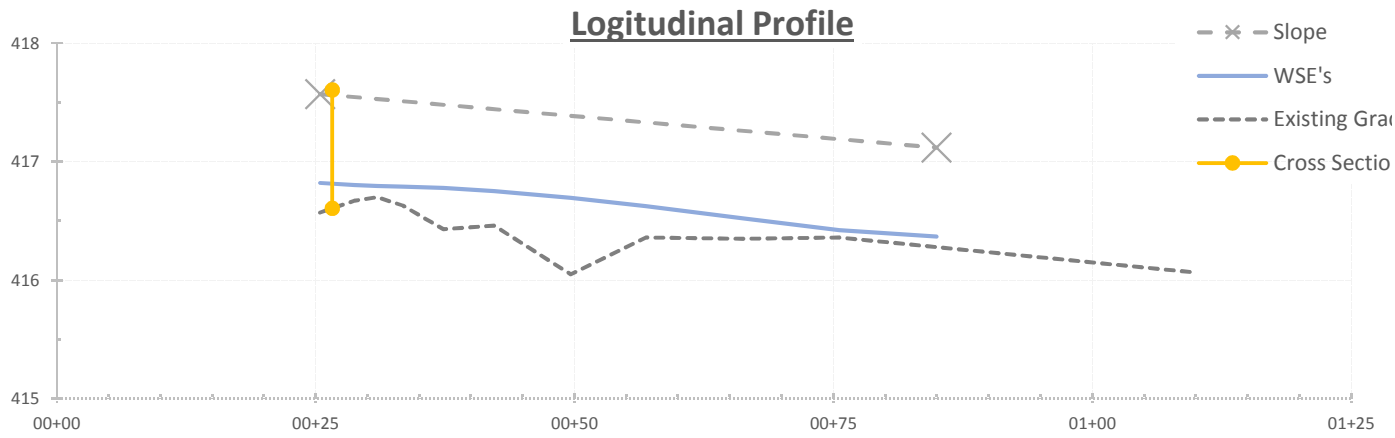
Project: **Little Catoctin Creek**
Project Number: **11102.48**
Site Name/Number: **P-1**

Date: September 28, 2017



						WSE
Benchmark Elev:	415.70			Starting Station	00+25.4	416.82
Benchmark RH:	4.00			Ending Station	00+85.0	416.37
Cross Section Location:	00+26.6	El: 416.61		Slope	0.758%	
	00+26.6	417.61				

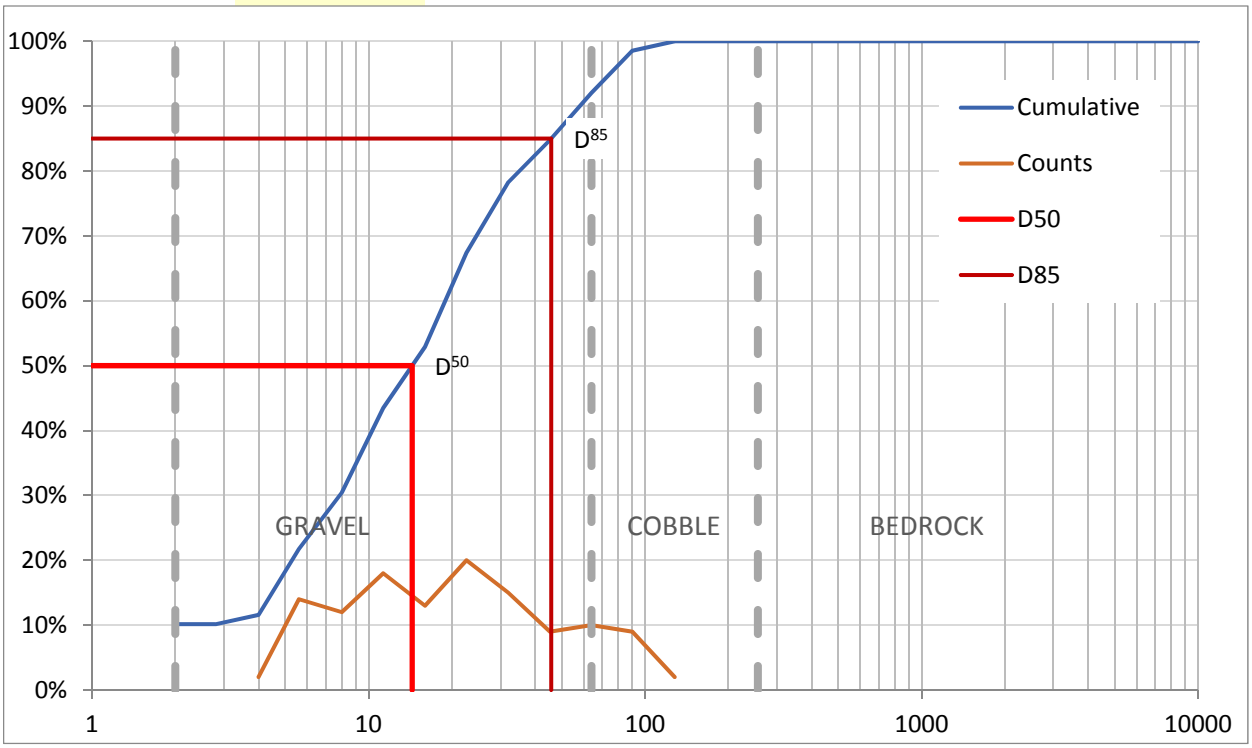
Pnt Num	*Station (ft)*	*Rod Height (ft)*	*Adj. Elev (ft)*	*Water Depth (ft)*	*Adj. WS Elev (ft)*
1	00+25.4	3.13	416.57	0.25	416.82
2	00+28.8	3.03	416.67	0.13	416.80
3	00+31.0	3.00	416.70	0.10	416.80
4	00+33.4	3.07	416.63	0.16	416.79
5	00+37.4	3.27	416.43	0.35	416.78
6	00+42.3	3.24	416.46	0.29	416.75
7	00+49.7	3.65	416.05	0.65	416.70
8	00+56.9	3.34	416.36	0.26	416.62
9	00+66.2	3.35	416.35	0.17	416.52
10	00+75.6	3.34	416.36	0.06	416.42
11	00+85.0	3.42	416.28	0.09	416.37
12	01+09.5	3.63	416.07		
13					
14					
15					
16					
17					
18					

Project: **Little Catoctin Creek**
Project Number: **11102.48**
Site Name/Number: **P-1**

Date: September 28, 2017

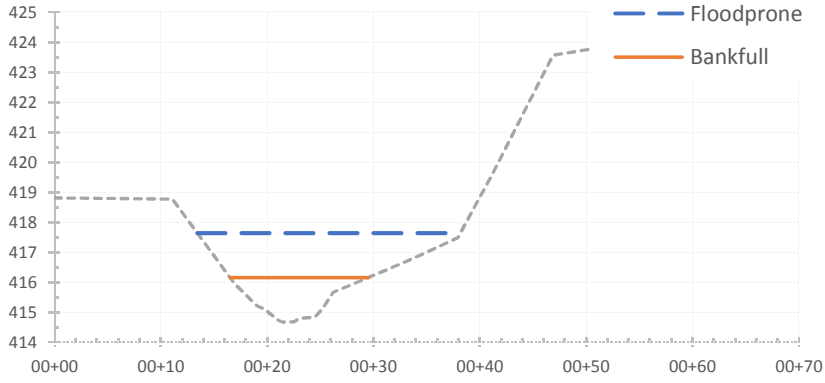
	Class Name	*Particle Size Class (mm)*		*Study Total*	*Study by Size %*	*Study Cumulative %*
	Silt/Clay	Consolidated $< D \leq$ 0.063			0.0	0.0
		Unconsolidate $< D \leq$ 0.063			0.0	0.0
	Sand	0.063 $< D \leq$ 2	2		0.0	0.0
Gravel	VF Gravel	2 $< D \leq$ 2.8	2.8	2	1.0	1.0
		2.8 $< D \leq$ 4	4	30	14.4	15.3
	Fine Gravel	4 $< D \leq$ 5.6	5.6	16	7.7	23.0
		5.6 $< D \leq$ 8	8	8	3.8	26.8
	Med. Gravel	8 $< D \leq$ 11.2	11.3	43	20.6	47.4
		11.2 $< D \leq$ 16	16	22	10.5	57.9
	Coarse Gravel	16 $< D \leq$ 22.4	22.6	22	10.5	68.4
		22.4 $< D \leq$ 31.5	32	37	17.7	86.1
	VC Gravel	31.5 $< D \leq$ 45	45.3	17	8.1	94.3
		45 $< D \leq$ 63	64	5	2.4	96.7
Cobble	Sm. Cobble	63 $< D \leq$ 90	90	3	1.4	98.1
		90 $< D \leq$ 128	128	2	1.0	99.0
	Lg. Cobble	128 $< D \leq$ 180	180	2	1.0	100.0
		180 $< D \leq$ 256	256		0.0	100.0
Boulder	Sm. Boulder	256 $< D \leq$ 362	362		0.0	100.0
		362 $< D \leq$ 512	512		0.0	100.0
	Med. Boulder	512 $< D \leq$ 724	724		0.0	100.0
		724 $< D \leq$ 1024	1024		0.0	100.0
	Lg. Boulder	1024 $< D \leq$ 1450	1450		0.0	100.0
		1450 $< D \leq$ 2048	2048		0.0	100.0
	VL Boulder	2048 $< D \leq$ 2900	2900		0.0	100.0
		2900 $< D \leq$ 4096	4096		0.0	100.0
	Bedrock	$>$ 10000	10000		0.0	100.0
			Totals	209		

D^{16} =	4.1 mm	16	**Andrews 1994**
D^{35} =	9.2 mm	35	Tc* = 0.00356
D^{50} =	12.3 mm	50	Tc = 0.132 lb/ft² (Boundary Shear from Shields)
D^{65} =	20.2 mm	65	d = 0.1156 ft
D^{85} =	31.3 mm	85	S = 3.00%
D^{95} =	50.4 mm	95	
D^{i} =	180.0 mm		



Project: Little Catoctin Creek
Project Number: 11102.48
Site Name/Number: P-2
Date: November 24, 2015

Cross Section



		Rogen Classification
ver. 1.0		
BF Width:	12.99 ft	
BF Max Depth:	1.48 ft	
BF Area:	10.77 ft²	
BF R_h:	0.80 ft	
BF WP:	13.47 ft	
BF W/D Ratio:	8.78	*A, E, G*
FP Width:	24.72 ft	
Entrenchment:	1.90	*B*
Slope:	1.15%	*D, C, E, F*
Sinuosity:	1.35	*B, C, F, G*
Manning's n:	0.032	
BF Discharge:	46.42 ft³/s	
BF Velocity:	4.31 ft/s	
BF Boundary Shear Stress:	0.576 lbs/ft²	
Critical Shear Stress:		
Most Probable Classification →		F

	↓Use This ↓	
Is Benchmark in XS Data?		Yes
Benchmark Elev:	418.77	
Station for Benchmark:	00+11.1	
RH at Benchmark:	5.39	6.20
Bankfull RH/Elevation:	8.00	416.16
Floodprone RH/Elevation:		417.64

Pnt Num	Station (ft)	Rod Height (ft)	Notes	Adj. Elev (ft)	BF Wetted Perimeter (ft)	BF Area (ft²)	BF Top Width (ft)	FP Top Width (ft)
					13.47	10.77	12.99	24.72
1	00+00.0	5.35		418.81	0.00	0.00	0.00	0.00
2	00+06.7	5.37		418.79	0.00	0.00	0.00	0.00
3	00+11.1	5.39	LPIN	418.77	0.00	0.00	0.00	0.00
4	00+16.9	8.20		415.96	0.46	0.04	0.42	3.49
5	00+19.1	8.94		415.22	2.24	1.20	2.11	2.11
6	00+19.9	9.06		415.10	0.82	0.81	0.81	0.81
7	00+20.1	9.15		415.01	0.24	0.24	0.22	0.22
8	00+20.8	9.34		414.82	0.75	0.91	0.73	0.73
9	00+21.1	9.42		414.74	0.30	0.40	0.29	0.29
10	00+21.5	9.48		414.68	0.39	0.57	0.39	0.39
11	00+22.5	9.47		414.69	1.03	1.52	1.03	1.03
12	00+23.0	9.35		414.81	0.49	0.68	0.48	0.48
13	00+24.5	9.32		414.84	1.45	1.94	1.45	1.45
14	00+25.2	9.06		415.10	0.75	0.83	0.70	0.70
15	00+26.2	8.49		415.67	1.19	0.81	1.05	1.05
16	00+27.5	8.31		415.85	1.26	0.50	1.25	1.25

Pnt Num	Station (ft)	Rod Height (ft)	Notes	Adj. Elev (ft)	BF Wetted Perimeter (ft)	BF Area (ft^2)	BF Top Width (ft)	FP Top Width (ft)
17	00+33.0	7.48		416.68	2.08	0.32	2.06	5.52
18	00+34.8	7.19		416.97	0.00	0.00	0.00	1.80
19	00+37.9	6.67		417.49	0.00	0.00	0.00	3.17
20	00+41.1	4.63	RPIN	419.53	0.00	0.00	0.00	0.23
21	00+46.9	0.60		423.56	0.00	0.00	0.00	0.00
22	00+57.3	0.00		424.16	0.00	0.00	0.00	0.00
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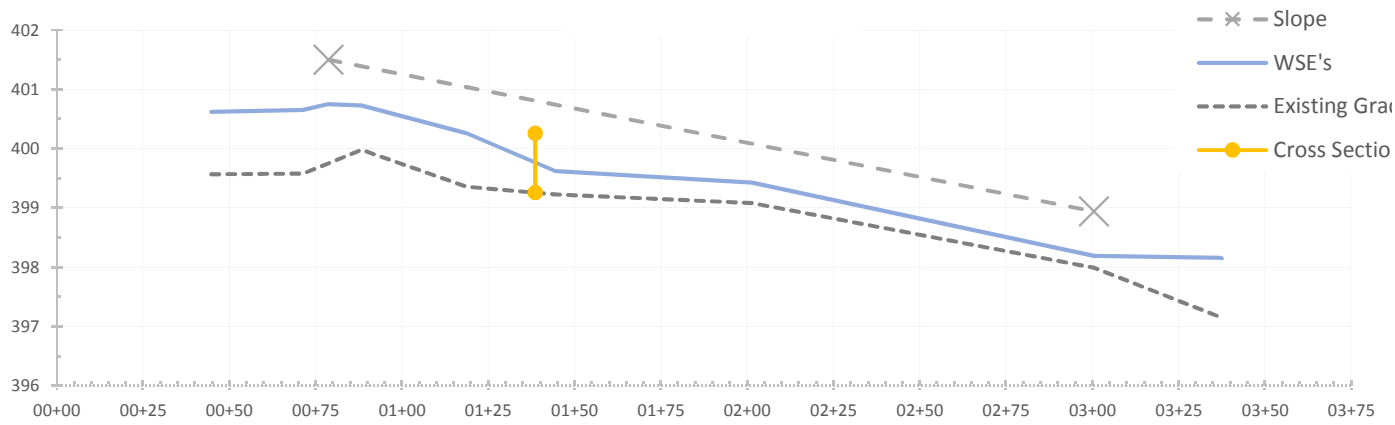
Project: **Little Catoctin Creek**
Project Number: **11102.48**
Site Name/Number: **P-2**

Date: November 24, 2015



Benchmark Elev:			Starting Station		400.75
Benchmark RH:			Ending Station		398.19
Cross Section Location:		399.26	Slope	1.154%	
	01+38.6	400.259658			

Pnt Num	*Station (ft)*	*Rod Height (ft)*	*Adj. Elev (ft)*	*Water Depth (ft)*	*Adj. WS Elev (ft)*
1	00+44.8	5.41	399.57	1.05	400.62
2	00+71.4	5.40	399.58	1.07	400.65
3	00+78.7	5.23	399.75	1.00	400.75
4	00+88.3	5.00	399.98	0.75	400.73
5	01+18.8	5.62	399.36	0.90	400.26
6	01+44.5	5.75	399.23	0.39	399.62
7	02+01.4	5.90	399.08	0.35	399.43
8	03+00.5	6.99	397.99	0.20	398.19
9	03+37.0	7.82	397.16	1.00	398.16
10	03+37.5	7.83	397.15	1.00	398.15
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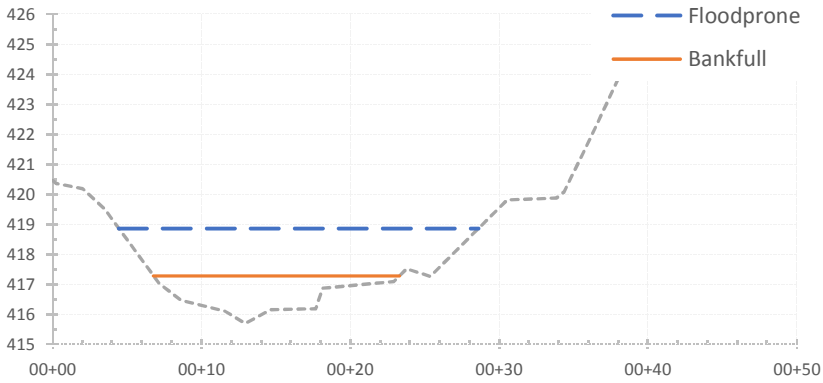
Project: Little Catoctin Creek
Project Number: 11102.48
Site Name/Number: P-2
Date: September 28, 2017

Cross Section



		Rogen Classification
ver. 1.0		
BF Width:	16.60 ft	
BF Max Depth:	1.58 ft	
BF Area:	13.07 ft²	
BF R_h:	0.75 ft	
BF WP:	17.34 ft	
BF W/D Ratio:	10.51	*A, E, G*
FP Width:	24.17 ft	
Entrenchment:	1.46	*B*
Slope:	1.97%	*D, C, E, F*
Sinuosity:	1.35	*B, C, F, G*
Manning's n:	0.032	
BF Discharge:	70.74 ft³/s	
BF Velocity:	5.41 ft/s	
BF Boundary Shear Stress:	0.927 lbs/ft²	
Critical Shear Stress:	0.188 lbs/ft²	
Most Probable Classification →		F

	↓Use This ↓	
Is Benchmark in XS Data?		Yes
Benchmark Elev:	420.46	
Station for Benchmark:	00+00.0	
RH at Benchmark:	4.82	6.20
Bankfull RH/Elevation:	8.00	417.28
Floodprone RH/Elevation:		418.86

Pnt Num	Station (ft)	Rod Height (ft)	Notes	Adj. Elev (ft)	BF Wetted Perimeter (ft)	BF Area (ft²)	BF Top Width (ft)	FP Top Width (ft)
					17.34	13.07	16.60	24.17
1	00+00.0	4.82	LPIN	420.46	0.00	0.00	0.00	0.00
2	00+00.3	4.93		420.35	0.00	0.00	0.00	0.00
3	00+02.0	5.10		420.18	0.00	0.00	0.00	0.00
4	00+03.5	5.77		419.51	0.00	0.00	0.00	0.00
5	00+07.1	8.24		417.04	0.43	0.04	0.35	2.69
6	00+08.6	8.80		416.48	1.57	0.76	1.47	1.47
7	00+11.6	9.17		416.11	2.96	2.90	2.94	2.94
8	00+13.0	9.58		415.70	1.46	1.92	1.40	1.40
9	00+14.7	9.12		416.16	1.77	2.31	1.71	1.71
10	00+17.7	9.09		416.19	3.03	3.35	3.03	3.03
11	00+18.1	8.41		416.87	0.81	0.33	0.44	0.44
12	00+22.9	8.18		417.10	4.82	1.42	4.81	4.81
13	00+23.8	7.76		417.52	0.40	0.03	0.36	0.84
14	00+25.4	8.01		417.27	0.07	0.00	0.06	1.61
15	00+30.6	5.47		419.81	0.02	0.00	0.02	3.23
16	00+33.9	5.41		419.87	0.00	0.00	0.00	0.00

Pnt Num	Station (ft)	Rod Height (ft)	Notes	Adj. Elev (ft)	BF Wetted Perimeter (ft)	BF Area (ft^2)	BF Top Width (ft)	FP Top Width (ft)
17	00+34.4	5.20		420.08	0.00	0.00	0.00	0.00
18	00+36.2	3.33		421.95	0.00	0.00	0.00	0.00
19	00+39.4	0.00		425.28	0.00	0.00	0.00	0.00
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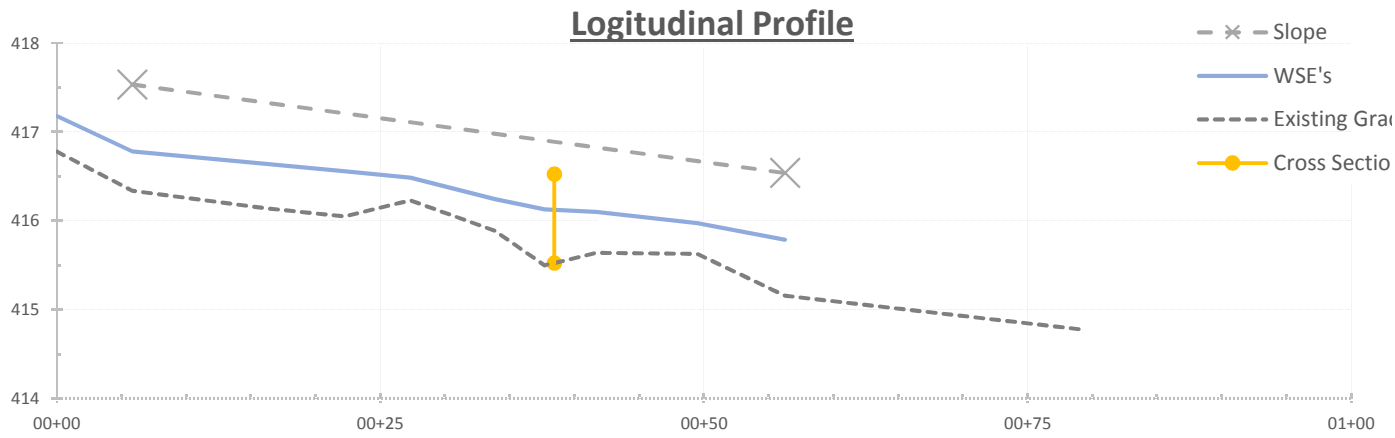
Project: **Little Catoctin Creek**
Project Number: **11102.48**
Site Name/Number: **P-2**

Date: September 28, 2017



					WSE
Benchmark Elev:	416.78		Starting Station	00+05.9	416.78
Benchmark RH:	5.00		Ending Station	00+56.3	415.79
Cross Section Location:	00+38.4	415.53	Slope	1.971%	
	00+38.4	416.526316			

Pnt Num	*Station (ft)*	*Rod Height (ft)*	*Adj. Elev (ft)*	*Water Depth (ft)*	*Adj. WS Elev (ft)*
1	00+00.0	5.00	416.78	0.40	417.18
2	00+05.9	5.44	416.34	0.44	416.78
3	00+16.2	5.64	416.14	0.50	416.64
4	00+22.3	5.73	416.05	0.51	416.56
5	00+27.3	5.55	416.23	0.25	416.48
6	00+33.9	5.89	415.89	0.36	416.25
7	00+37.7	6.28	415.50	0.63	416.13
8	00+41.7	6.14	415.64	0.46	416.10
9	00+49.5	6.15	415.63	0.35	415.98
10	00+56.3	6.62	415.16	0.63	415.79
11	00+79.2	7.00	414.78		
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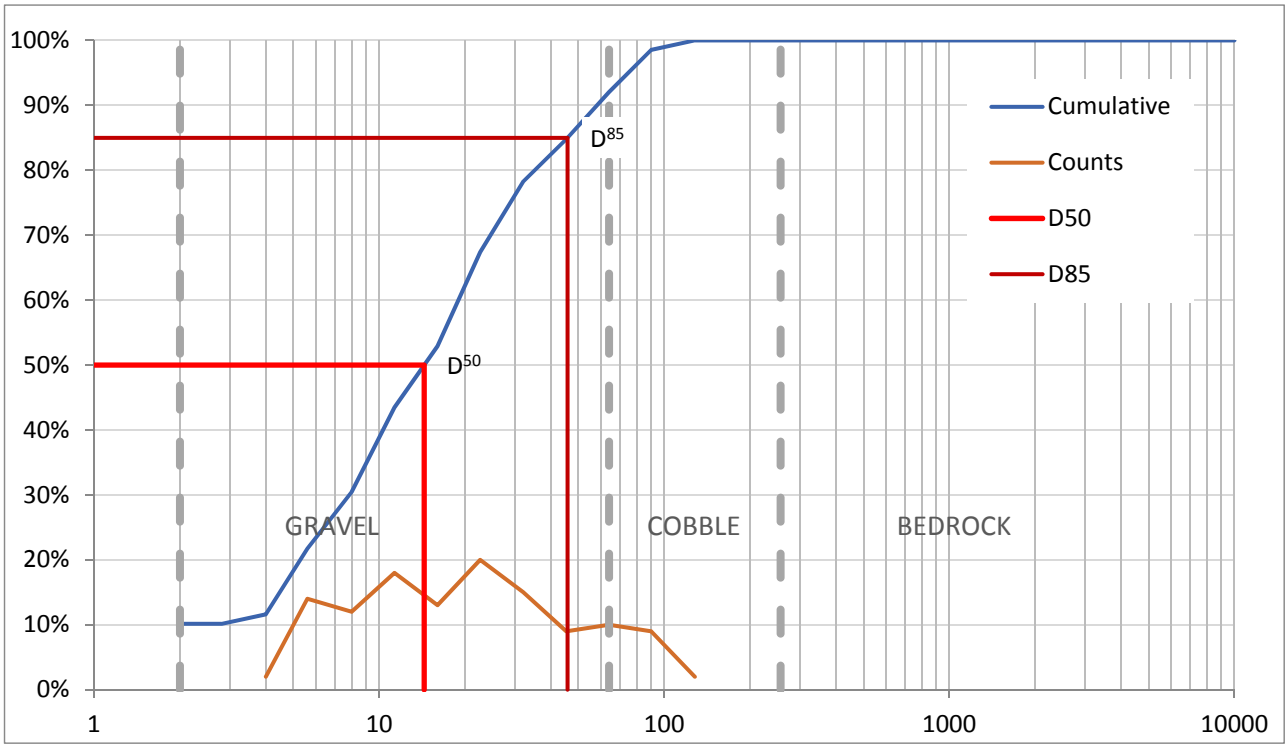
Project: **Little Catoctin Creek**
Project Number: **11102.48**
Site Name/Number: **P-2**

Date: September 28, 2017

	Class Name	Particle Size Class (mm)		Study Total	Study by Size %	Study Cumulative %
	Silt/Clay	Consolidated < D ≤ 0.063			0.0	0.0
		Unconsolidate < D ≤ 0.063			0.0	0.0
	Sand	0.063 < D ≤ 2	2		0.0	0.0
Gravel	VF Gravel	2 < D ≤ 2.8	2.8	10	8.3	8.3
		2.8 < D ≤ 4	4	4	3.3	11.6
	Fine Gravel	4 < D ≤ 5.6	5.6	5	4.1	15.7
		5.6 < D ≤ 8	8	4	3.3	19.0
	Med. Gravel	8 < D ≤ 11.2	11.3	15	12.4	31.4
		11.2 < D ≤ 16	16	14	11.6	43.0
	Coarse Gravel	16 < D ≤ 22.4	22.6	16	13.2	56.2
		22.4 < D ≤ 31.5	32	10	8.3	64.5
	VC Gravel	31.5 < D ≤ 45	45.3	9	7.4	71.9
		45 < D ≤ 63	64	5	4.1	76.0
Cobble	Sm. Cobble	63 < D ≤ 90	90	2	1.7	77.7
		90 < D ≤ 128	128	1	0.8	78.5
	Lg. Cobble	128 < D ≤ 180	180		0.0	78.5
		180 < D ≤ 256	256		0.0	78.5
Boulder	Sm. Boulder	256 < D ≤ 362	362		0.0	78.5
		362 < D ≤ 512	512		0.0	78.5
	Med. Boulder	512 < D ≤ 724	724		0.0	78.5
		724 < D ≤ 1024	1024		0.0	78.5
	Lg. Boulder	1024 < D ≤ 1450	1450		0.0	78.5
		1450 < D ≤ 2048	2048		0.0	78.5
	VL Boulder	2048 < D ≤ 2900	2900		0.0	78.5
		2900 < D ≤ 4096	4096		0.0	78.5
	Bedrock	> 10000	10000	26	21.5	100.0
			Totals	121		

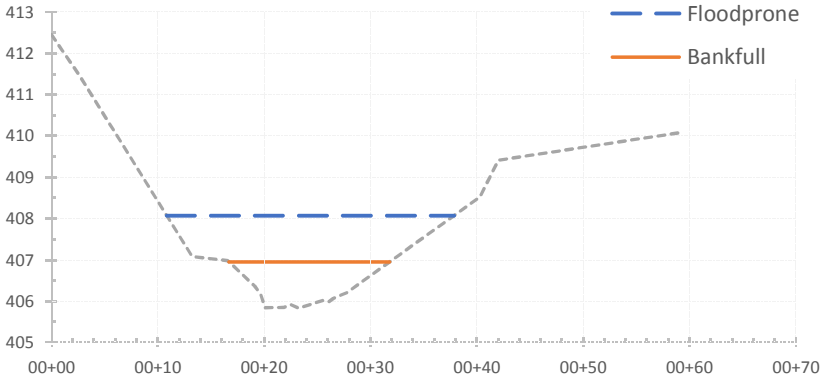
D^{16} =	5.8 mm	16	**Andrews 1994**		
D^{35} =	12.6 mm	35	Tc* =	0.00714	
D^{50} =	19.2 mm	50	Tc =	0.188 lb/ft²	(Boundary Shear from Shields)
D^{65} =	32.8 mm	65	d =	0.1547 ft	
D^{85} =	5362.9 mm	85	S =	3.20%	
D^{95} =	8124.5 mm	95			
D^{i} =	128.0 mm				



Project: Little Catoctin Creek
Project Number: 11102.48
Site Name/Number: P-3

Date: November 30, 2015

Cross Section



		Rogen Classification
ver. 1.0		
BF Width:	15.11 ft	
BF Max Depth:	1.12 ft	
BF Area:	10.72 ft²	
BF R_h:	0.69 ft	
BF WP:	15.43 ft	
BF W/D Ratio:	13.50	*B, C, F*
FP Width:	27.02 ft	
Entrenchment:	1.79	*B*
Slope:	1.27%	*D, C, E, F*
Sinuosity:	1.35	*B, C, F, G*
Manning's n:	0.032	
BF Discharge:	44.08 ft³/s	
BF Velocity:	4.11 ft/s	
BF Boundary Shear Stress:	0.550 lbs/ft²	
Critical Shear Stress:		
Most Probable Classification →		F

Is Benchmark in XS Data?	Yes	
↓Use This ↓		
Benchmark Elev:	411.43	
Station for Benchmark:	00+02.7	
RH at Benchmark:	1.02	6.20
Bankfull RH/Elevation:	5.50	406.95
Floodprone RH/Elevation:		408.07

Pnt Num	Station (ft)	Rod Height (ft)	Notes	Adj. Elev (ft)	BF Wetted Perimeter (ft)	BF Area (ft²)	BF Top Width (ft)	FP Top Width (ft)
					15.43	10.72	15.11	27.02
1	00+00.0	0.00		412.45	0.00	0.00	0.00	0.00
2	00+02.7	1.02		411.43	0.00	0.00	0.00	0.00
3	00+13.2	5.37		407.08	0.00	0.00	0.00	2.39
4	00+16.6	5.47		406.98	0.00	0.00	0.00	3.32
5	00+19.1	6.08		406.37	2.47	0.70	2.41	2.53
6	00+19.7	6.28		406.17	0.60	0.39	0.57	0.57
7	00+20.1	6.61		405.84	0.54	0.41	0.43	0.43
8	00+21.9	6.60		405.85	1.79	1.98	1.79	1.79
9	00+22.5	6.53		405.92	0.61	0.65	0.61	0.61
10	00+23.3	6.62		405.83	0.77	0.82	0.76	0.76
11	00+25.6	6.43		406.02	2.33	2.38	2.32	2.32
12	00+26.1	6.47		405.98	0.49	0.47	0.49	0.49
13	00+26.5	6.38		406.07	0.45	0.41	0.44	0.44
14	00+28.0	6.22		406.23	1.50	1.19	1.49	1.49
15	00+28.3	6.15		406.30	0.30	0.20	0.29	0.29
16	00+40.3	3.93		408.52	3.58	1.14	3.52	9.58

Pnt Num	Station (ft)	Rod Height (ft)	Notes	Adj. Elev (ft)	BF Wetted Perimeter (ft)	BF Area (ft^2)	BF Top Width (ft)	FP Top Width (ft)
17	00+42.0	3.04		409.41	0.00	0.00	0.00	0.00
18	00+58.9	2.38		410.07	0.00	0.00	0.00	0.00
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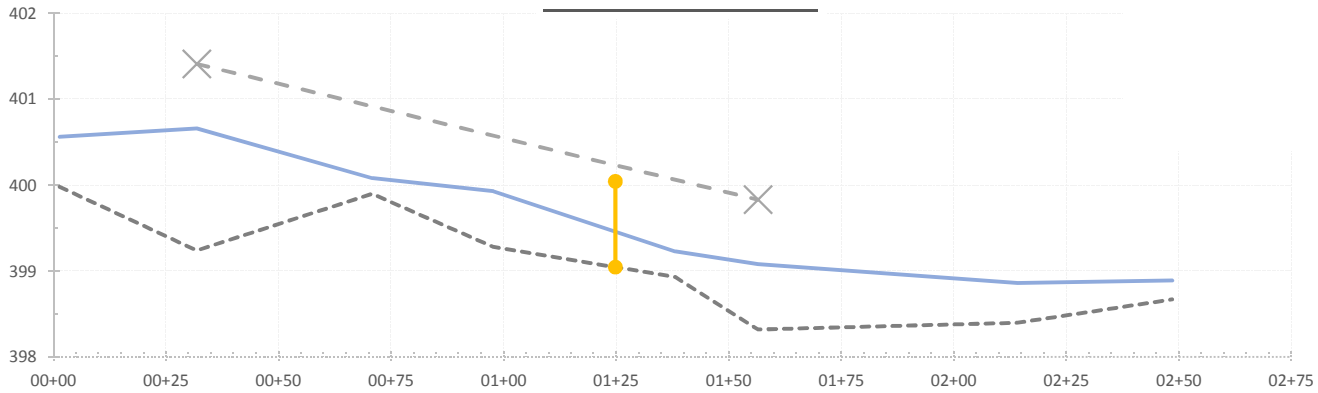
Project: **Little Catoctin Creek**
Project Number: **11102.48**
Site Name/Number: **P-3**

Date: November 30, 2015



					WSE
Benchmark Elev:	402.69		Starting Station	00+31.8	400.66
Benchmark RH:	2.29		Ending Station	01+56.5	399.08
Cross Section Location:	01+24.8	399.04	Slope	1.267%	
	01+24.8	400.04			

Pnt Num	*Station (ft)*	*Rod Height (ft)*	*Adj. Elev (ft)*	*Water Depth (ft)*	*Adj. WS Elev (ft)*
1	00+01.4	5.00	399.98	0.58	400.56
2	00+31.8	5.74	399.24	1.42	400.66
3	00+70.8	5.08	399.90	0.18	400.08
4	00+97.7	5.70	399.28	0.65	399.93
5	01+38.1	6.05	398.93	0.30	399.23
6	01+56.5	6.66	398.32	0.76	399.08
7	02+14.2	6.58	398.40	0.46	398.86
8	02+48.5	6.31	398.67	0.22	398.89
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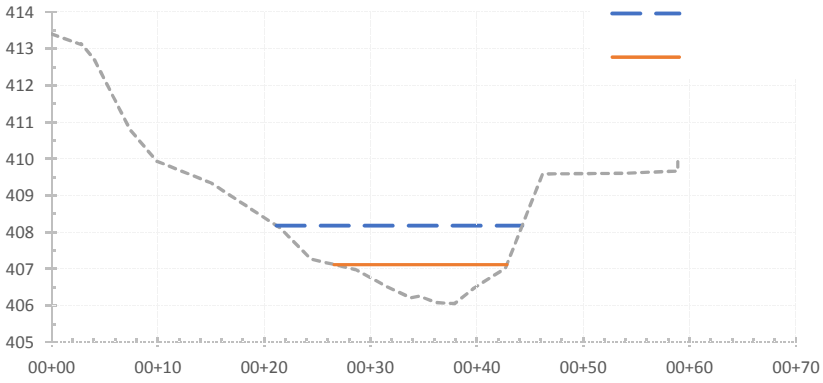
Project:

Project Number:

Site Name/Number:

Date:

Cross Section



		Rogen Classification
ver. 1.0		
BF Width:	16.25 ft	
BF Max Depth:	1.06 ft	
BF Area:	9.57 ft²	
BF R_h:	0.58 ft	
BF WP:	16.45 ft	
BF W/D Ratio:	15.33	*B, C, F*
FP Width:	23.09 ft	
Entrenchment:	1.42	*B*
Slope:	1.23%	*D, C, E, F*
Sinuosity:	1.35	*B, C, F, G*
Manning's n:	0.032	
BF Discharge:	34.54 ft³/s	
BF Velocity:	3.61 ft/s	
BF Boundary Shear Stress:	0.449 lbs/ft²	
Critical Shear Stress:	0.117 lbs/ft²	
Most Probable Classification →	F	

Is Benchmark in XS Data?	Yes	
	↓Use This ↓	
Benchmark Elev:	413.11	
Station for Benchmark:	00+02.8	
RH at Benchmark:	5.01	6.20
Bankfull RH/Elevation:	11.00	407.12
Floodprone RH/Elevation:		408.18

Pnt Num	*Station (ft)*	*Rod Height (ft)*	*Notes*	*Adj. Elev (ft)*	*Bf Wetted Perimeter (ft)*	*Bf Area (ft²)*	*BF Top Width (ft)*	*FP Top Width (ft)*
					16.45	9.57	16.25	23.09
1	00+00.0	4.72		413.40	0.00	0.00	0.00	0.00
2	00+02.8	5.01		413.11	0.00	0.00	0.00	0.00
3	00+02.8	4.98	LPIN	413.14	0.00	0.00	0.00	0.00
4	00+04.0	5.39		412.73	0.00	0.00	0.00	0.00
5	00+07.4	7.33		410.79	0.00	0.00	0.00	0.00
6	00+09.9	8.18		409.94	0.00	0.00	0.00	0.00
7	00+15.0	8.77		409.35	0.00	0.00	0.00	0.00
8	00+21.5	10.00		408.12	0.00	0.00	0.00	0.32
9	00+24.4	10.85		407.27	0.00	0.00	0.00	2.90
10	00+28.6	11.14		406.98	2.03	0.14	2.03	4.20
11	00+31.6	11.61	EOW	406.51	3.04	1.13	3.00	3.00
12	00+33.8	11.90		406.22	2.22	1.66	2.20	2.20
13	00+34.6	11.86		406.26	0.80	0.70	0.80	0.80
14	00+36.2	12.03		406.09	1.61	1.51	1.60	1.60
15	00+37.9	12.06		406.06	1.70	1.78	1.70	1.70
16	00+39.7	11.65	EOW	406.47	1.85	1.54	1.80	1.80

Pnt Num	Station (ft)	Rod Height (ft)	Notes	Adj. Elev (ft)	Bf Wetted Perimeter (ft)	Bf Area (ft^2)	BF Top Width (ft)	FP Top Width (ft)
17	00+42.7	11.09		407.03	3.05	1.11	3.00	3.00
18	00+46.2	8.53		409.59	0.15	0.01	0.12	1.57
19	00+53.8	8.51		409.61	0.00	0.00	0.00	0.00
20	00+58.9	8.45		409.67	0.00	0.00	0.00	0.00
21	00+58.9	8.20	RPIN	409.92	0.00	0.00	0.00	0.00
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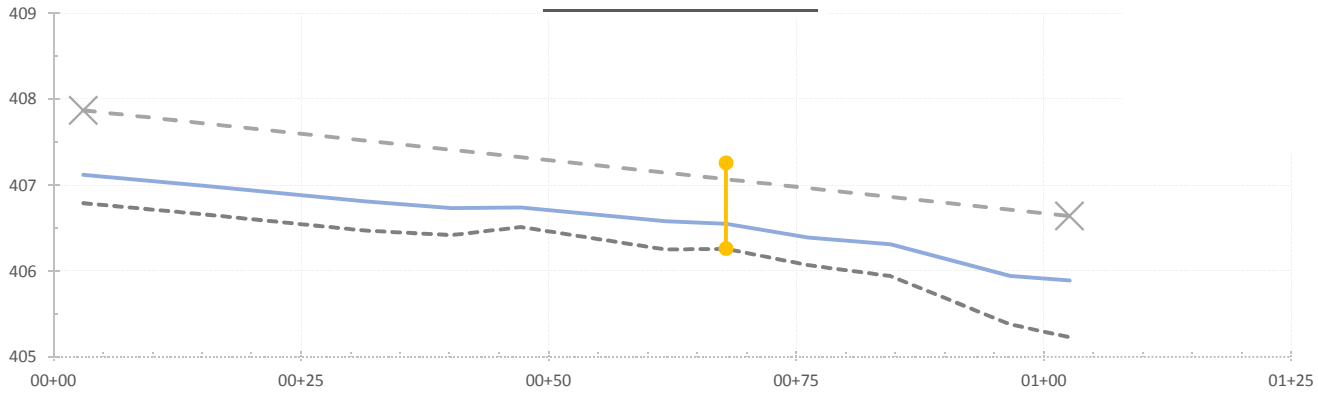
Project: **Little Catoctin Creek**
Project Number: **11102.48**
Site Name/Number: **P-3**

Date: 09/19/2017 (collected)



					WSE
Benchmark Elev:	406.26		Starting Station	00+03.0	407.12
Benchmark RH:	11.85		Ending Station	01+02.6	405.89
Cross Section Location:	00+67.9	406.26	Slope	1.235%	
	00+67.9	407.26			

Pnt Num	*Station (ft)*	*Rod Height (ft)*	*Adj. Elev (ft)*	*Water Depth (ft)*	*Adj. WS Elev (ft)*
1	00+03.0	11.32	406.79	0.33	407.12
2	00+15.1	11.45	406.66	0.33	406.99
3	00+31.5	11.64	406.47	0.34	406.81
4	00+40.2	11.69	406.42	0.31	406.73
5	00+47.2	11.60	406.51	0.23	406.74
6	00+61.8	11.86	406.25	0.33	406.58
7	00+67.9	11.85	406.26	0.29	406.55
8	00+76.2	12.04	406.07	0.32	406.39
9	00+84.5	12.17	405.94	0.37	406.31
10	00+96.6	12.73	405.38	0.56	405.94
11	01+02.6	12.88	405.23	0.66	405.89
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Project: **Little Catoctin Creek**

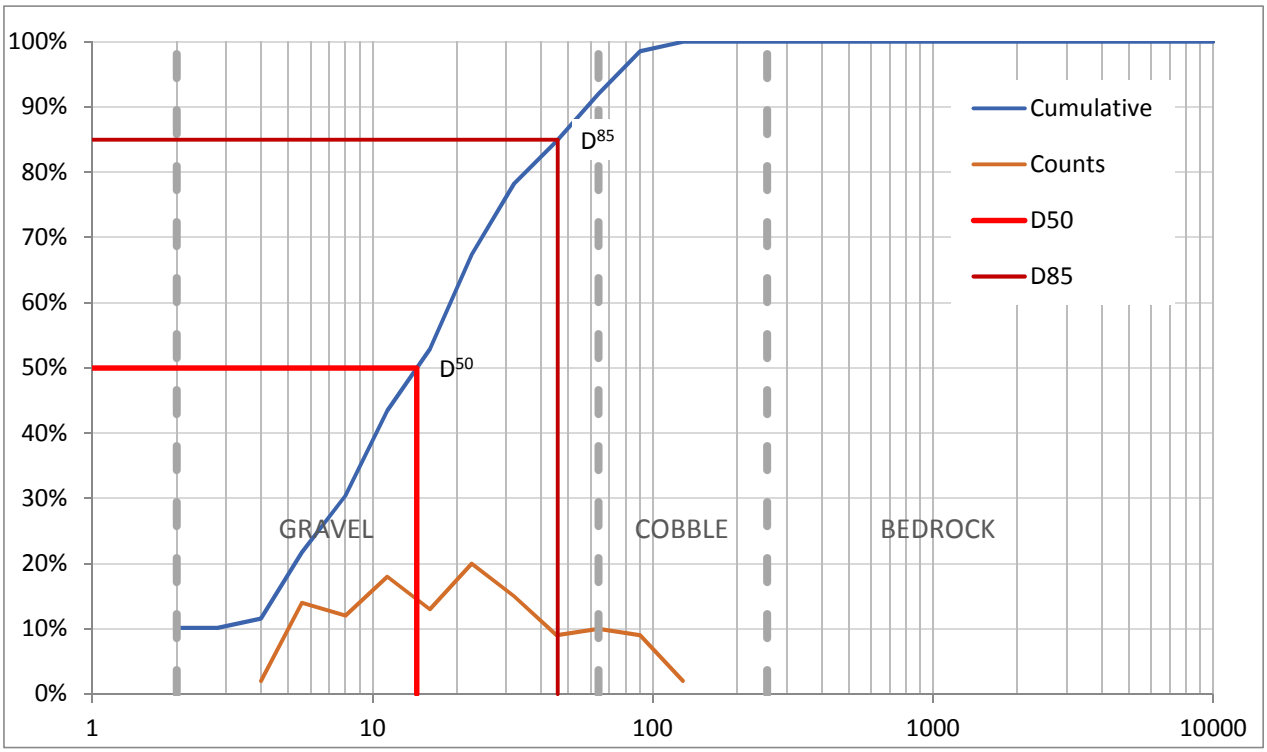
Project Number: **11102.48**

Site Name/Number: **P-3**

Date: 09/19/2017 (collected)

	Class Name	*Particle Size Class (mm)*		*Study Total*	*Study by Size %*	*Study Cumulative %*
	Silt/Clay	Consolidated < D ≤ 0.063			0.0	0.0
		Unconsolidate < D ≤ 0.063			0.0	0.0
	Sand	0.063 < D ≤ 2	2	5	3.1	3.1
Gravel	VF Gravel	2 < D ≤ 2.8	2.8	4	2.5	5.7
		2.8 < D ≤ 4	4	8	5.0	10.7
	Fine Gravel	4 < D ≤ 5.6	5.6	16	10.1	20.8
		5.6 < D ≤ 8	8	23	14.5	35.2
	Med. Gravel	8 < D ≤ 11.2	11.3	27	17.0	52.2
		11.2 < D ≤ 16	16	28	17.6	69.8
	Coarse Gravel	16 < D ≤ 22.4	22.6	31	19.5	89.3
		22.4 < D ≤ 31.5	32	9	5.7	95.0
	VC Gravel	31.5 < D ≤ 45	45.3	6	3.8	98.7
		45 < D ≤ 63	64	2	1.3	100.0
Cobble	Sm. Cobble	63 < D ≤ 90	90		0.0	100.0
		90 < D ≤ 128	128		0.0	100.0
	Lg. Cobble	128 < D ≤ 180	180		0.0	100.0
		180 < D ≤ 256	256		0.0	100.0
Boulder	Sm. Boulder	256 < D ≤ 362	362		0.0	100.0
		362 < D ≤ 512	512		0.0	100.0
	Med. Boulder	512 < D ≤ 724	724		0.0	100.0
		724 < D ≤ 1024	1024		0.0	100.0
	Lg. Boulder	1024 < D ≤ 1450	1450		0.0	100.0
		1450 < D ≤ 2048	2048		0.0	100.0
	VL Boulder	2048 < D ≤ 2900	2900		0.0	100.0
		2900 < D ≤ 4096	4096		0.0	100.0
	Bedrock	> 10000	10000		0.0	100.0
			Totals	159		

D^{16} =	4.8 mm	16	**Andrews 1994**
D^{35} =	8.0 mm	35	Tc* = 0.00317
D^{50} =	10.8 mm	50	Tc = 0.117 lb/ft² (Boundary Shear from Shields)
D^{65} =	14.5 mm	65	d = 0.0965 ft
D^{85} =	20.9 mm	85	S = 3.20%
D^{95} =	32.1 mm	95	
D^{i} =	180.0 mm		



Project:

Project Number:

Site Name/Number:

Date:

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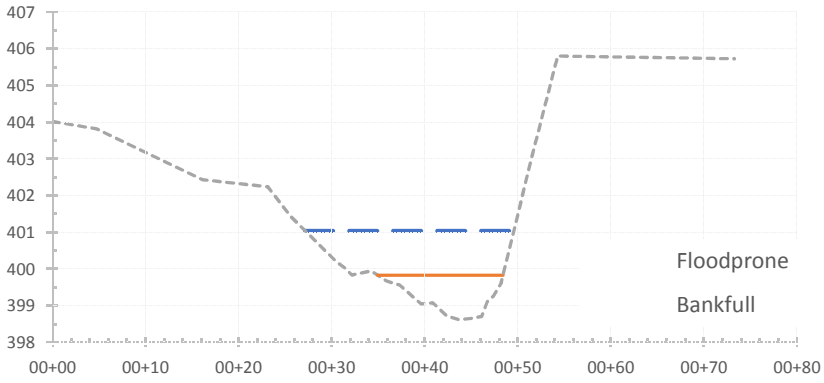
Cross Section



		Rogen Classification
BF Width:	13.47 ft	
BF Max Depth:	1.21 ft	
BF Area:	9.63 ft²	
BF R_h:	0.69 ft	
BF WP:	13.90 ft	
BF W/D Ratio:	11.13	*A, E, G*
FP Width:	22.43 ft	
Entrenchment:	1.67	*B*
Slope:	0.57%	*D, C, E, F*
Sinuosity:	1.35	*B, C, F, G*
Manning's n:	0.032	
BF Discharge:	26.56 ft³/s	
BF Velocity:	2.76 ft/s	
BF Boundary Shear Stress:	0.248 lbs/ft²	
Critical Shear Stress:		
Most Probable Classification →		F

Is Benchmark in XS Data?	Yes	
	↓Use This ↓	
Benchmark Elev:	403.82	
Station for Benchmark:	00+04.8	
RH at Benchmark:	1.98	6.20
Bankfull RH/Elevation:	5.97	399.83
Floodprone RH/Elevation:		401.04

Pnt Num	*Station (ft)*	*Rod Height (ft)*	*Notes*	*Adj. Elev (ft)*	*BF Wetted Perimeter (ft)*	*BF Area (ft²)*	*BF Top Width (ft)*	*FP Top Width (ft)*
					13.90	9.63	13.47	22.43
1	00+00.0	1.78		404.02	0.00	0.00	0.00	0.00
2	00+04.8	1.98	LPIN	403.82	0.00	0.00	0.00	0.00
3	00+16.1	3.37		402.43	0.00	0.00	0.00	0.00
4	00+23.2	3.56		402.24	0.00	0.00	0.00	0.00
5	00+25.6	4.37		401.43	0.00	0.00	0.00	0.00
6	00+30.5	5.60		400.20	0.00	0.00	0.00	3.33
7	00+31.4	5.77		400.03	0.00	0.00	0.00	0.93
8	00+32.2	5.96		399.84	0.00	0.00	0.00	0.77
9	00+34.2	5.85		399.95	0.00	0.00	0.00	2.05
10	00+35.9	6.13		399.67	0.98	0.08	0.97	1.69
11	00+37.3	6.23		399.57	1.40	0.29	1.40	1.40
12	00+39.6	6.75		399.05	2.34	1.19	2.28	2.28
13	00+40.9	6.72		399.08	1.29	0.99	1.29	1.29
14	00+42.4	7.08		398.72	1.55	1.40	1.51	1.51
15	00+43.7	7.18		398.62	1.27	1.47	1.27	1.27
16	00+45.2	7.14		398.66	1.49	1.77	1.49	1.49

Pnt Num	Station (ft)	Rod Height (ft)	Notes	Adj. Elev (ft)	BF Wetted Perimeter (ft)	BF Area (ft^2)	BF Top Width (ft)	FP Top Width (ft)
17	00+46.2	7.09		398.71	0.99	1.13	0.99	0.99
18	00+46.7	6.69		399.11	0.70	0.53	0.58	0.58
19	00+47.4	6.54		399.26	0.66	0.41	0.64	0.64
20	00+48.2	6.19		399.61	0.91	0.33	0.84	0.84
21	00+51.5	2.72		403.08	0.30	0.02	0.21	1.37
22	00+54.3	0.00		405.80	0.00	0.00	0.00	0.00
23	00+73.3	0.07		405.73	0.00	0.00	0.00	0.00
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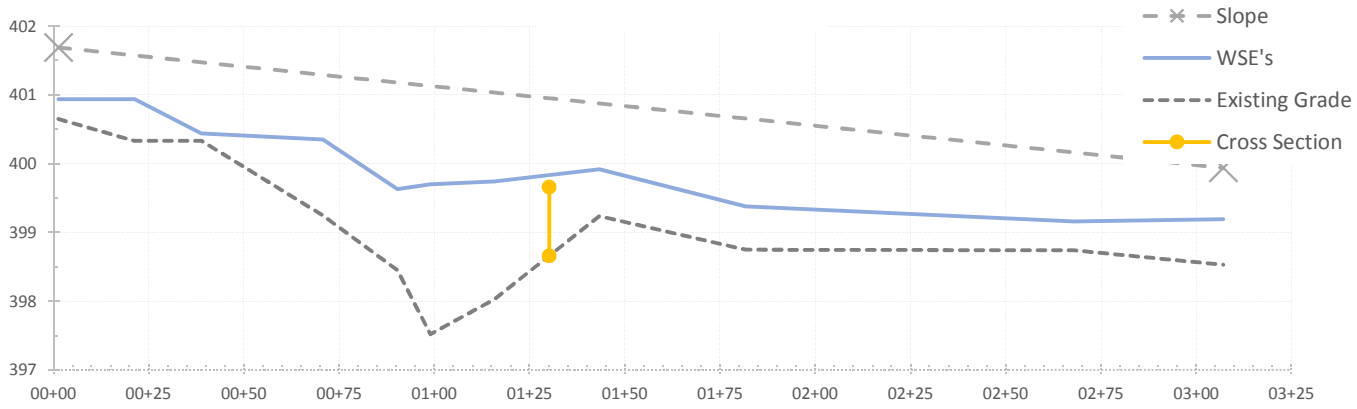
Project: **Little Catoctin Creek**
Project Number: **11102.48**
Site Name/Number: **P-4**

Date: December 4, 2015



					WSE
Benchmark Elev:	398.66		Starting Station	00+01.3	400.94
Benchmark RH:	6.99		Ending Station	03+07.1	399.19
Cross Section Location:	01+30.1	El: 398.66	Slope	0.572%	

Pnt Num	*Station (ft)*	*Rod Height (ft)*	*Adj. Elev (ft)*	*Water Depth (ft)*	*Adj. WS Elev (ft)*
1	00+01.3	5.00	400.65	0.29	400.94
2	00+21.2	5.32	400.33	0.61	400.94
3	00+38.8	5.32	400.33	0.11	400.44
4	00+70.7	6.40	399.25	1.10	400.35
5	00+90.3	7.20	398.45	1.18	399.63
6	00+98.9	8.13	397.52	2.18	399.70
7	01+15.7	7.62	398.03	1.71	399.74
8	01+43.3	6.41	399.24	0.68	399.92
9	01+81.7	6.90	398.75	0.63	399.38
10	02+67.8	6.91	398.74	0.42	399.16
11	03+07.1	7.12	398.53	0.66	399.19
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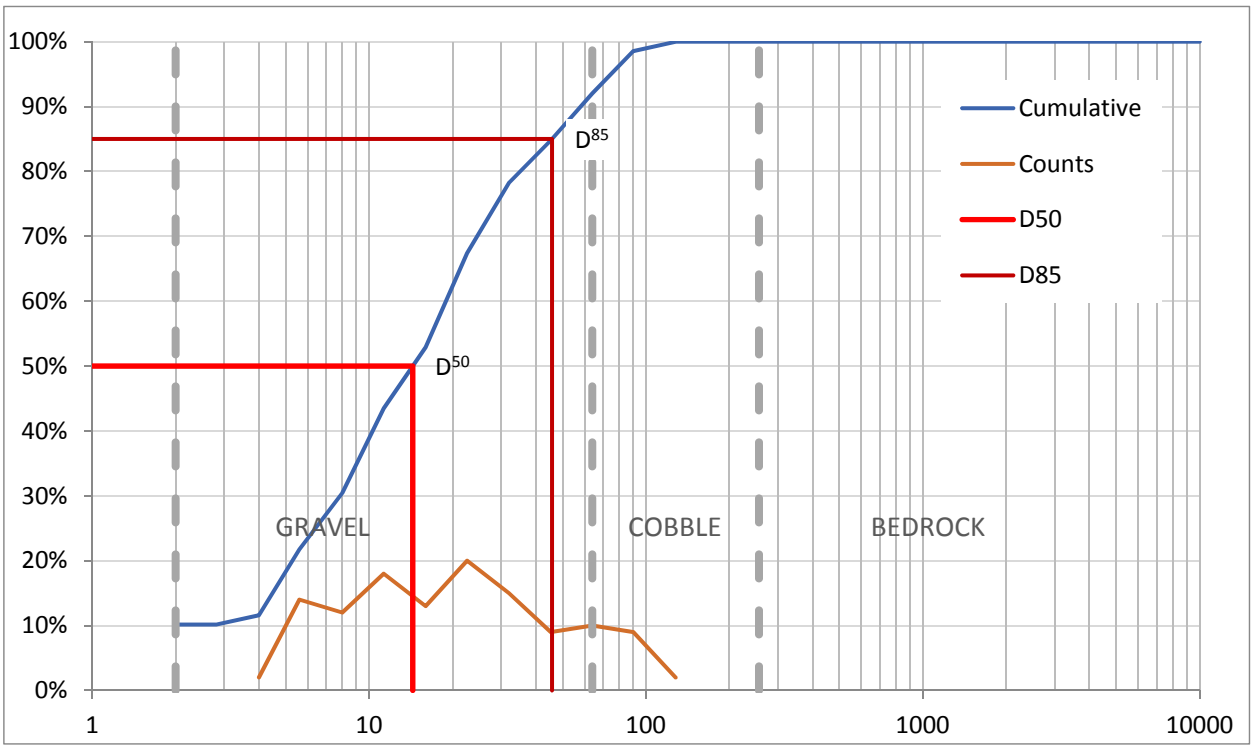
20					

Project: **Little Catoctin Creek**
Project Number: **11102.48**
Site Name/Number: **P-4**

Date: December 4, 2015

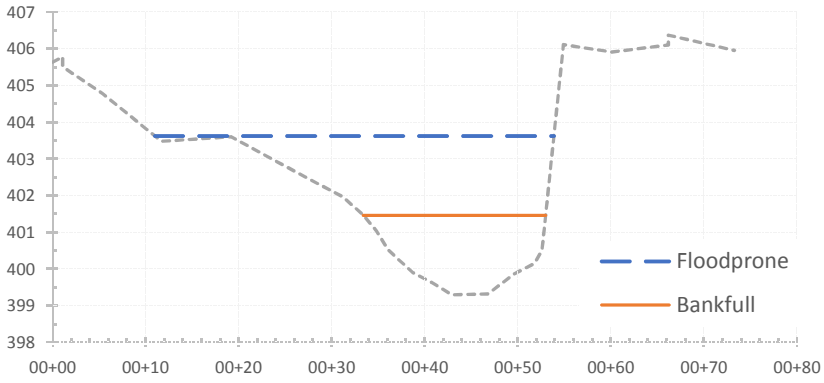
	Class Name	*Particle Size Class (mm)*		*Study Total*	*Study by Size %*	*Study Cumulative %*
	Silt/Clay	Consolidated $< D \leq$ 0.063			#DIV/0!	#DIV/0!
		Unconsolidate $< D \leq$ 0.063			#DIV/0!	#DIV/0!
	Sand	0.063 $< D \leq$ 2	2		#DIV/0!	#DIV/0!
Gravel	VF Gravel	2 $< D \leq$ 2.8	2.8		#DIV/0!	#DIV/0!
		2.8 $< D \leq$ 4	4		#DIV/0!	#DIV/0!
	Fine Gravel	4 $< D \leq$ 5.6	5.6		#DIV/0!	#DIV/0!
		5.6 $< D \leq$ 8	8		#DIV/0!	#DIV/0!
	Med. Gravel	8 $< D \leq$ 11.2	11.3		#DIV/0!	#DIV/0!
		11.2 $< D \leq$ 16	16		#DIV/0!	#DIV/0!
	Coarse Gravel	16 $< D \leq$ 22.4	22.6		#DIV/0!	#DIV/0!
		22.4 $< D \leq$ 31.5	32		#DIV/0!	#DIV/0!
	VC Gravel	31.5 $< D \leq$ 45	45.3		#DIV/0!	#DIV/0!
		45 $< D \leq$ 63	64		#DIV/0!	#DIV/0!
Cobble	Sm. Cobble	63 $< D \leq$ 90	90		#DIV/0!	#DIV/0!
		90 $< D \leq$ 128	128		#DIV/0!	#DIV/0!
	Lg. Cobble	128 $< D \leq$ 180	180		#DIV/0!	#DIV/0!
		180 $< D \leq$ 256	256		#DIV/0!	#DIV/0!
Boulder	Sm. Boulder	256 $< D \leq$ 362	362		#DIV/0!	#DIV/0!
		362 $< D \leq$ 512	512		#DIV/0!	#DIV/0!
	Med. Boulder	512 $< D \leq$ 724	724		#DIV/0!	#DIV/0!
		724 $< D \leq$ 1024	1024		#DIV/0!	#DIV/0!
	Lg. Boulder	1024 $< D \leq$ 1450	1450		#DIV/0!	#DIV/0!
		1450 $< D \leq$ 2048	2048		#DIV/0!	#DIV/0!
	VL Boulder	2048 $< D \leq$ 2900	2900		#DIV/0!	#DIV/0!
		2900 $< D \leq$ 4096	4096		#DIV/0!	#DIV/0!
	Bedrock	$>$ 10000	10000		#DIV/0!	#DIV/0!
			Totals	0		

D^{16} =	#N/A	16	**Andrews 1994**	
D^{35} =	#N/A	35	Tc* = #N/A	
D^{50} =	#N/A	50	Tc = #N/A	(Boundary Shear from Shields)
D^{65} =	#N/A	65	d = #N/A	
D^{85} =	#N/A	85	S = #N/A	
D^{95} =	#N/A	95		
D^{i} =	180.0 mm			



Project: Little Catoctin Creek
Project Number: 11102.48
Site Name/Number: P-4
Date: 9/19/2017 (collected)

Cross Section



		Rogen Classification
ver. 1.0		
BF Width:	19.59 ft	
BF Max Depth:	2.16 ft	
BF Area:	30.05 ft²	
BF R_h:	1.46 ft	
BF WP:	20.65 ft	
BF W/D Ratio:	9.07	*A, E, G*
FP Width:	42.86 ft	
Entrenchment:	2.19	*B*
Slope:	0.78%	*D, C, E, F*
Sinuosity:	1.35	*B, C, F, G*
Manning's n:	0.032	
BF Discharge:	159.07 ft³/s	
BF Velocity:	5.29 ft/s	
BF Boundary Shear Stress:	0.712 lbs/ft²	
Critical Shear Stress:	0.143 lbs/ft²	
Most Probable Classification →		F

	↓Use This ↓	
Is Benchmark in XS Data?		Yes
Benchmark Elev:	406.10	
Station for Benchmark:	00+66.2	
RH at Benchmark:	6.06	6.20
Bankfull RH/Elevation:	10.70	401.46
Floodprone RH/Elevation:		403.62

Pnt Num	*Station (ft)*	*Rod Height (ft)*	*Notes*	*Adj. Elev (ft)*	*BF Wetted Perimeter (ft)*	*BF Area (ft²)*	*BF Top Width (ft)*	*FP Top Width (ft)*
					20.65	30.05	19.59	42.86
1	00+00.0	6.53		405.63	0.00	0.00	0.00	0.00
2	00+01.1	6.38	LPIN	405.78	0.00	0.00	0.00	0.00
3	00+01.1	6.65		405.51	0.00	0.00	0.00	0.00
4	00+05.4	7.38		404.78	0.00	0.00	0.00	0.00
5	00+11.7	8.68		403.48	0.00	0.00	0.00	0.68
6	00+19.2	8.56		403.60	0.00	0.00	0.00	7.50
7	00+27.2	9.66		402.50	0.00	0.00	0.00	8.00
8	00+31.2	10.19		401.97	0.00	0.00	0.00	4.00
9	00+33.3	10.67		401.49	0.00	0.00	0.00	2.10
10	00+34.8	11.11		401.05	1.46	0.29	1.40	1.50
11	00+36.1	11.64	EOW	400.52	1.40	0.88	1.30	1.30
12	00+38.7	12.25		399.91	2.67	3.24	2.60	2.60
13	00+40.8	12.53		399.63	2.12	3.55	2.10	2.10
14	00+42.9	12.86		399.30	2.13	4.19	2.10	2.10
15	00+46.8	12.84		399.32	3.90	8.39	3.90	3.90
16	00+49.6	12.30		399.86	2.85	5.24	2.80	2.80

Pnt Num	Station (ft)	Rod Height (ft)	Notes	Adj. Elev (ft)	BF Wetted Perimeter (ft)	BF Area (ft^2)	BF Top Width (ft)	FP Top Width (ft)
17	00+51.8	12.01		400.15	2.22	3.20	2.20	2.20
18	00+52.6	11.65	EOW	400.51	0.88	0.90	0.80	0.80
19	00+54.9	6.05		406.11	1.03	0.19	0.39	1.28
20	00+60.1	6.25		405.91	0.00	0.00	0.00	0.00
21	00+66.2	6.06		406.10	0.00	0.00	0.00	0.00
22	00+66.2	5.79	RPIN	406.37	0.00	0.00	0.00	0.00
23	00+73.3	6.21		405.95	0.00	0.00	0.00	0.00
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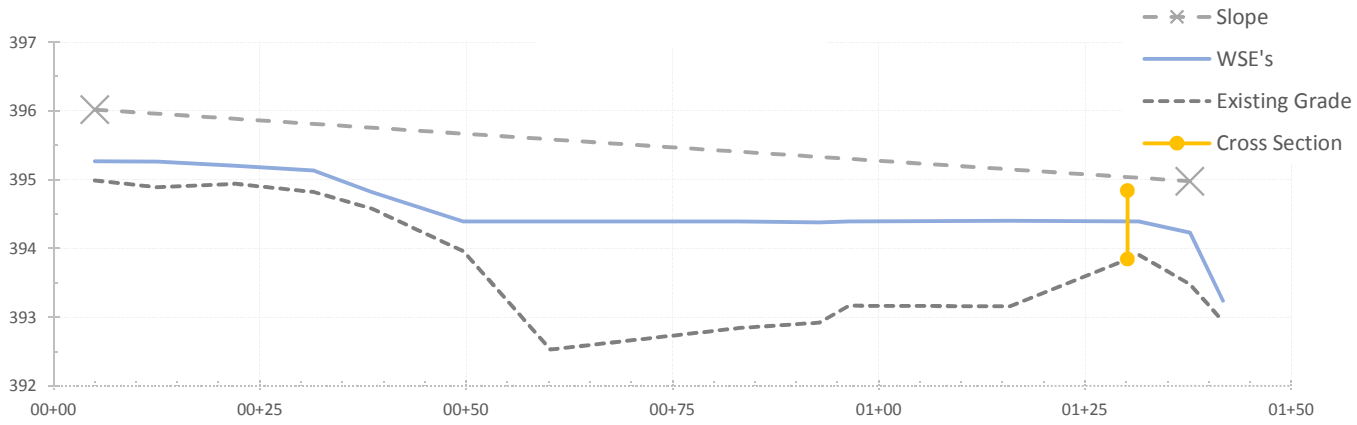
Project: **Little Catoctin Creek**
Project Number: **11102.48**
Site Name/Number: **P-4**

Date: 9/19/2017 (collected)



Benchmark Elev:			Starting Station		395.27
Benchmark RH:			Ending Station		394.23
Cross Section Location:		El: 393.84	Slope	0.784%	
	01+30.1	394.84			

Pnt Num	*Station (ft)*	*Rod Height (ft)*	*Adj. Elev (ft)*	*Water Depth (ft)*	*Adj. WS Elev (ft)*
1	00+05.0	11.04	394.99	0.28	395.27
2	00+12.6	11.14	394.89	0.37	395.26
3	00+22.0	11.09	394.94	0.26	395.20
4	00+31.6	11.21	394.82	0.31	395.13
5	00+38.6	11.45	394.58	0.24	394.82
6	00+49.7	12.07	393.96	0.43	394.39
7	00+60.2	13.50	392.53	1.86	394.39
8	00+83.0	13.19	392.84	1.55	394.39
9	00+92.8	13.11	392.92	1.46	394.38
10	00+96.4	12.86	393.17	1.22	394.39
11	01+15.9	12.87	393.16	1.24	394.40
12	01+31.5	12.12	393.91	0.48	394.39
13	01+37.7	12.55	393.48	0.75	394.23
14	01+41.7	13.09	392.94	0.30	393.24
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Project: **Little Catoctin Creek**

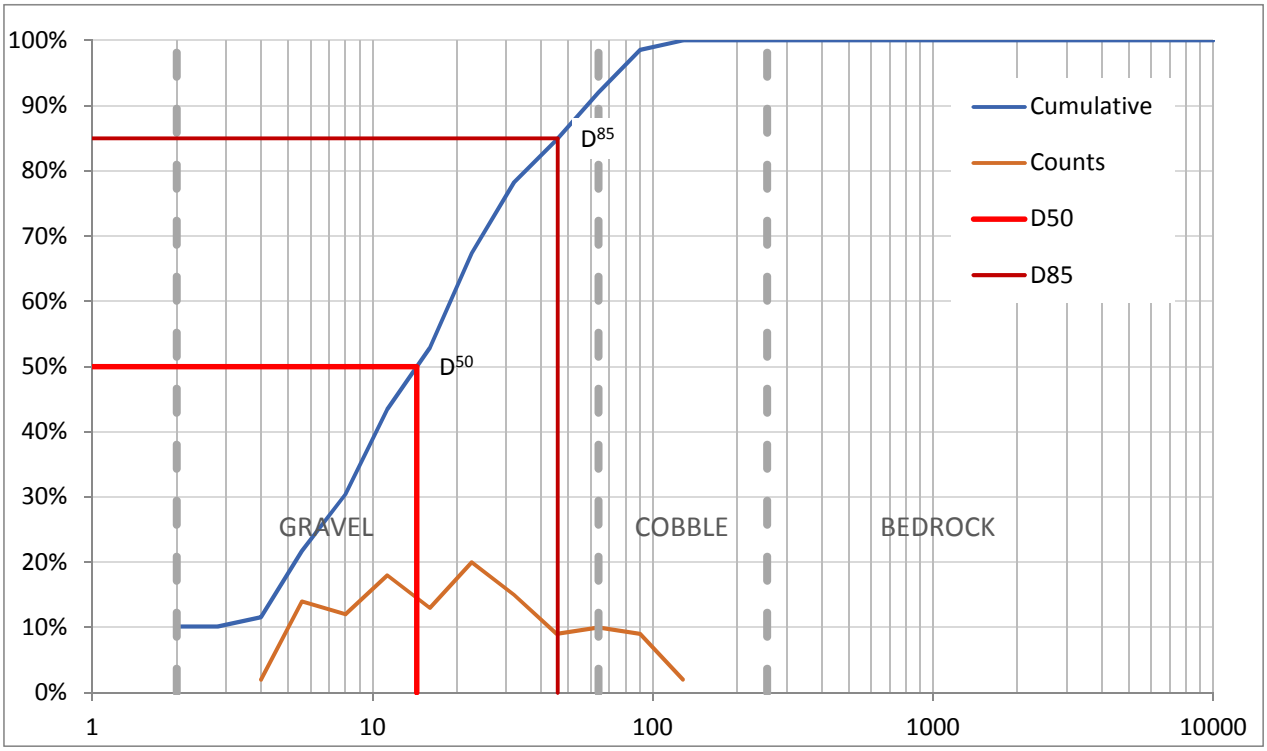
Project Number: **11102.48**

Site Name/Number: **P-4**

Date: 9/19/2017 (collected)

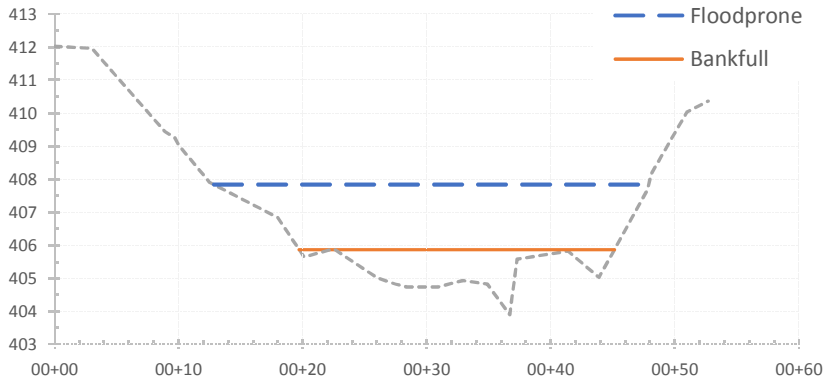
	Class Name	*Particle Size Class (mm)*		*Study Total*	*Study by Size %*	*Study Cumulative %*
	Silt/Clay	Consolidated $< D \leq 0.063$			0.0	0.0
		Unconsolidate $< D \leq 0.063$			0.0	0.0
	Sand	$0.063 < D \leq 2$	2	8	5.3	5.3
Gravel	VF Gravel	$2 < D \leq 2.8$	2.8	9	6.0	11.3
		$2.8 < D \leq 4$	4	10	6.6	17.9
	Fine Gravel	$4 < D \leq 5.6$	5.6	9	6.0	23.8
		$5.6 < D \leq 8$	8	10	6.6	30.5
	Med. Gravel	$8 < D \leq 11.2$	11.3	18	11.9	42.4
		$11.2 < D \leq 16$	16	22	14.6	57.0
	Coarse Gravel	$16 < D \leq 22.4$	22.6	21	13.9	70.9
		$22.4 < D \leq 31.5$	32	21	13.9	84.8
	VC Gravel	$31.5 < D \leq 45$	45.3	11	7.3	92.1
		$45 < D \leq 63$	64	11	7.3	99.3
Cobble	Sm. Cobble	$63 < D \leq 90$	90	1	0.7	100.0
		$90 < D \leq 128$	128		0.0	100.0
	Lg. Cobble	$128 < D \leq 180$	180		0.0	100.0
		$180 < D \leq 256$	256		0.0	100.0
Boulder	Sm. Boulder	$256 < D \leq 362$	362		0.0	100.0
		$362 < D \leq 512$	512		0.0	100.0
	Med. Boulder	$512 < D \leq 724$	724		0.0	100.0
		$724 < D \leq 1024$	1024		0.0	100.0
	Lg. Boulder	$1024 < D \leq 1450$	1450		0.0	100.0
		$1450 < D \leq 2048$	2048		0.0	100.0
	VL Boulder	$2048 < D \leq 2900$	2900		0.0	100.0
		$2900 < D \leq 4096$	4096		0.0	100.0
	Bedrock	> 10000	10000		0.0	100.0
			Totals	151		

D^{16} =	3.6 mm	16	**Andrews 1994**
D^{35} =	9.1 mm	35	Tc* = 0.00387
D^{50} =	13.6 mm	50	Tc = 0.143 lb/ft² (Boundary Shear from Shields)
D^{65} =	19.5 mm	65	d = 0.1179 ft
D^{85} =	32.4 mm	85	S = 3.20%
D^{95} =	52.1 mm	95	
D^{i} =	180.0 mm		



Project: Little Catoctin Creek
Project Number: 11102.48
Site Name/Number: P-5
Date: 9/19/2017 (collected)

Cross Section



		Rogen Classification
ver. 1.0		
BF Width:	25.15 ft	
BF Max Depth:	1.97 ft	
BF Area:	15.31 ft²	
BF R_h:	0.56 ft	
BF WP:	27.15 ft	
BF W/D Ratio:	12.77	*B, C, F*
FP Width:	35.04 ft	
Entrenchment:	1.39	*A, F, G*
Slope:	0.99%	*D, C, E, F*
Sinuosity:	1.20	*A*
Manning's n:	0.032	
BF Discharge:	48.55 ft³/s	
BF Velocity:	3.17 ft/s	
BF Boundary Shear Stress:	0.350 lbs/ft²	
Critical Shear Stress:	0.100 lbs/ft²	
Most Probable Classification →		F

	↓Use This ↓	
Is Benchmark in XS Data?		Yes
Benchmark Elev:	409.26	100.00
Station for Benchmark:	00+09.7	
RH at Benchmark:	8.61	6.20
Bankfull RH/Elevation:	12.00	405.87
Floodprone RH/Elevation:		407.84

Pnt Num	*Station (ft)*	*Rod Height (ft)*	*Notes*	*Adj. Elev (ft)*	*BF Wetted Perimeter (ft)*	*BF Area (ft²)*	*BF Top Width (ft)*	*FP Top Width (ft)*
					27.15	15.31	25.15	35.04
1	00+00.0	5.85		412.02	0.00	0.00	0.00	0.00
2	00+03.0	5.91		411.96	0.00	0.00	0.00	0.00
3	00+08.9	8.42		409.45	0.00	0.00	0.00	0.00
4	00+09.7	8.61	LPIN	409.26	0.00	0.00	0.00	0.00
5	00+10.0	8.83		409.04	0.00	0.00	0.00	0.00
6	00+12.5	9.96		407.91	0.00	0.00	0.00	0.00
7	00+18.0	11.03		406.84	0.00	0.00	0.00	5.14
8	00+20.1	12.22		405.65	0.45	0.04	0.39	2.10
9	00+22.5	11.98		405.89	2.21	0.24	2.20	2.40
10	00+26.0	12.85	EOW	405.02	3.52	1.45	3.42	3.50
11	00+27.5	13.04		404.83	1.51	1.42	1.50	1.50
12	00+28.4	13.13		404.74	0.90	0.98	0.90	0.90
13	00+30.9	13.13		404.74	2.50	1.41	2.50	2.50
14	00+32.9	12.94		404.93	2.01	2.07	2.00	2.00
15	00+34.9	13.04		404.83	2.00	1.98	2.00	2.00
16	00+36.7	13.97	EOW	403.90	2.03	2.71	1.80	1.80

Pnt Num	Station (ft)	Rod Height (ft)	Notes	Adj. Elev (ft)	BF Wetted Perimeter (ft)	BF Area (ft^2)	BF Top Width (ft)	FP Top Width (ft)
17	00+37.3	12.29		405.58	1.78	0.68	0.60	0.60
18	00+41.4	12.05		405.82	4.11	0.70	4.10	4.10
19	00+43.9	12.84		405.03	2.62	1.11	2.50	2.50
20	00+47.8	10.20		407.67	1.50	0.52	1.24	3.90
21	00+48.1	9.71	RPIN	408.16	0.00	0.00	0.00	0.10
22	00+51.0	7.83		410.04	0.00	0.00	0.00	0.00
23	00+52.7	7.50		410.37	0.00	0.00	0.00	0.00
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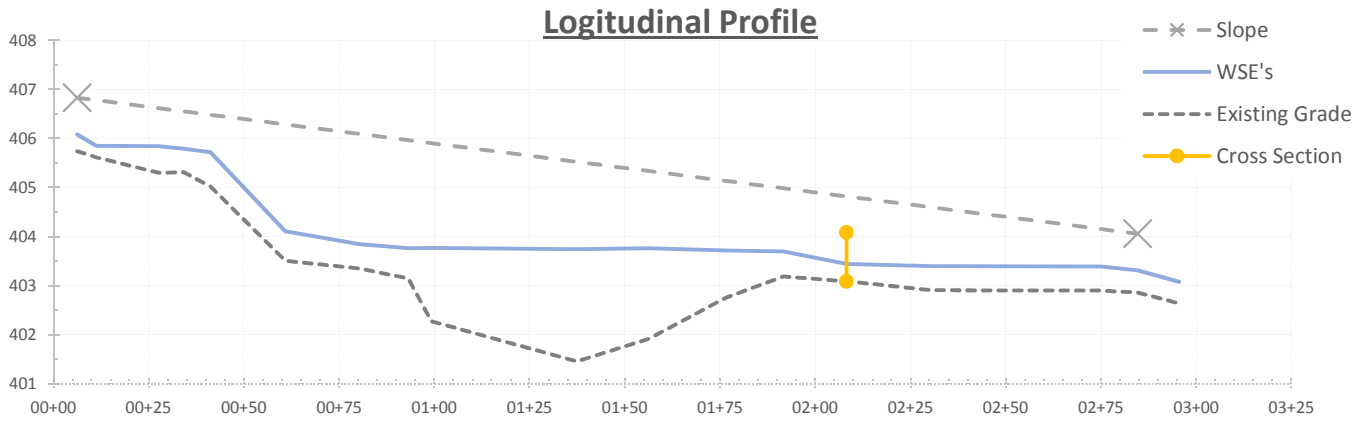
Project: **Little Catoctin Creek**
Project Number: **11102.48**
Site Name/Number: **P-5**

Date: 9/19/2017 (collected)



					WSE
Benchmark Elev:	403.90		Starting Station	00+06.2	406.08
Benchmark RH:	6.05		Ending Station	02+84.6	403.31
Cross Section Location:	02+08.2	El: 403.09	Slope	0.995%	

Pnt Num	*Station (ft)*	*Rod Height (ft)*	*Adj. Elev (ft)*	*Water Depth (ft)*	*Adj. WS Elev (ft)*
1	00+06.2	4.21	405.74	0.34	406.08
2	00+11.3	4.34	405.61	0.24	405.85
3	00+27.6	4.65	405.30	0.54	405.84
4	00+34.2	4.64	405.31	0.48	405.79
5	00+41.2	4.93	405.02	0.70	405.72
6	00+60.9	6.44	403.51	0.60	404.11
7	00+80.2	6.60	403.35	0.50	403.85
8	00+93.1	6.80	403.15	0.61	403.76
9	00+99.2	7.67	402.28	1.49	403.77
10	01+37.4	8.49	401.46	2.28	403.74
11	01+56.2	8.03	401.92	1.84	403.76
12	01+76.6	7.19	402.76	0.96	403.72
13	01+91.6	6.76	403.19	0.51	403.70
14	02+08.2	6.86	403.09	0.35	403.44
15	02+30.7	7.04	402.91	0.49	403.40
16	02+74.9	7.05	402.90	0.49	403.39
17	02+84.6	7.09	402.86	0.45	403.31
18	02+95.5	7.31	402.64	0.44	403.08
19					
20					

Project: **Little Catoctin Creek**

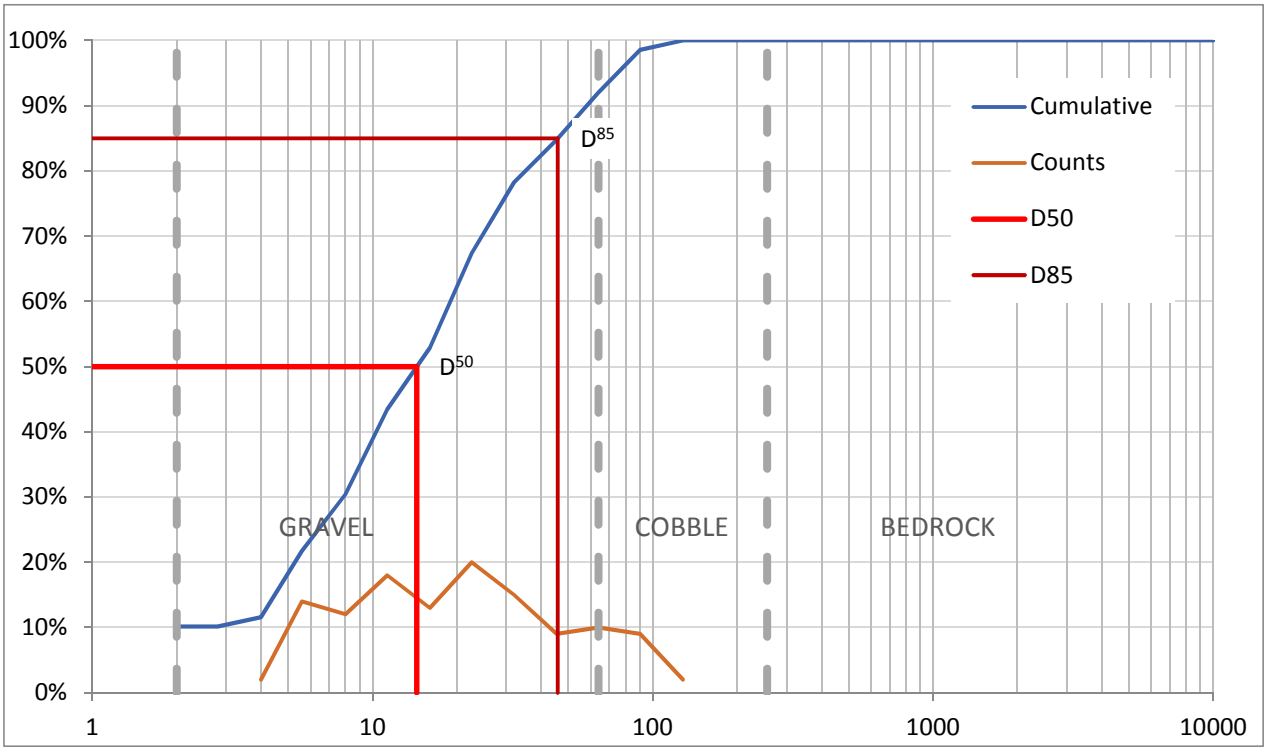
Project Number: **11102.48**

Site Name/Number: **P-5**

Date: 9/19/2017 (collected)

	Class Name	*Particle Size Class (mm)*		*Study Total*	*Study by Size %*	*Study Cumulative %*
	Silt/Clay	Consolidated $< D \leq 0.063$			0.0	0.0
		Unconsolidate $< D \leq 0.063$			0.0	0.0
	Sand	$0.063 < D \leq 2$	2	25	11.4	11.4
Gravel	VF Gravel	$2 < D \leq 2.8$	2.8	17	7.8	19.2
Gravel		$2.8 < D \leq 4$	4	20	9.1	28.3
Gravel	Fine Gravel	$4 < D \leq 5.6$	5.6	17	7.8	36.1
Gravel		$5.6 < D \leq 8$	8	23	10.5	46.6
Gravel	Med. Gravel	$8 < D \leq 11.2$	11.3	21	9.6	56.2
Gravel		$11.2 < D \leq 16$	16	33	15.1	71.2
Gravel	Coarse Gravel	$16 < D \leq 22.4$	22.6	20	9.1	80.4
Gravel		$22.4 < D \leq 31.5$	32	15	6.8	87.2
Gravel	VC Gravel	$31.5 < D \leq 45$	45.3	9	4.1	91.3
Gravel		$45 < D \leq 63$	64	14	6.4	97.7
Cobble	Sm. Cobble	$63 < D \leq 90$	90	4	1.8	99.5
Cobble		$90 < D \leq 128$	128	1	0.5	100.0
Cobble	Lg. Cobble	$128 < D \leq 180$	180		0.0	100.0
Cobble		$180 < D \leq 256$	256		0.0	100.0
Boulder	Sm. Boulder	$256 < D \leq 362$	362		0.0	100.0
Boulder		$362 < D \leq 512$	512		0.0	100.0
Boulder	Med. Boulder	$512 < D \leq 724$	724		0.0	100.0
Boulder		$724 < D \leq 1024$	1024		0.0	100.0
Boulder	Lg. Boulder	$1024 < D \leq 1450$	1450		0.0	100.0
Boulder		$1450 < D \leq 2048$	2048		0.0	100.0
Boulder	VL Boulder	$2048 < D \leq 2900$	2900		0.0	100.0
Boulder		$2900 < D \leq 4096$	4096		0.0	100.0
	Bedrock	> 10000	10000		0.0	100.0
			Totals	219		

D^{16} =	2.4 mm	16	**Andrews 1994**
D^{35} =	5.3 mm	35	Tc* = 0.00271
D^{50} =	9.1 mm	50	Tc = 0.100 lb/ft² (Boundary Shear from Shields)
D^{65} =	13.9 mm	65	d = 0.0824 ft
D^{85} =	28.6 mm	85	S = 3.20%
D^{95} =	55.3 mm	95	
D^{i} =	180.0 mm		



Maryland Department of Transportation

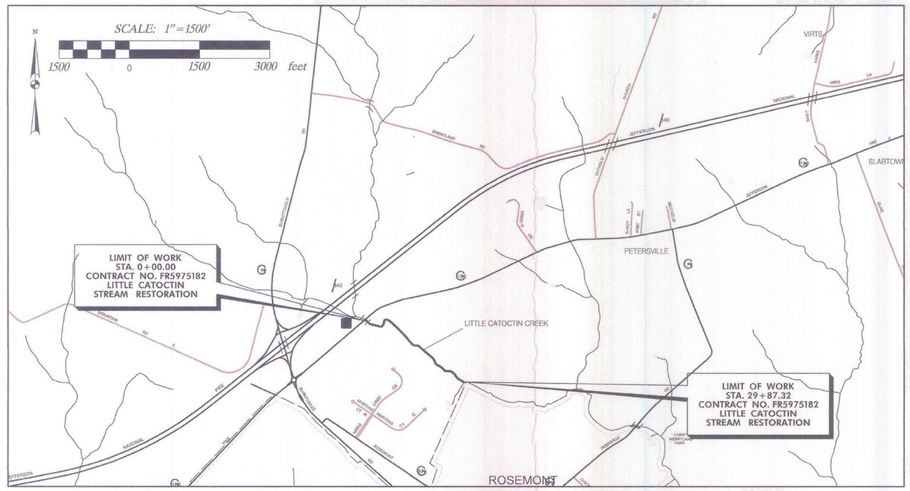
STATE HIGHWAY ADMINISTRATION

LITTLE CATOCTIN CREEK STREAM RESTORATION

S.H.A. CONTRACT NO. FR5975182
FEDERAL AID PROJECT NO. N/A

INDEX OF SHEETS

SHEET #	DWG. #	DRAWING TITLE
1	—	TITLE SHEET
2	GN–1	ABBREVIATIONS /GENERAL NOTES
3–4	GS–1 – GS–2	STREAM RESTORATION GEOMETRY
5	TS–1	STREAM TYPICAL SECTIONS
6–10	SRV–1 – SRV–5	STREAM RESTORATION PROFILES
11	KM–1	KEY MAP
12–15	SR–1 – SR–4	STREAM RESTORATION PLANS
16–18	SD–1 – SD–3	STREAM RESTORATION DETAILS
19–22	EN–01 – EN–04	ESC NOTES & SEQUENCE OF CONSTRUCTION
23–42	ES–01 – ES–20	ESC PLANS
43–44	EN–05 – EN–06	ESC DETAILS
45–48	LP–1 – LP–4	LANDSCAPING PLANS
49–52	CS–1 – CS–4	STREAM RESTORATION CROSS SECTIONS
53	MOT–1	MOT PLANS



FREDERICK COUNTY, MD

LOCATION MAP

SCALE : 1" = 1,500'
PROJECT LENGTH = 2987.32 FT

HORIZONTAL DATUM	NAD 83 /91
VERTICAL DATUM	NAVD 88

AASHTO DESIGN CRITERIA

THIS PROJECT WAS DESIGNED IN ACCORDANCE WITH THE 2004 PUBLICATION OF AASHTO'S "A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS."

STANDARD SPECIFICATIONS BOOK, BOOK OF STANDARDS AND MUTCD

ALL WORK ON THIS PROJECT SHALL CONFORM TO: THE MARYLAND DEPARTMENT OF TRANSPORTATION, STATE HIGHWAY ADMINISTRATIONS SPECIFICATIONS ENTITLED STANDARD SPECIFICATIONS FOR CONSTRUCTION AND MATERIALS DATED JULY 2008 REVISIONS THEREOF OR ADDITIONS THERETO; THE SPECIAL PROVISIONS INCLUDED IN THE INVITATION FOR BIDS BOOK; THE ADMINISTRATIONS BOOK OF STANDARDS FOR HIGHWAYS AND INCIDENTAL STRUCTURES AND THE LATEST MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES (MUTCD)

RIGHT OF WAY

RIGHT OF WAY AND EASEMENT LINES SHOWN ON THESE PLANS ARE FOR ASSISTANCE IN INTERPRETING THE PLANS. THEY ARE NOT OFFICIAL. FOR OFFICIAL FEE RIGHT OF WAY AND EASEMENT INFORMATION, SEE APPROPRIATE RIGHT OF WAY PLATS.

UTILITIES

THE LOCATION OF THE UNDERGROUND AND SURFACE UTILITIES SHOWN ON THE PLANS ARE FOR INFORMATION AND GUIDANCE ONLY. NO GUARANTEE IS MADE AS TO THE ACCURACY OF SAID LOCATIONS. CONTRACTOR SHALL CONTACT "MISS UTILITY" AT 1-800-257-7777, 48 HOURS PRIOR TO EXCAVATION FOR MARKING AND LOCATION OF UTILITIES.

COMPLETENESS OF DOCUMENTS

THE STATE HIGHWAY ADMINISTRATION SHALL ONLY BE RESPONSIBLE FOR THE COMPLETENESS OF DOCUMENTS OBTAINED DIRECTLY FROM THE STATE HIGHWAY ADMINISTRATION'S CASHIER'S OFFICE. FAILURE TO ATTACH ADDENDA MAY CAUSE THE BID TO BE IRREGULAR.

ADA COMPLIANCE

THE DESIGN OF THIS PROJECT HAS INCORPORATED FACILITIES FOR THE ELDERLY AND HANDICAPPED IN COMPLIANCE WITH THE STATE AND FEDERAL LEGISLATION

ENVIRONMENTAL INFORMATION

PRD # 16–PR–0067
MDE # 16–NT–3224
USACE # 201661387

ALL STORMWATER MANAGEMENT FACILITIES CONSTRUCTED FOR CONTRACT NO. FR5975182 SHALL BE INSPECTED AND MAINTAINED IN ACCORDANCE WITH THE STATE HIGHWAY ADMINISTRATIONS BEST MANAGEMENT PRACTICES (BMP) INSPECTION AND REMEDIATION PROGRAM.

STANDARD STABILIZATION NOTE :

FOLLOWING INITIAL SOIL DISTURBANCE OR REDISTURBANCE, PERMANENT OR TEMPORARY STABILIZATION SHALL BE COMPLETED WITHIN THREE (3) CALENDER DAYS AS TO THE SURFACE OF ALL PERIMETER CONTROLS, DIKES, SWALES, DITCHES, PERIMETER SLOPES, AND ALL SLOPES GREATER THAN 3 HORIZONTAL TO 1 VERTICAL (3:1), AND SEVEN DAYS (7) AS TO ALL OTHER DISTURBED OR GRADED AREAS ON THE PROJECT SITE.

OWNERS / DEVELOPERS CERTIFICATION :

I / WE HEREBY CERTIFY THAT ANY CLEARING, GRADING, CONSTRUCTION AND/OR DEVELOPMENT WILL BE DONE PURSUANT TO THIS PLAN, AND THAT ANY RESPONSIBLE PERSONNEL INVOLVED IN THE CONSTRUCTION PROJECT WILL HAVE A CERTIFICATE OF ATTENDANCE AT A MARYLAND DEPARTMENT OF THE ENVIRONMENT APPROVED TRAINING PROGRAM FOR THE CONTROL OF SEDIMENT AND EROSION BEFORE BEGINNING THE PROJECT. I HEREBY AUTHORIZE THE RIGHT OF ENTRY FOR PERIODIC ON-SITE EVALUATION BY STATE OF MARYLAND, DEPARTMENT OF THE ENVIRONMENT, COMPLIANCE INSPECTORS.

SEDIMENT AND EROSION CONTROL REGULATIONS WILL BE STRICTLY ENFORCED DURING CONSTRUCTION

JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future®

STATE OF MARYLAND — DANIEL F. CLEMENT — PROFESSIONAL ENGINEER
03/21/17

PROFESSIONAL CERTIFICATION. I HEREBY CERTIFY THAT THESE DOCUMENTS WERE PREPARED OR APPROVED BY ME, AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MARYLAND, LICENSE NO. 15466, EXPIRATION DATE: 07/15/17.

R-O-W PLAT NUMBERS	*SURVEY BOOK NUMBERS*
	18301, 23661

REVISIONS	

REVIEW AND APPROVAL RECOMMENDED
Barbara M Coffman 3/20/17
CHIEF, WATER PROGRAMS DIVISION — DATE

APPROVAL RECOMMENDED
Jamal Rana 3.22.17
DIRECTOR OFFICE OF ENVIRONMENTAL DESIGN — DATE

APPROVED
3/22/17
DEPUTY ADMINISTRATOR /CHIEF ENGINEER FOR PLANNING, ENGINEERING, REAL ESTATE AND ENVIRONMENT. — DATE

BY: BARRANGER

SURVEY BOOK NO.

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INDEXED

ABBREVIATIONS

ACCEL – ACCELERATION
A.A.S.H.T.O. – AMERICAN ASSOCIATION OF STATE HIGHWAY TRANSPORTATION OFFICIALS
ADT – AVERAGE DAILY TRAFFIC
AHD – AHEAD
APPROX. – APPROXIMATE
℄ : B℄ – BASELINE
BK – BACK
BIT. – BITUMINOUS
B.C. – BITUMINOUS CONCRETE
B.M. – BENCH MARK
BOT. – BOTTOM
CC – CENTER OF CURVE
CATV – CABLE TELEVISION
C.B.R. – CALIFORNIA BEARING RATIO
℄ : C℄–CENTERLINE
CL. – CLASS
CLF – CHAINLINK FENCE
CMP – CORRUGATED METAL PIPE
C.O. – CLEANOUT
COMB. – COMBINATION
CONC. – CONCRETE
CONSTR. – CONSTRUCTION
COR. – CORNER
CORR. – CORRECTION
CPP–SP – CORRUGATED POLYETHYLENE PIPE – TYPE 'S'
DC – DEGREE OF CURVE
D.H.V. – DESIGN HOURLY VOLUME
D.I. – DROP INLET
DIA. – DIAMETER
D.O. – DOUBLE OPENING
ELEC. – ELECTRIC
E – EXTERNAL DISTANCE
EA. – EACH
E.B. – EASTBOUND
ELEV. – ELEVATION
E.R.C.C.P. – ELLIPTICAL REINFORCED CEMENT CONCRETE PIPE
ES – END SECTION
EX. – EXISTING
FT. – FEET
F : FL – FLOWLINE
F.B.D. – FLAT BOTTOM DITCH
F.H. – FIRE HYDRANT
FWD. – FORWARD
G – GAS
GAB – GRADED AGGREGATE BASE
G.V. – GAS VALVE
H.B. – HANDBOX
H.D.P. – HIGH DENSITY POLYETHEYLENE
HDWL. – HEADWALL
H.E.R.C.P. – HORIZONTAL ELLIPITICAL REINFORCED CONCRETE PIPE
HMA – HOT MIX ASPHALT
H.P.–HIGH POINT

IN. – INCH
I.S.T. – INLET SEDIMENT TRAP
INV. – INVERT
J.B. – JUNCTION BOX
K – K INLET
L – LENGTH
L.F. – LINEAR FEET
L.L. – LIQUID LIMIT
L.P. – LIGHT POLE
MAC. – MACADAM
LT. – LEFT
M.C. – MOISTURE CONTENT
MAX. – MAXIMUM
M.D.D. – MAXIMUM DRY DENSITY
MOD. – MODIFIED
MIN. – MINIMUM
N – NORTH
N.B. – NORTHBOUND
N.E. – NORTHEAST
N.P. – NON–PLASTIC
O.C. – ON CENTER
OCF – ORANGE CONSTRUCTION FENCE
OHE – OVERHEAD ELECTRIC
O.M. – OPTIMUM MOISTURE
PAVT. – PAVEMENT
PC – POINT OF CURVATURE
PCC – POINT OF COMPOUND CURVATURE
P/C – POINT OF CROWN
P/GE – PROFILE GRADE ELEVATION
P.G.L. – PROFILE GRADE LINE
P/GL – PROFILE GROUND LINE
P/R – POINT OF ROTATION
PI – POINT OF INTERSECTION
P.O.C. – POINT ON CURVE
P.O.T. – POINT ON TANGENT
PPWP – POLYVINYL CHLORIDE PROFILE WALL PIPE
PROP. – PROPOSED
P.R.C. – POINT OF REVERSE CURVE
PT. – POINT
PT – POINT OF TANGENCY
PVC – POINT OF VERTICAL CURVATURE
PVI – POINT OF VERTICAL INTERSECTION
PVRC – POINT OF VERTICAL REVERSE CURVE
PVT – POINT OF VERTICAL CURVE TANGENCY
R – RADIUS
R.F. – ROCK FRAGMENTS
RT. – RIGHT

RW : RW – RIGHT OF WAY
RCP – REINFORCED CONCRETE PIPE
R.C.C.P. – REINFORCED CEMENT CONCRETE PIPE
R.Q.D. – ROCK QUALITY DESIGNATION
R.M. – ROOTMAT
S – SOUTH
SAN. – SANITARY SEWER
SB : SB – SOUTH BOUND
S.D. – STORM DRAIN
S.D.D. – SURFACE DRAIN DITCH
S/E – SUPER ELEVATION
SF – SILT FENCE
SHT. – SHEET
S.P.P. – STRUCTURAL PLATE PIPE
S.P.T. – STANDARD PENETRATION TESTING
SSD – STOPPING SIGHT DISTANCE
SSF – SUPER SILT FENCE
STD. – STANDARD
STA. – STATION
SO. – SINGLE OPENING
S.Y. – SQUARE YARDS
SWM – STORMWATER MANAGEMENT
T – TANGENT
TEL. – TELEPHONE
T.C. – TOP OF COVER
T.G. – TOP OF GRATE
℡ : TL – TRAVERSE LINE
T.M. – TOP OF MANHOLE
TP – TRAVERSE POINT
TS – TEMPORARY SWALE
T.S. – TOP OF SLAB
TYP. – TYPICAL
U.G. – UNDERGROUND
U.P. – UTILITY POLE
U.S.D.A. – UNITED STATES DEPARTMENT OF AGRICULTURE
VCL – VERTICAL CLEARANCE
V.C.L. – VERTICAL CURVE LENGTH
W – WATER
W.B. – WESTBOUND
WB – WETLAND BUFFER
W.M. – WATER METER
W.S. – WRAPPED STEEL
W.V. – WATER VALVE

CONVENTIONAL SIGNS

PROPOSED MEDIAN BARRIER
ELECTRICAL HAND BOX – SIGNALS — H.B.
FLOW LINE
STATE, COUNTY OR CITY LINES
PROPOSED TRAFFIC BARRIER
EXISTING TRAFFIC BARRIER
EXISTING FENCE LINE — X — X —
RIGHT OF WAY LINE
EXISTING ROADWAY
RAILROAD
BASE OR SURVEY LINE — 3 +50 32
FIRE HYDRANT — F.H.
HISTORIC BOUNDRY
TRAVERSE POINT
EXISTING GROUND CONTOURS (5') — 265
EXISTING GROUND CONTOURS (1') — 264
LIMIT OF DISTURBANCE — LOD
LIMIT OF PLANTING — LOP
TEMPORARY EASEMENT
PERPETUAL EASEMENT
MAILBOX — M.B.
PROPOSED PIPE/CULVERT
EXISTING SANITARY SEWER LINE — – – SAN – –
GROUND ELEVATION — DATUM LINE 173.48
GRADE ELEVATION — DATUM LINE 210.22
EXISTING PIPE/CULVERT
EXISTING DROP INLET
STAGING AND STOCKPILE AREA
RIPRAP

EXISTING 100–YEAR FLOODPLAIN
PROPOSED 100–YEAR FLOODPLAIN
UTILITY POLE
WETLAND
WETLAND BUFFER — B
WATERS OF THE US — WUS
HEDGE /TREE LINE
SIGN
LIGHT POLE
SANITARY — S — 8" SAN — H/C — S — 8" SAN — S
WATER — W — WV — 24"W
GAS
ELECTRIC (UNDERGROUND) — E — J.B.
ELECTRIC (OVERHEAD) — POLE # — OHW — POLE #
TELEPHONE (UNDERGROUND) — T — TMH — T
TELEPHONE (OVERHEAD) — POLE # — T/OH — POLE #
STREAM FLOW ARROWS
EXISTING TREES
PROPOSED BANKFULL CHANNEL
PROPOSED 5 STRAND POST & WIRE ELECTRIC FENCE
PROPOSED GROUND ELEVATION — 100.00
CREATED FLOODPLAIN WETLANDS LIMITS
STABILIZED CONSTRUCTION ENTRANCE — SCE
HAUL ACCESS ROAD
STEEP SLOPES (>25%)
IN–CHANNEL/FLOODPLAIN LOG SILLS
LIVE FASCINES
ROCK CROSS VANE

GENERAL NOTES

1. TO PROTECT AQUATIC SPECIES, IN–STREAM WORK IS PROHIBITED AS DETERMINED BY THE CLASSIFICATION OF THE STREAM: USE I–P. IN–STREAM WORK SHALL NOT BE CONDUCTED DURING THE PERIOD OF MARCH 1 THROUGH JUNE 15, INCLUSIVE, DURING ANY YEAR.
2. WHERE REFERENCE IS MADE TO STANDARD PLATES IT IS TO BE THE CONTRACTOR'S RESPONSIBILITY TO HAVE IN HIS POSSESSION THE LATEST UP TO DATE MSHA STANDARD PLATES AND SHA STANDARD DETAILS FOR CONSTRUCTION AS OF THE DATE OF ADVERTISEMENT FOR THESE PLANS.
3. HORIZONTAL CONTROL: THIS PROJECT IS ORIENTED TO CONFORM TO THE MARYLAND GRID SYSTEM. (NAD 83⁄91)
4. VERTICAL CONTROL: THE LOCATION AND ELEVATION OF BENCHMARKS ARE SHOWN ON THE PLANS. ALL ELEVATIONS ARE IN SURVEY FEET AND ARE BASED ON NAVD 88 DATUM.
5. MATERIALS SALVAGED: MATERIAL SALVAGED DURING CONSTRUCTION TO BECOME THE CONTRACTOR'S PROPERTY UNLESS OTHERWISE NOTED ON THE PLANS OR IN THE SPECIAL PROVISIONS. MATERIALS SUCH AS TREE BRANCHES, TREE TOPS, STUMPS, STREAMBED GRAVEL, ETC. MAY BE UTILIZED IN THE PROPOSED FLOODPLAIN UNDER THE DIRECTION OF DESIGNATED STREAM SPECIALIST OR ENGINEER AS SPECIFIED IN THE CONTRACT SPECIAL PROVISIONS.
6. ALL EXCAVATION HAS BEEN SPECIFIED AS CLASS I ACCORDING TO SECTION 201.04 OF THE STANDARD SPECIFICATIONS FOR CONSTRUCTION AND MATERIALS, JULY 2008. THERE MAY BE A LIMITED AMOUNT OF CLASS 5 EXCAVATION REQUIRED FOR CHANNEL CHANGES. NO SEPERATE COMPENSATION WILL BE PROVIDED FOR CLASS 5 EXCAVATION.
7. CONTRACTOR TO PROVIDE POSITIVE DRAINAGE AT ALL TIMES.
8. UTILITIES: THE LOCATIONS OF UNDERGROUND UTILITIES AND AERIAL UTILITY APPURTENANCES SHOWN ON THE PLANS ARE FOR INFORMATIONAL PURPOSES ONLY. THE CONTRACTOR IS TO VERIFY ALL UTILITY LOCATIONS PRIOR TO GRADING.
9. THE CONTRACTOR WILL NOTIFY THE STATE HIGHWAY ADMINISTRATION, WATER PROGRAMS DIVISION A MINIMUM OF 2 WEEKS PRIOR TO BEGINNING WORK.
10. ALL TOPOGRAPHY IS AVAILABLE IN DIGITAL FORMAT FOR GPS GRADING.

DATUM: NAD 83⁄91 Horizontal
NAVD 88 Vertical

BY: barranger

JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future®

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

CROSS REFERENCE

ITEM	SHEET NOs.
TITLE SHEET	1
ABBREVIATIONS /GENERAL NOTES	2
STREAM RESTORATION GEOMETRY	3–4
STREAM TYPICAL SECTIONS	5
STREAM RESTORATION PROFILES	6–10
KEY MAP	11
STREAM RESTORATION PLANS	12–15
STREAM RESTORATION DETAILS	16–18
ESC NOTES & SEQUENCE OF CONSTRUCTION	19–22
ESC PLANS	23–42
ESC DETAILS	43–44
LANDSCAPING PLANS	45–48
STREAM RESTORATION CROSS SECTIONS	49–52
MOT PLANS	53

R /W PLAT NUMBER

REVISIONS

ABBREVIATIONS /GENERAL NOTES

SCALE N.T.S. ADVERTISED DATE: JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY FAB — COUNTY FREDERICK COUNTY
DRAWN BY FAB/PVC — LOGMILE
CHECKED BY MRG/FAB — HORIZONTAL SCALE N./A
F.A.P. NO. SEE TITLE SHEET — VERTICAL SCALE N./A

DRAWING NO. **GN – 1** OF 1 — SHEET NO. 2 OF 53

PLOTTED: Tuesday, April 25, 2017 AT 07:37 AM
FILE: Q:\SMD\100079_017_Little_Catoctin_Cree\CADD\pGN-N001_LCC.dgn

BASELINE CONTROL COORDINATES LITTLE CATOCTIN CREEK MAIN STEM			
POINT	STATION	NORTH	EAST
P.O.B.	0+00.00	610500.0558	1132990.3899
P.C.	0+73.56	610469.4797	1133057.2977
P.T.	0+84.86	610466.6760	1133068.1815
P.C.	1+25.45	610463.6101	1133108.6584
P.T.	1+31.53	610463.7276	1133114.7252
P.C.	1+67.75	610467.8583	1133150.7037
P.T.	1+97.10	610457.5356	1133176.9395
P.C.	2+22.56	610438.1747	1133193.4724
P.T.	2+52.83	610427.9722	1133220.6296
P.C.	2+97.49	610434.4379	1133264.8180
P.T.	3+04.50	610436.2506	1133271.5740
P.C.	3+32.29	610446.5300	1133297.3861
P.T.	3+60.23	610442.3313	1133323.6713
P.C.	3+82.69	610427.9348	1133340.9103
P.T.	4+12.34	610425.7639	1133368.6215
P.C.	4+45.49	610442.7917	1133397.0652
P.T.	4+58.66	610446.7011	1133409.5195
P.C.	4+96.61	610449.3140	1133447.3813
P.T.	5+22.42	610439.7999	1133470.3974
P.C.	5+47.21	610421.1294	1133486.7050
P.T.	5+66.29	610411.5682	1133502.8404
P.C.	6+09.72	610402.2169	1133545.2528
P.T.	6+38.54	610382.7902	1133564.3675
P.C.	6+80.69	610341.4920	1133572.7745
P.T.	6+90.73	610332.3149	1133576.6716
P.C.	7+41.11	610290.8003	1133605.2153
P.T.	7+59.38	610280.6655	1133619.9363
P.C.	7+88.15	610273.8997	1133647.8984
P.T.	8+20.83	610249.8942	1133666.2445
P.C.	8+52.95	610217.7911	1133665.3363
P.T.	8+59.79	610211.0194	1133666.1130
P.C.	9+11.43	610161.0645	1133679.2250
P.T.	9+46.37	610137.9756	1133703.1233
P.C.	10+02.84	610125.5302	1133758.1978
P.T.	10+23.86	610113.2979	1133774.5348
P.C.	10+47.88	610092.3094	1133786.2099
P.T.	10+74.06	610079.4654	1133807.6602
P.C.	10+97.01	610079.1010	1133830.6032
P.T.	11+22.76	610066.6323	1133851.8406
P.C.	11+37.58	610053.8042	1133859.2691
P.T.	11+67.71	610039.8485	1133884.3482
P.C.	11+91.83	610040.5793	1133908.4503
P.T.	12+22.84	610023.8894	1133932.0409
P.C.	12+52.60	609995.5384	1133941.0919
P.T.	12+66.59	609981.7186	1133941.9112
P.C.	12+99.61	609949.2941	1133935.6555
P.T.	13+23.77	609926.5549	1133941.2391
P.C.	13+52.59	609904.0027	1133959.1856
P.T.	13+78.08	609893.8429	1133981.5390
P.C.	14+22.55	609895.8630	1134025.9655
P.T.	14+29.78	609897.0548	1134033.0803
P.C.	14+70.07	609908.4397	1134071.7271
P.T.	14+86.94	609908.5290	1134088.3728
P.C.	15+24.95	609898.1800	1134124.9460
P.T.	15+40.40	609889.9241	1134137.7425
P.C.	15+76.08	609862.6535	1134160.7407
P.T.	15+92.36	609847.8250	1134166.7930
P.C.	16+25.32	609814.9558	1134169.2438
P.C.	16+53.76	609793.8922	1134185.8315
P.C.	16+89.02	609783.1018	1134219.3929
P.T.	17+13.74	609765.7151	1134235.4173
P.C.	17+47.39	609732.9504	1134243.0743
P.T.	17+82.42	609714.5804	1134269.2840
P.C.	18+30.62	609720.2822	1134317.1398
P.T.	18+61.51	609705.8431	1134342.0650
P.C.	18+99.40	609670.9758	1134356.8930
P.T.	19+15.19	609655.5127	1134358.7614
P.C.	19+60.67	609610.6237	1134351.4434
P.T.	19+93.30	609584.4116	1134366.3867

CURVE DATA - LITTLE CATOCTIN CREEK MAIN STEM						
CURVE NO.	DELTA	Dc	RADIUS (ft.)	TANGENT (ft.)	LENGTH (ft.)	EXTERNAL (ft.)
C1	20°13'42.02"	179°02'57.52"	32	5.708	11.298	0.505
C2	10°52'51.96"	179°02'57.52"	32	3.048	6.077	0.145
C3	56°03'16.35"	190°59'09.35"	30	15.97	29.35	3.986
C4	57°49'46.01"	190°59'09.35"	30	16.571	30.279	4.282
C5	13°23'23.58"	190°59'09.35"	30	3.522	7.011	0.206
C6	61°34'48.09"	220°22'06.18"	26	15.493	27.944	4.266
C7	70°46'20.71"	238°43'56.69"	24	17.047	29.645	5.438
C8	26°57'32.40"	204°37'40.02"	28	6,712	13,175	0.793
C9	52°48'45.12"	204°37'40.02"	28	13.903	25.809	3.262
C10	36°25'51.12"	190°59'09.35"	30	9.872	19.075	1.583
C11	66°03'34.82"	229°10'59.22"	25	16.254	28.824	4.819
C12	23°00'15.52"	229°10'59.22"	25	5.087	10.038	0.512
C13	41°53'13.58"	229°10'59.22"	25	9.568	18.277	1.769
C14	78°01'05.79"	238°43'56.69"	24	19.441	32.68	6.886
C15	16°19'38.74"	238°43'56.69"	24	3,443	6.839	0,246
C16	62°33'34.26"	179°02'57.52"	32	19.441	34.94	5.443
C17	48°10'51.77"	229°10'59.22"	25	11.178	21.023	2.385
C18	60°00'16.47"	229°10'59.22"	25	14.435	26.182	3.868
C19	59°00'56.45"	229°10'59.22"	25	14.149	25.75	3.726
C20	61°39'44.62"	204°37'40.02"	28	16.712	30.134	4.608
C21	74°01'52.35"	238°43'56.69"	24	18.096	31.01	6.057
C22	28°37'31.82"	204°37'40.02"	28	7.144	13.989	0.897
C23	49°25'54.65"	204°37'40.02"	28	12.888	24.157	2.824
C24	54°05'29.67"	212°12'23.73"	27	13.784	25.49	3.315
C25	13°48'39.33"	190°59'09.35"	30	3.633	7.231	0.219
C26	32°12'50.84"	190°59'09.35"	30	8.663	16.867	1.226
C27	34°03'29.86"	220°22'06.18"	26	7.963	15.455	1.192
C28	35°52'39.90"	220°22'06.18"	26	8.417	16.281	1.329
C29	67°54'45.34"	238°43'56.69"	24	16.162	28.447	4.934
C30	59°01'23.70"	238°43'56.69"	24	13.585	24.724	3.578
C31	83°38'27.09"	238°43'56.69"	24	21.474	35.035	8.204
C32	73°45'21.07"	238°43'56.69"	24	18.005	30.895	6.003
C33	32°17'52.18"	204°37'40.02"	28	8.108	15.784	1.150
C34	77°53'34.40"	238°43'56.69"	24	19.398	32.628	6.859

BASELINE CONTROL COORDINATES - TRIBUTARY 1			
POINT	STATION	NORTH	EAST
P.O.B.	100+00.00	610397.7231	1133062.2352
P.C.	100+32.61	610405.7074	1133093.8556
P.T.	100+47.85	610405.6081	1133108.9272
P.C.	100+75.13	610398.5817	1133135.2866
P.T.	101+00.99	610402.8360	1133159.9916
P.C.	101+22.41	610414.9558	1133177.6476
P.T.	101+32.83	610419.2587	1133187.0835
P.O.E.	101+67.49	610427.9722	1133220.6296

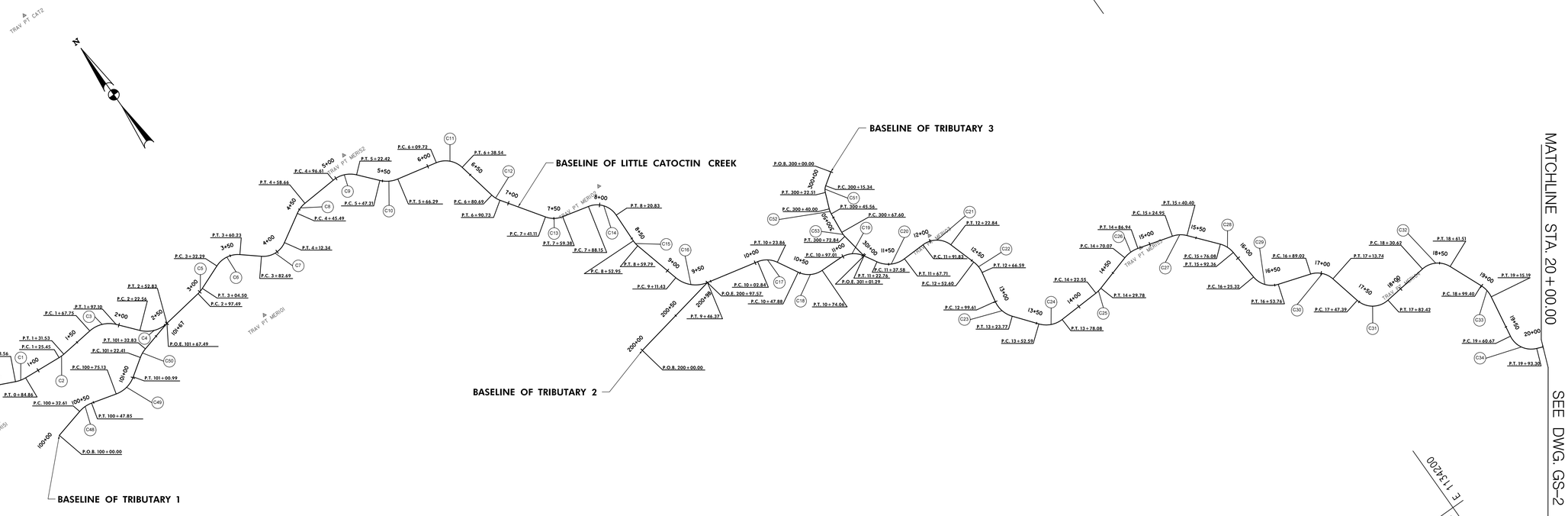
BASELINE CONTROL COORDINATES - TRIBUTARY 2			
POINT	STATION	NORTH	EAST
P.O.B.	200+00.00	610119.6853	1133607.2781
P.O.E.	200+97.57	610137.9756	1133703.1233

BASELINE CONTROL COORDINATES - TRIBUTARY 3			
POINT	STATION	NORTH	EAST
P.O.B.	300+00.00	610157.6386	1133874.1037
P.C.	300+15.34	610149.0225	1133861.4133
P.T.	300+22.51	610143.5136	1133856.9972
P.C.	300+40.00	610127.2461	1133850.5537
P.T.	300+45.56	610121.8600	1133849.2463
P.C.	300+67.60	610099.9298	1133847.0655
P.T.	300+72.84	610094.7111	1133847.2315
P.O.E.	301+01.29	610066.6323	1133851.8406

CURVE DATA - TRIBUTARY 1						
CURVE NO.	DELTA	Dc	RADIUS (ft.)	TANGENT (ft.)	LENGTH (ft.)	EXTERNAL (ft.)
C48	29°05'48.97"	190°59'09.35"	30	7.786	15.235	0.994
C49	49°23'34.69"	190°59'09.35"	30	13.796	25.862	3.02
C50	19°54'23.51"	190°59'09.35"	30	5.265	10.423	0.458

CURVE DATA - TRIBUTARY 3						
CURVE NO.	DELTA	Dc	RADIUS (ft.)	TANGENT (ft.)	LENGTH (ft.)	EXTERNAL (ft.)
C51	34°13'02.08"	477°27'53.39"	12	3.694	7.166	0.556
C52	15°55'46.19"	286°28'44.03"	20	2.798	5.56	0.195
C53	15°00'02.87"	286°28'44.03"	20	2.633	5.236	0.173

SURVEY TRAVERSE CONTROL COORDINATE TABLE			
POINT NO.	NORTH	EAST	ELEVATION
CAT2	610774.317	1133284.295	444.06
MER104	609724.877	1134289.915	409.73
MER100	610347.043	1132851.463	437.93
MER101	610376.493	1133308.095	418.29
MER102	610284.794	1133668.8030	414.36
MER103	610044.602	1133919.275	411.52
MER150	610548.663	1132900.682	419.75
MER151	610445.587	1133017.808	421.22
MER152	610464.095	1133471.181	416.57
MER153	609907.318	1134091.186	411.06



60' 0 60' 120'

SCALE: 1" = 60'

DATUM: NAD 83\91 Horizontal
NAVD 88 Vertical

JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future®

BY: barranger

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

CROSS REFERENCE		R /W PLAT NUMBER	REVISIONS
ITEM	SHEET NOs.		
TITLE SHEET	1		
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STREAM RESTORATION GEOMETRY

SCALE 1" = 60' ADVERTISED DATE: JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY FAB COUNTY FREDERICK COUNTY
DRAWN BY FAB/PVC LOGMILE
CHECKED BY MRG/FAB HORIZONTAL SCALE N/A
F.A.P. NO. SEE TITLE SHEET VERTICAL SCALE N/A

DRAWING NO. GS– 1 OF 2 SHEET NO. 3 OF 53

PLOTTED: Tuesday, April 25, 2017 AT 07:39 AM
FILE: O:\SMD\100079_017_Little_Catoctin_Over\CADD\pGS_P001_LCC.dgn

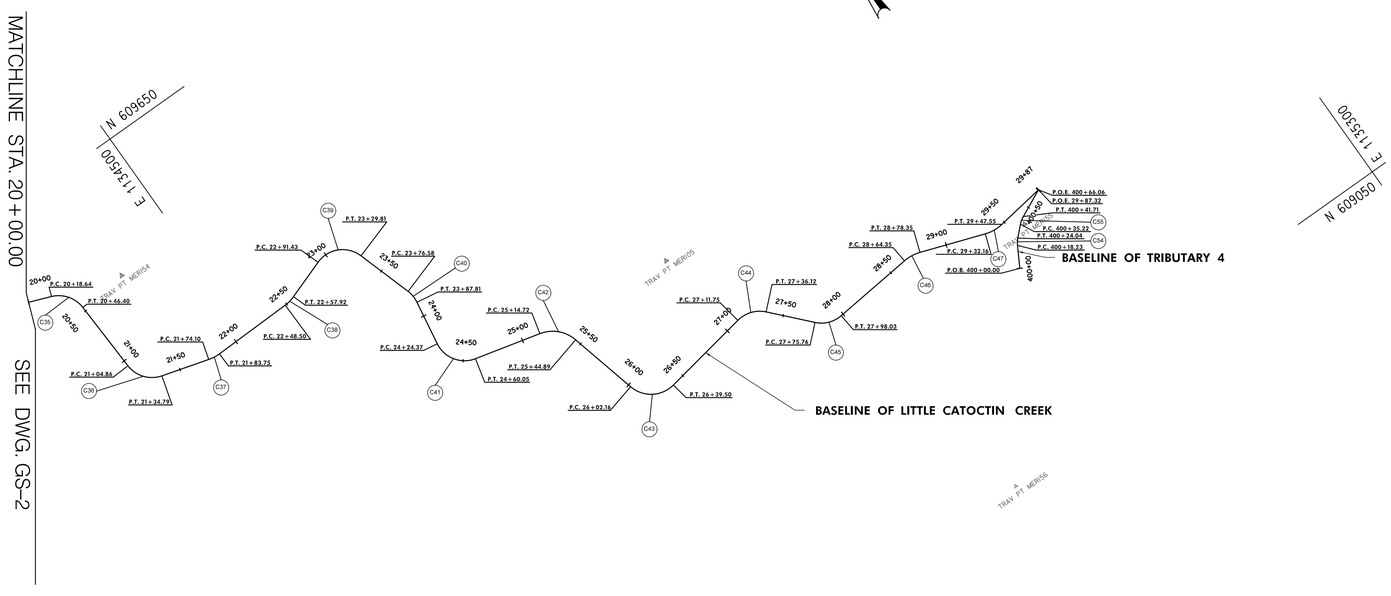
BASELINE CONTROL COORDINATES - LITTLE CATOCTIN CREEK MAIN STEM			
POINT	STATION	NORTH	EAST
P.C.	20+18.64	609575.1768	1134389.9919
P.T.	20+46.40	609553.8189	1134405.2274
P.C.	21+04.86	609495.4112	1134407.6452
P.T.	21+34.79	609473.3519	1134424.9457
P.C.	21+74.10	609462.4136	1134462.6985
P.T.	21+83.75	609461.1556	1134472.2266
P.C.	22+48.50	609462.4159	1134536.9679
P.T.	22+57.92	609464.0630	1134546.2042
P.C.	22+91.43	609475.0306	1134577.8634
P.T.	23+29.81	609459.5573	1134608.6127
P.C.	23+76.58	609414.9472	1134622.6515
P.T.	23+87.81	609403.8501	1134623.4405
P.C.	24+24.37	609367.7727	1134617.5104
P.T.	24+60.05	609340.6077	1134635.3272
P.C.	25+14.72	609327.2470	1134688.3382
P.T.	25+44.89	609306.9244	1134708.6498
P.C.	26+02.16	609251.3815	1134722.6165
P.T.	26+39.50	609232.8345	1134751.0679
P.C.	27+11.75	609244.9909	1134822.2914
P.T.	27+36.12	609237.5822	1134844.4117
P.C.	27+75.76	609208.3116	1134871.1438
P.T.	27+98.03	609200.6103	1134891.2014
P.C.	28+64.35	609207.0649	1134957.2027
P.T.	28+78.35	609205.3829	1134970.9948
P.C.	29+32.16	609187.4295	1135021.7166
P.T.	29+47.55	609185.9122	1135036.8846
P.O.E.	29+87.32	609191.4931	1135076.2616

BASELINE CONTROL COORDINATES - TRIBUTARY 4			
POINT	STATION	NORTH	EAST
P.O.B.	400+00.00	609167.7239	1135038.6931
P.C.	400+14.11	609177.4772	1135048.8839
P.T.	400+20.59	609181.1294	1135054.2067
P.O.E.	400+44.96	609191.4931	1135076.2616

CURVE DATA - LITTLE CATOCTIN CREEK MAIN STEM						
CURVE NO.	DELTA	Dc	RADIUS (ft.)	TANGENT (ft.)	LENGTH (ft.)	EXTERNAL (ft.)
C35	66°15'47.77"	238°43'56.69"	24	15.664	27.756	4.660
C36	71°28'17.15"	238°43'56.69"	24	17.268	29.938	5.567
C37	17°16'24.40"	179°02'57.52"	32	4.861	9.647	0.367
C38	17°59'31.61"	190°59'09.35"	30	4.749	9.421	0.374
C39	91°38'18.96"	238°43'56.69"	24	24.696	38.385	10.437
C40	26°48'11.34"	238°43'56.69"	24	5.718	11.227	0.672
C41	85°11'18.10"	238°43'56.69"	24	22.065	35.684	8.601
C42	61°44'20.93"	204°37'40.02"	28	16.737	30.171	4.621
C43	85°34'15.84"	229°10'59.22"	25	23.139	37.337	9.065
C44	58°09'22.36"	238°43'56.69"	24	13.346	24.36	3.461
C45	53°10'50.86"	238°43'56.69"	24	12.013	22.276	2.839
C46	25°04'38.20"	179°02'57.52"	32	7.117	14.006	0.782
C47	27°33'30.65"	179°02'57.52"	32	7.848	15.392	0.948

CURVE DATA - TRIBUTARY 4						
CURVE NO.	DELTA	Dc	RADIUS (ft.)	TANGENT (ft.)	LENGTH (ft.)	EXTERNAL (ft.)
C54	16°38'30.09"	286°28'44.03"	20	2.925	5.809	0.213
C55	18°34'26.89"	286°28'44.03"	20	3.270	6.484	0.266

SURVEY TRAVERSE CONTROL COORDINATE TABLE			
POINT NO.	NORTH	EAST	ELEVATION
MER105	609316.325	1134803.285	405.65
MER154	609556.598	1134444.970	408.39
MER155	609175.529	1135051.562	402.23
MER156	609010.465	1134925.696	408.30



60' 0 60' 120'

SCALE: 1" = 60'

DATUM: NAD 8391 Horizontal
NAVD 88 Vertical

JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future®

BY: barranger

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STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

STREAM RESTORATION GEOMETRY

SCALE 1" = 60' ADVERTISED DATE: JUNE 2017 CONTRACT NO. FR5975182

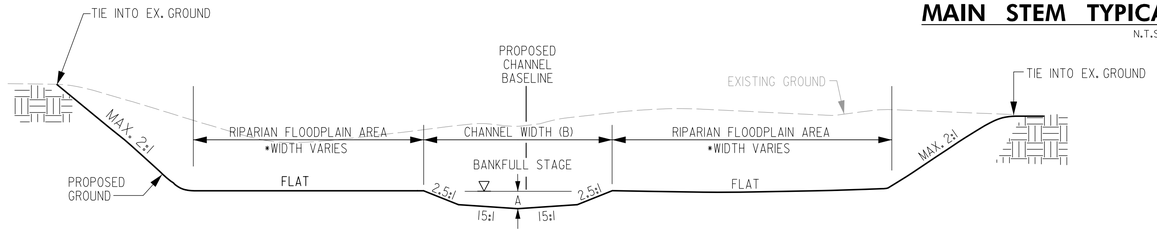
DESIGNED BY FAB COUNTY FREDERICK COUNTY
DRAWN BY FAB/PVC LOGMILE
CHECKED BY MRG/FAB HORIZONTAL SCALE N/A
F.A.P. NO. SEE TITLE SHEET VERTICAL SCALE N/A

DRAWING NO. GS-2 OF 2 SHEET NO. 4 OF 53

PLOTTED: Tuesday, April 25, 2017 AT 07:40 AM
FILE: O:\SMD\120079_017_Little_Catoctin_Cree\CADD\pGS_P002_LCC.dgn

MAIN STEM TYPICAL CROSS SECTIONS

N.T.S.



RIFFLE SECTION

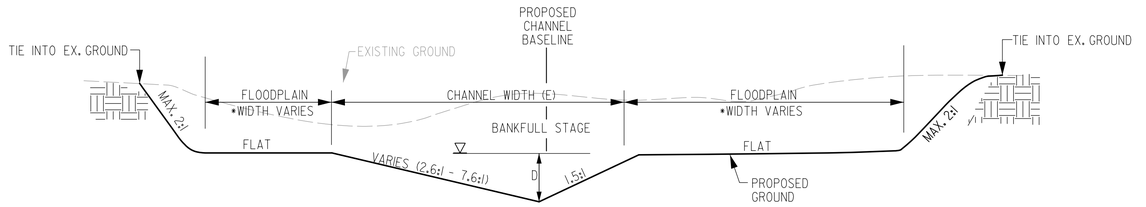
N.T.S.

STA. 0+84.86 TO STA. 10+23.86 (REACH 1)
STA. 10+23.86 TO STA. 25+44.89 (REACH 2)
STA. 25+44.89 TO STA. 29+87.32 (REACH 3)

RIFFLE DIMENSION TABLE		
BANKFULL DEPTH (A)	CHANNEL WIDTH (B)	REACH
0.65' - 0.90'	8'	1
0.52' - 0.90'	8'	2
0.55' - 0.90'	8'	3

NOTES:

1. SEE THE LONGITUDINAL PROFILES FOR LOCATIONS OF RIFFLE AND POOL SECTIONS.
2. POOL CROSS-SECTION REPRESENTS THE MAXIMUM POOL CONDITION. POOL CROSS-SECTION WILL NEED TO TRANSITION INTO RIFFLE CROSS-SECTION, AS SHOWN ON PROFILE.
3. THE FLOODPLAIN AREAS SHOWN AS FLAT ON THE TYPICAL SECTIONS, WILL ACTUALLY CONTAINED VARIED MICROTOPOGRAPHY TO BE CREATED DURING CONSTRUCTION UNDER THE GUIDANCE OF THE DESIGNATED SPECIALIST.



RIGHT POOL SECTION

N.T.S.

STA. 0+84.86 TO STA. 10+23.86 (REACH 1)
STA. 10+23.86 TO STA. 25+44.89 (REACH 2)
STA. 25+44.89 TO STA. 29+87.32 (REACH 3)

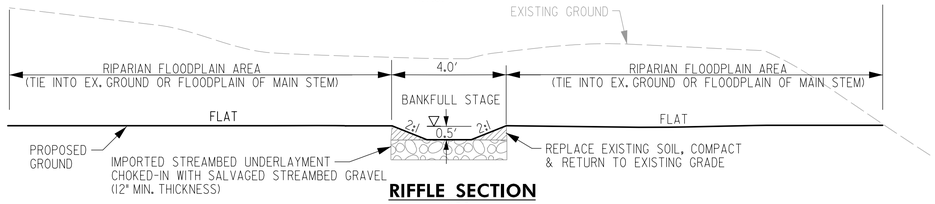
POOL DIMENSION TABLE		
BANKFULL DEPTH (D)	CHANNEL WIDTH (E)	REACH
1.5' - 3.3'	10.4' - 13.6'	1
1.5' - 3.3'	10.4' - 13.6'	2
1.5' - 3.3'	10.4' - 13.6'	3

NOTE:

1. LEFT POOL SECTION IS MIRROR IMAGE OF RIGHT POOL SHOWN.
2. SEE PLANS FOR POOL WIDTHS.

TRIBUTARIES TYPICAL CROSS SECTIONS

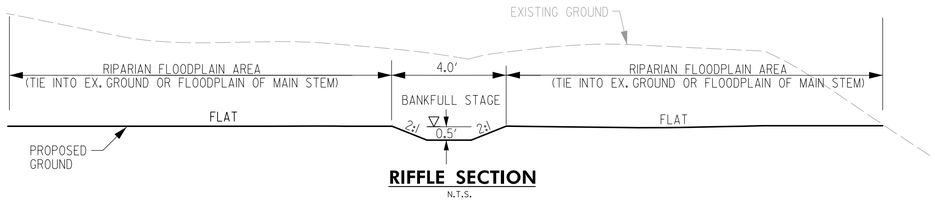
N.T.S.



RIFFLE SECTION

N.T.S.

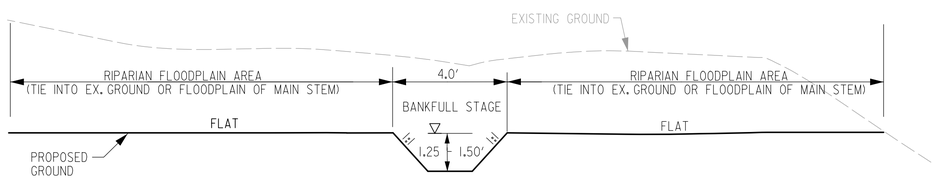
STA. 100+00.00 TO STA. 100+32.61 (TRIBUTARY 1)
STA. 200+00.00 TO STA. 200+89.20 (TRIBUTARY 2)
STA. 400+00.00 TO STA. 400+23.55 (TRIBUTARY 4)



RIFFLE SECTION

N.T.S.

STA. 100+32.61 TO STA. 101+22.41 (TRIBUTARY 1)
STA. 300+00.00 TO STA. 301+01.29 (TRIBUTARY 3)



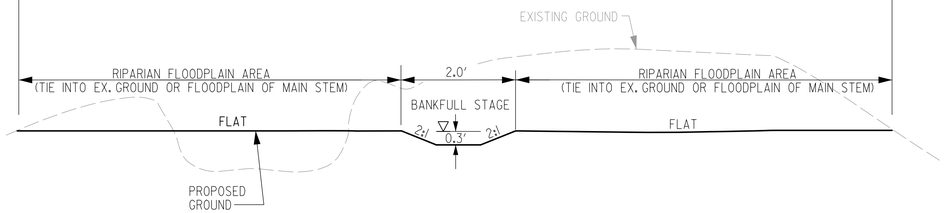
POOL SECTION

N.T.S.

STA. 100+32.61 TO STA. 101+22.41 (TRIBUTARY 1)
STA. 300+00.00 TO STA. 301+01.29 (TRIBUTARY 3)

OXBOW PILOT CHANNELS TYPICAL CROSS SECTION

N.T.S.



NOTE:

1. TYPICAL SECTION APPLIES TO ALL OXBOW PILOT CHANNELS.

DATUM: NAD 8391 Horizontal
NAVD 88 Vertical

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future®

BY: barranger

CROSS REFERENCE

ITEM	SHEET NOs.
TITLE SHEET	1
ABBREVIATIONS /GENERAL NOTES	2
STREAM RESTORATION GEOMETRY	3-4
STREAM TYPICAL SECTIONS	5
STREAM RESTORATION PROFILES	6-10
KEY MAP	11
STREAM RESTORATION PLANS	12-15
STREAM RESTORATION DETAILS	16-18
ESC NOTES & SEQUENCE OF CONSTRUCTION	19-22
ESC PLANS	23-42
ESC DETAILS	43-44
LANDSCAPING PLANS	45-48
STREAM RESTORATION CROSS SECTIONS	49-52
MOT PLANS	53

R /W PLAT NUMBER

REVISIONS

STREAM TYPICAL SECTIONS

SCALE N.T.S. ADVERTISED DATE: JUNE 2017 CONTRACT NO. FR5975182

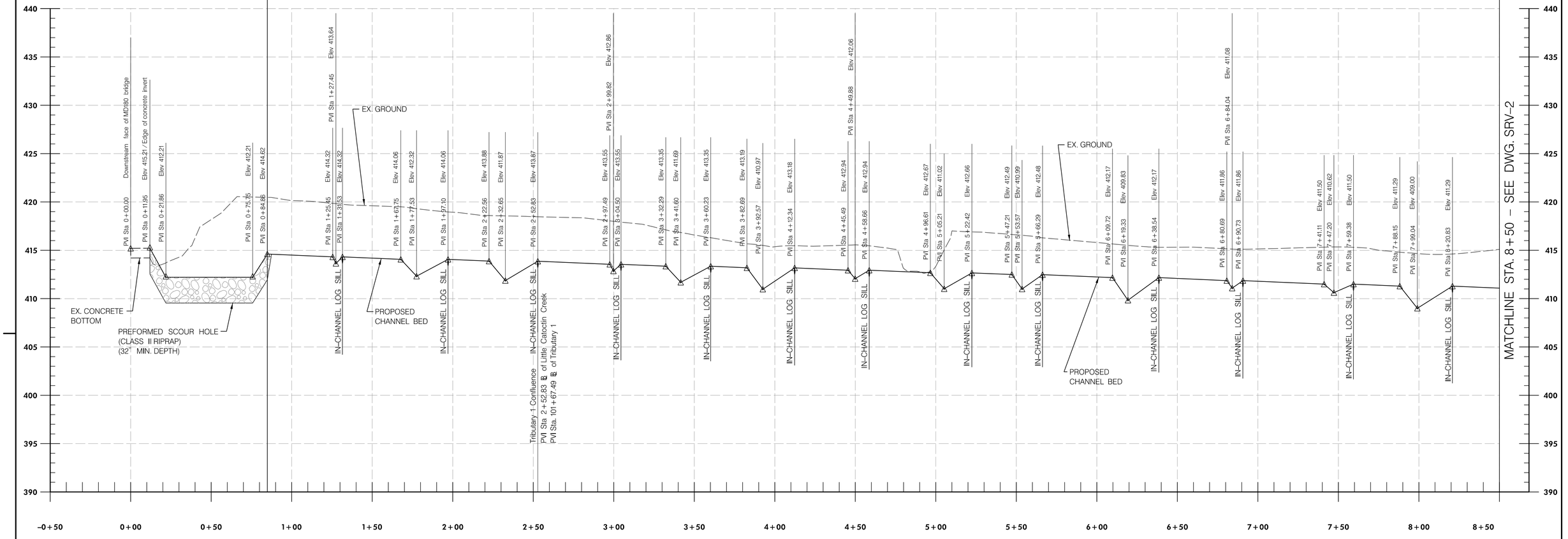
DESIGNED BY FAB
DRAWN BY FAB/PVC
CHECKED BY MRG/FAB
F.A.P. NO. SEE TITLE SHEET

COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. TS - 1 OF 1

SHEET NO. 5 OF 53

PLOTTED: Tuesday, April 25, 2017 AT 07:42 AM
FILE: G:\SMD\120079_017_Little_Catoctin_Cree\CADD\pTS_P001_LCC.dgn



BASELINE OF LITTLE CATOCTIN CREEK LONGITUDINAL PROFILE
SCALE: HOR. 1″ = 30′
VERT. 1″ = 5′

DATUM: NAD 83⁄91 Horizontal
NAVD 88 Vertical

BY: barranger

JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future®

CROSS REFERENCE		R /W PLAT NUMBER	REVISIONS

ITEM	SHEET NOs.
TITLE SHEET	1
ABBREVIATIONS /GENERAL NOTES	2
STREAM RESTORATION GEOMETRY	3–4
STREAM TYPICAL SECTIONS	5
STREAM RESTORATION PROFILES	6–10
KEY MAP	11
STREAM RESTORATION PLANS	12–15
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MOT PLANS	53

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

STREAM RESTORATION PROFILE

SCALE 1" = 30' ADVERTISED DATE: JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY FAB COUNTY FREDERICK COUNTY
DRAWN BY FAB/PVC LOGMILE
CHECKED BY MRG/FAB HORIZONTAL SCALE N/A
F.A.P. NO. SEE TITLE SHEET VERTICAL SCALE N/A

DRAWING NO. SRV–1 OF 5 SHEET NO. 6 OF 53

PLOTTED: Tuesday, April 25, 2017 AT 07:43 AM
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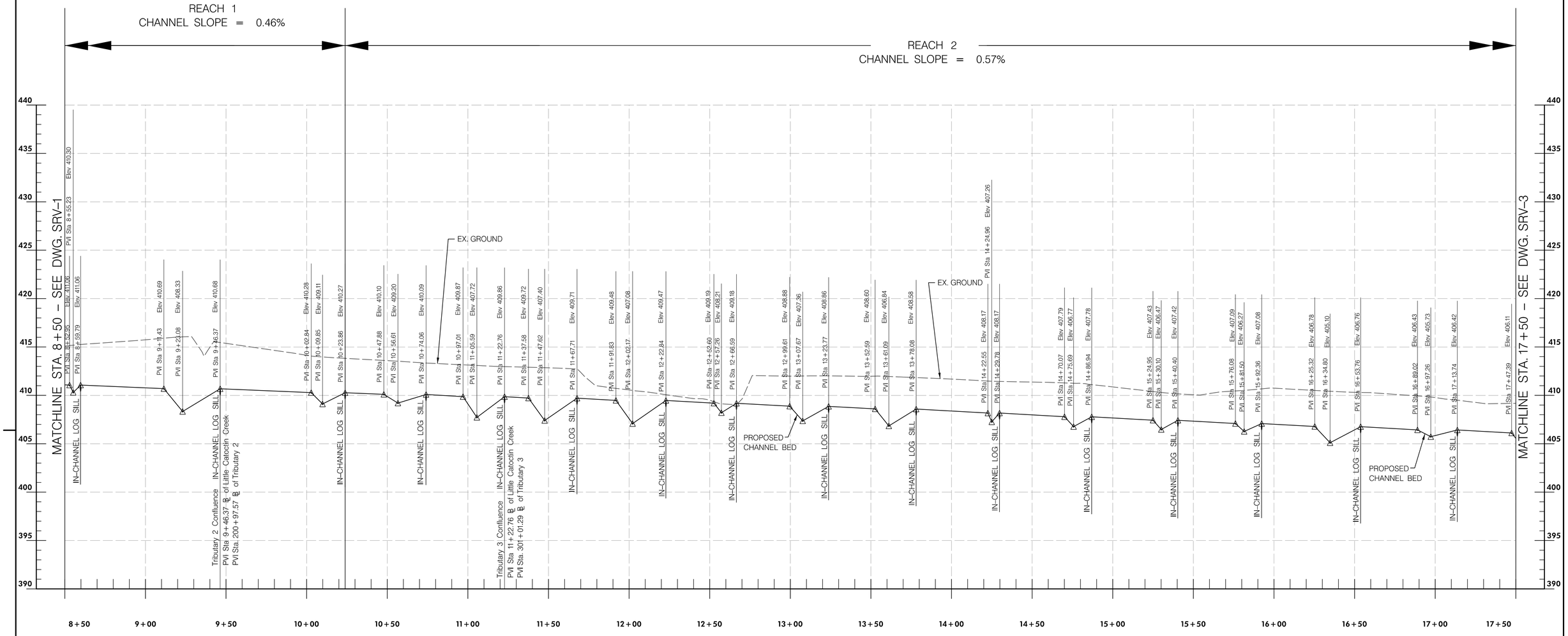

BASELINE OF LITTLE CATOCTIN CREEK LONGITUDINAL PROFILE
SCALE: HOR. 1″ = 30′
VERT. 1″ = 5′

DATUM: NAD 83\91 Horizontal
NAVD 88 Vertical

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future®

BY: barranger

CROSS REFERENCE

ITEM	SHEET NOs.
TITLE SHEET	1
ABBREVIATIONS /GENERAL NOTES	2
STREAM RESTORATION GEOMETRY	3–4
STREAM TYPICAL SECTIONS	5
STREAM RESTORATION PROFILES	6–10
KEY MAP	11
STREAM RESTORATION PLANS	12–15
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ESC NOTES & SEQUENCE OF CONSTRUCTION	19–22
ESC PLANS	23–42
ESC DETAILS	43–44
LANDSCAPING PLANS	45–48
STREAM RESTORATION CROSS SECTIONS	49–52
MOT PLANS	53

R /W PLAT NUMBER

REVISIONS

STREAM RESTORATION PROFILE

SCALE 1″=30′ ADVERTISED DATE: JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY FAB
DRAWN BY FAB/PVC
CHECKED BY MRG/FAB
F.A.P. NO. SEE TITLE SHEET

COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. SRV– 2 OF 5 SHEET NO. 7 OF 53

PLOTTED: Tuesday, April 25, 2017 AT 07:44 AM
FILE: O:\SMD\120079_017_Little_Catoctin_Cree\CADD\pSR_V002_LCC.dgn

REACH 2
CHANNEL SLOPE = 0.57%

REACH 3
CHANNEL SLOPE = 0.67%

MATCHLINE STA. 17+50 – SEE DWG. SRV–2

MATCHLINE STA. 26+50 – SEE DWG. SRV–4

EX. GROUND

EX. GROUND

PROPOSED CHANNEL BED

IN–CHANNEL LOG SILL

PVI Sta. 17+59.07 Elev. 403.62
PVI Sta. 17+82.42 Elev. 406.09
PVI Sta. 18+30.62 Elev. 405.64
PVI Sta. 18+40.92 Elev. 403.30
PVI Sta. 18+61.51 Elev. 405.63
PVI Sta. 18+99.40 Elev. 405.28
PVI Sta. 19+04.66 Elev. 404.05
PVI Sta. 19+15.19 Elev. 405.27
PVI Sta. 19+60.67 Elev. 404.95
PVI Sta. 19+71.55 Elev. 402.76
PVI Sta. 19+93.30 Elev. 405.00
PVI Sta. 20+18.64 Elev. 404.68
PVI Sta. 20+27.89 Elev. 402.60
PVI Sta. 20+46.40 Elev. 404.67
PVI Sta. 21+04.86 Elev. 404.29
PVI Sta. 21+14.84 Elev. 401.94
PVI Sta. 21+34.79 Elev. 404.28
PVI Sta. 21+74.10 Elev. 403.96
PVI Sta. 21+77.32 Elev. 402.99
PVI Sta. 21+83.75 Elev. 403.95
PVI Sta. 22+46.50 Elev. 403.51
PVI Sta. 22+51.64 Elev. 402.32
PVI Sta. 22+57.92 Elev. 403.50
PVI Sta. 22+91.43 Elev. 403.23
PVI Sta. 23+04.23 Elev. 400.54
PVI Sta. 23+23.81 Elev. 403.22
PVI Sta. 23+76.58 Elev. 402.85
PVI Sta. 23+80.32 Elev. 401.79
PVI Sta. 23+87.81 Elev. 402.84
PVI Sta. 24+24.37 Elev. 402.56
PVI Sta. 24+38.26 Elev. 399.86
PVI Sta. 24+60.05 Elev. 402.55
PVI Sta. 25+14.72 Elev. 401.91
PVI Sta. 25+24.78 Elev. 399.50
PVI Sta. 25+44.89 Elev. 401.90
PVI Sta. 26+02.16 Elev. 401.56
PVI Sta. 26+14.60 Elev. 400.33
PVI Sta. 26+39.50 Elev. 401.55

440 435 430 425 420 415 410 405 400 395 390

17+50 18+00 18+50 19+00 19+50 20+00 20+50 21+00 21+50 22+00 22+50 23+00 23+50 24+00 24+50 25+00 25+50 26+00 26+50

BASELINE OF LITTLE CATOCTIN CREEK LONGITUDINAL PROFILE
SCALE: HOR. 1″ = 30′
VERT. 1″ = 5′

DATUM: NAD 83⁄91 Horizontal
NAVD 88 Vertical

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future®

BY: barranger

CROSS REFERENCE

ITEM	SHEET NOs.
TITLE SHEET	1
ABBREVIATIONS /GENERAL NOTES	2
STREAM RESTORATION GEOMETRY	3–4
STREAM TYPICAL SECTIONS	5
STREAM RESTORATION PROFILES	6–10
KEY MAP	11
STREAM RESTORATION PLANS	12–15
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ESC DETAILS	43–44
LANDSCAPING PLANS	45–48
STREAM RESTORATION CROSS SECTIONS	49–52
MOT PLANS	53

R /W PLAT NUMBER

REVISIONS

STREAM RESTORATION PROFILE

SCALE 1″=30′ ADVERTISED DATE: JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY FAB
DRAWN BY FAB/PVC
CHECKED BY MRG/FAB
F.A.P. NO. SEE TITLE SHEET

COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. **SRV– 3** OF **5** SHEET NO. 8 OF 53

PLOTTED: Tuesday, April 25, 2017 AT 07:55 AM
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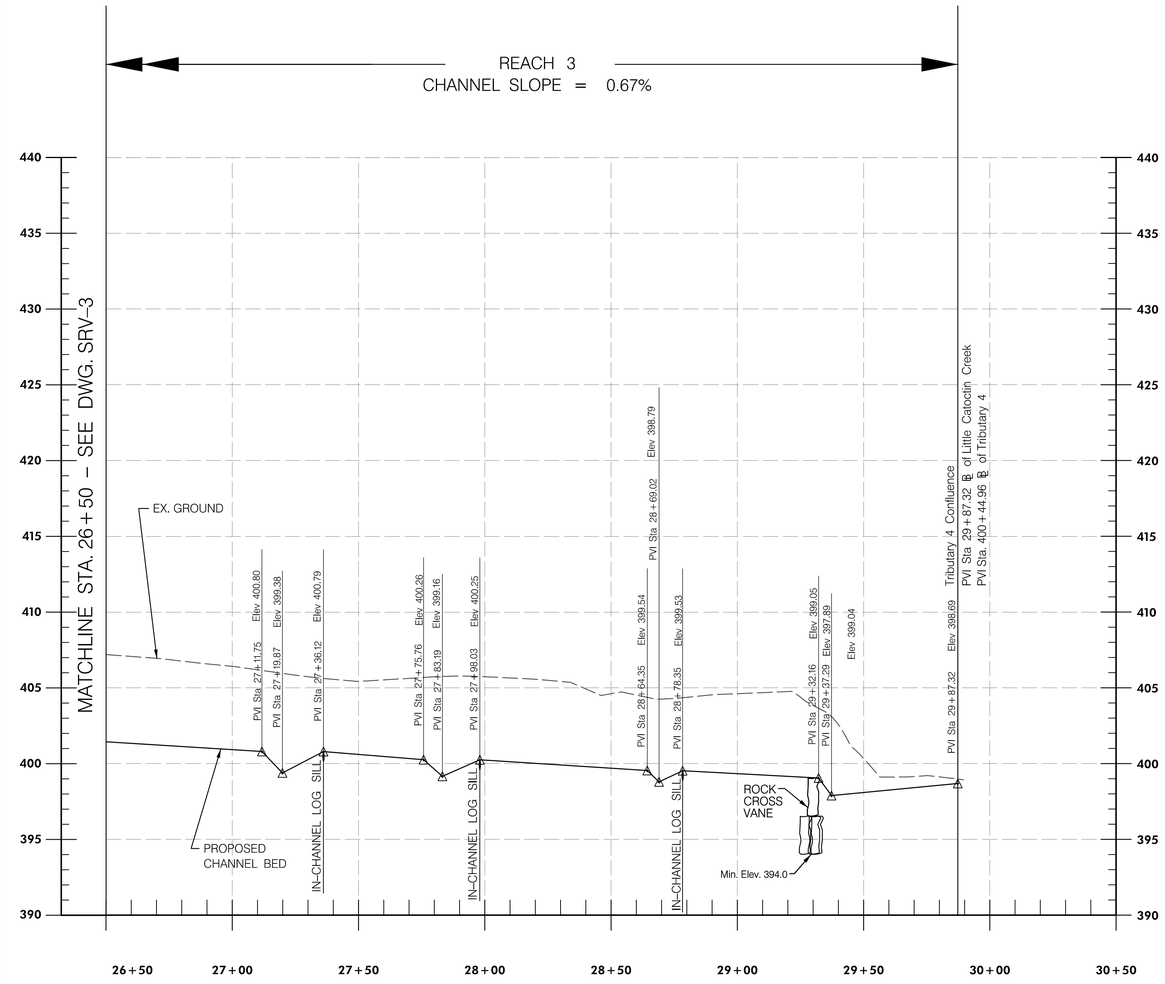


BASELINE OF LITTLE CATOCTIN CREEK LONGITUDINAL PROFILE
SCALE: HOR. 1″ = 30′
VERT. 1″ = 5′

DATUM: NAD 83⁄91 Horizontal
NAVD 88 Vertical

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future®

BY: barranger

CROSS REFERENCE

ITEM	SHEET NOs.
TITLE SHEET	1
ABBREVIATIONS /GENERAL NOTES	2
STREAM RESTORATION GEOMETRY	3–4
STREAM TYPICAL SECTIONS	5
STREAM RESTORATION PROFILES	6–10
KEY MAP	11
STREAM RESTORATION PLANS	12–15
STREAM RESTORATION DETAILS	16–18
ESC NOTES & SEQUENCE OF CONSTRUCTION	19–22
ESC PLANS	23–42
ESC DETAILS	43–44
LANDSCAPING PLANS	45–48
STREAM RESTORATION CROSS SECTIONS	49–52
MOT PLANS	53

R /W PLAT NUMBER

REVISIONS

STREAM RESTORATION PROFILE

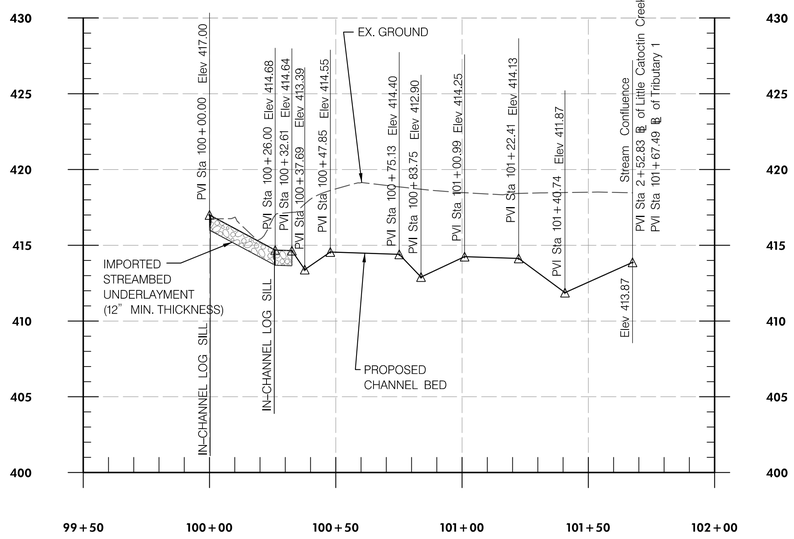
SCALE 1″ = 30′ ADVERTISED DATE: JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY FAB
DRAWN BY FAB⁄PVC
CHECKED BY MRG⁄FAB
F.A.P. NO. SEE TITLE SHEET

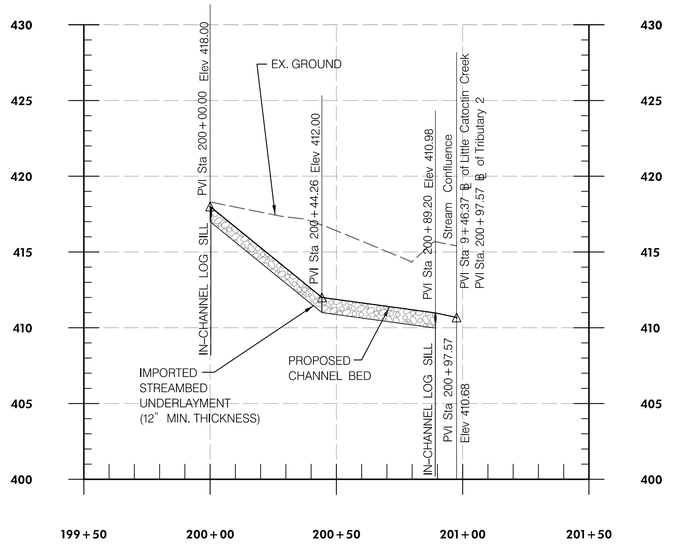
COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N /A
VERTICAL SCALE N /A

DRAWING NO. SRV– 4 OF 5 SHEET NO. 9 OF 53

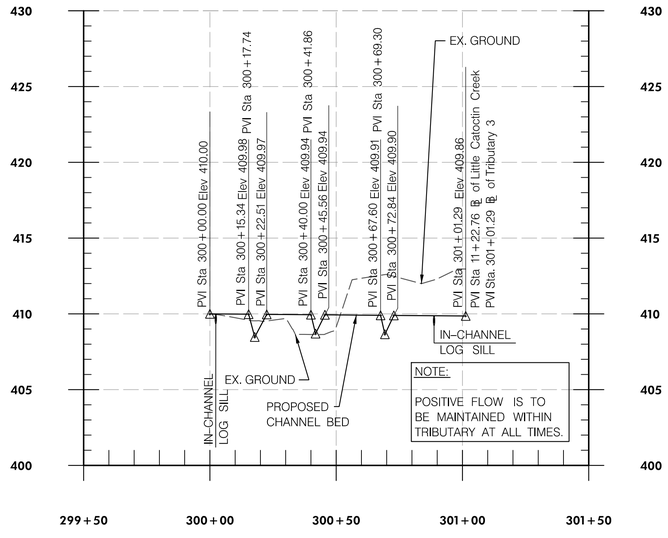
PLOTTED: Tuesday, April 25, 2017 AT 08:02 AM
FILE: G:\SMD\120079_017_Little_Catoctin_Creek\CADD\pSR_V004_LCC.dgn



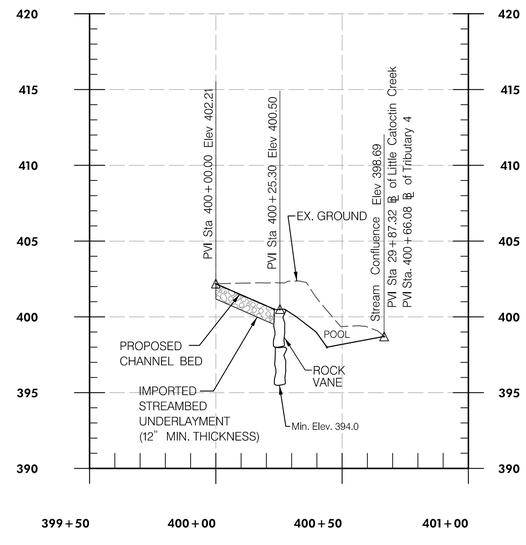
BASELINE OF UNNAMED TRIBUTARY NO. 1 LONGITUDINAL PROFILE
SCALE: HOR. 1" = 30'
VERT. 1" = 5'



BASELINE OF UNNAMED TRIBUTARY NO. 2 LONGITUDINAL PROFILE
SCALE: HOR. 1" = 30'
VERT. 1" = 5'



BASELINE OF UNNAMED TRIBUTARY NO. 3 LONGITUDINAL PROFILE
SCALE: HOR. 1" = 30'
VERT. 1" = 5'



BASELINE OF UNNAMED TRIBUTARY NO. 4 LONGITUDINAL PROFILE
SCALE: HOR. 1" = 30'
VERT. 1" = 5'

DATUM: NAD 83\91 Horizontal
NAVD 88 Vertical

BY: barranger

JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future®

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

CROSS REFERENCE

ITEM	SHEET NOs.
TITLE SHEET	1
ABBREVIATIONS /GENERAL NOTES	2
STREAM RESTORATION GEOMETRY	3–4
STREAM TYPICAL SECTIONS	5
STREAM RESTORATION PROFILES	6–10
KEY MAP	11
STREAM RESTORATION PLANS	12–15
STREAM RESTORATION DETAILS	16–18
ESC NOTES & SEQUENCE OF CONSTRUCTION	19–22
ESC PLANS	23–42
ESC DETAILS	43–44
LANDSCAPING PLANS	45–48
STREAM RESTORATION CROSS SECTIONS	49–52
MOT PLANS	53

R /W PLAT NUMBER

REVISIONS

STREAM RESTORATION PROFILE

SCALE 1"=30' ADVERTISED DATE: JUNE 2017 CONTRACT NO. FR5975182

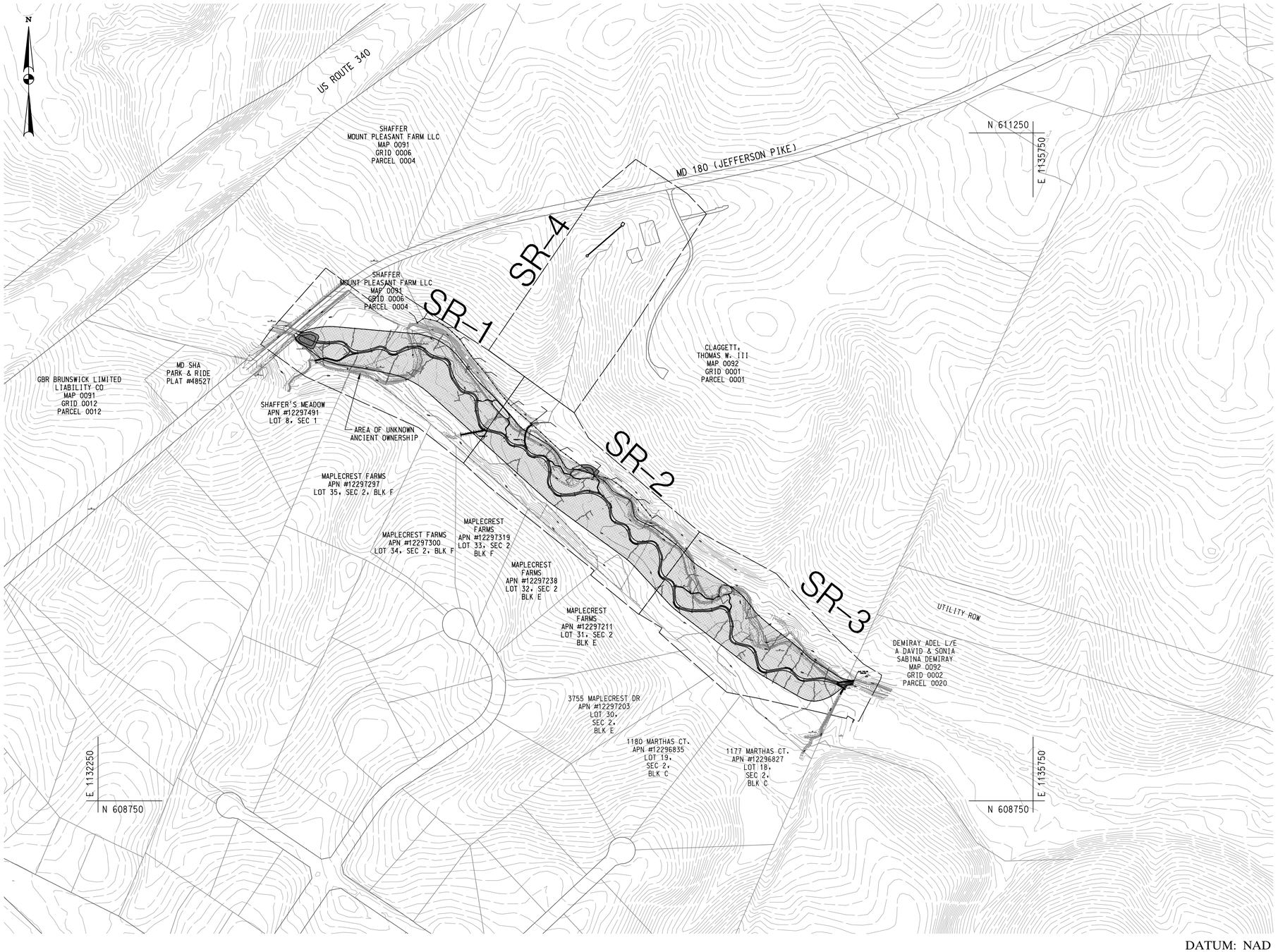
DESIGNED BY FAB
DRAWN BY FAB/PVC
CHECKED BY MRG/FAB
F.A.P. NO. SEE TITLE SHEET

COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. SRV– 5 OF 5

SHEET NO. 10 OF 53

PLOTTED: Tuesday, April 25, 2017 AT 08:13 AM
FILE: O:\SMD\190079_017_Little_Catoctin_Creek\CADD\pSR_V005_LCC.dgn



DATUM: NAD 83\91 Horizontal
NAVD 88 Vertical

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future®

200' 0 200' 400'
SCALE: 1" = 200'

BY: barranger

CROSS REFERENCE	
ITEM	SHEET NOs.
TITLE SHEET	1
ABBREVIATIONS /GENERAL NOTES	2
STREAM RESTORATION GEOMETRY	3–4
STREAM TYPICAL SECTIONS	5
STREAM RESTORATION PROFILES	6–10
KEY MAP	11
STREAM RESTORATION PLANS	12–15
STREAM RESTORATION DETAILS	16–18
ESC NOTES & SEQUENCE OF CONSTRUCTION	19–22
ESC PLANS	23–42
ESC DETAILS	43–44
LANDSCAPING PLANS	45–48
STREAM RESTORATION CROSS SECTIONS	49–52
MOT PLANS	53

R /W PLAT NUMBER

REVISIONS

KEY MAP

SCALE 1" = 200' ADVERTISED DATE: JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY FAB
DRAWN BY FAB/PVC
CHECKED BY MRG/FAB
F.A.P. NO. SEE TITLE SHEET

COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. KM – 1 OF 1

SHEET NO. 11 OF 53

PLOTTED: Tuesday, April 25, 2017 AT 08:16 AM
FILE: C:\SMD\120079_017_Little_Catoctin_Creek\CADD\pKM_P001_LCC.dgn

* FLOODPLAIN LOG SILL

STATION	BASELINE	OFFSET	LENGTH (FT)	STATION	BASELINE	OFFSET	LENGTH (FT)
1+00.79	LITTLE CATOCTIN CREEK	25.92', RT.	20	5+60.15	LITTLE CATOCTIN CREEK	17.25', RT.	20
1+01.46	LITTLE CATOCTIN CREEK	14.92, RT.	20	5+84.94	LITTLE CATOCTIN CREEK	42.02', LT.	37
1+08.91	LITTLE CATOCTIN CREEK	29.45', RT.	47	6+65.21	LITTLE CATOCTIN CREEK	61.38', LT.	36
1+22.82	LITTLE CATOCTIN CREEK	12.74', RT.	23	6+69.55	LITTLE CATOCTIN CREEK	72.24', LT.	20
1+95.55	LITTLE CATOCTIN CREEK	40.09', LT.	72	7+50.43	LITTLE CATOCTIN CREEK	21.90', RT.	38
2+14.56	LITTLE CATOCTIN CREEK	14.88', RT.	20	7+51.98	LITTLE CATOCTIN CREEK	40.87', RT.	20
2+22.69	LITTLE CATOCTIN CREEK	22.53', RT.	20	7+53.70	LITTLE CATOCTIN CREEK	14.19', RT.	20
3+53.38	LITTLE CATOCTIN CREEK	40.11', LT.	67	8+20.81	LITTLE CATOCTIN CREEK	63.13', LT.	28
3+96.43	LITTLE CATOCTIN CREEK	60.57', RT.	117	8+21.46	LITTLE CATOCTIN CREEK	6.48', LT.	16
4+15.37	LITTLE CATOCTIN CREEK	94.64', RT.	36	9+71.87	LITTLE CATOCTIN CREEK	67.28', LT.	20
4+88.56	LITTLE CATOCTIN CREEK	14.40', LT.	48	100+22.84	TRIBUTARY #1	9.03', RT.	20
5+36.48	LITTLE CATOCTIN CREEK	58.52', LT.	73	100+27.73	TRIBUTARY #1	18.93', RT.	20
5+50.23	LITTLE CATOCTIN CRREK	90.21', RT.	20	101+14.69	TRIBUTARY #1	46.83', RT.	28
5+52.07	LITTLE CATOCTIN CREEK	74.34', RT.	32	101+53.14	TRIBUTARY #1	27.09', RT.	38
5+55.56	LITTLE CATOCTIN CREEK	49.92', RT.	54				

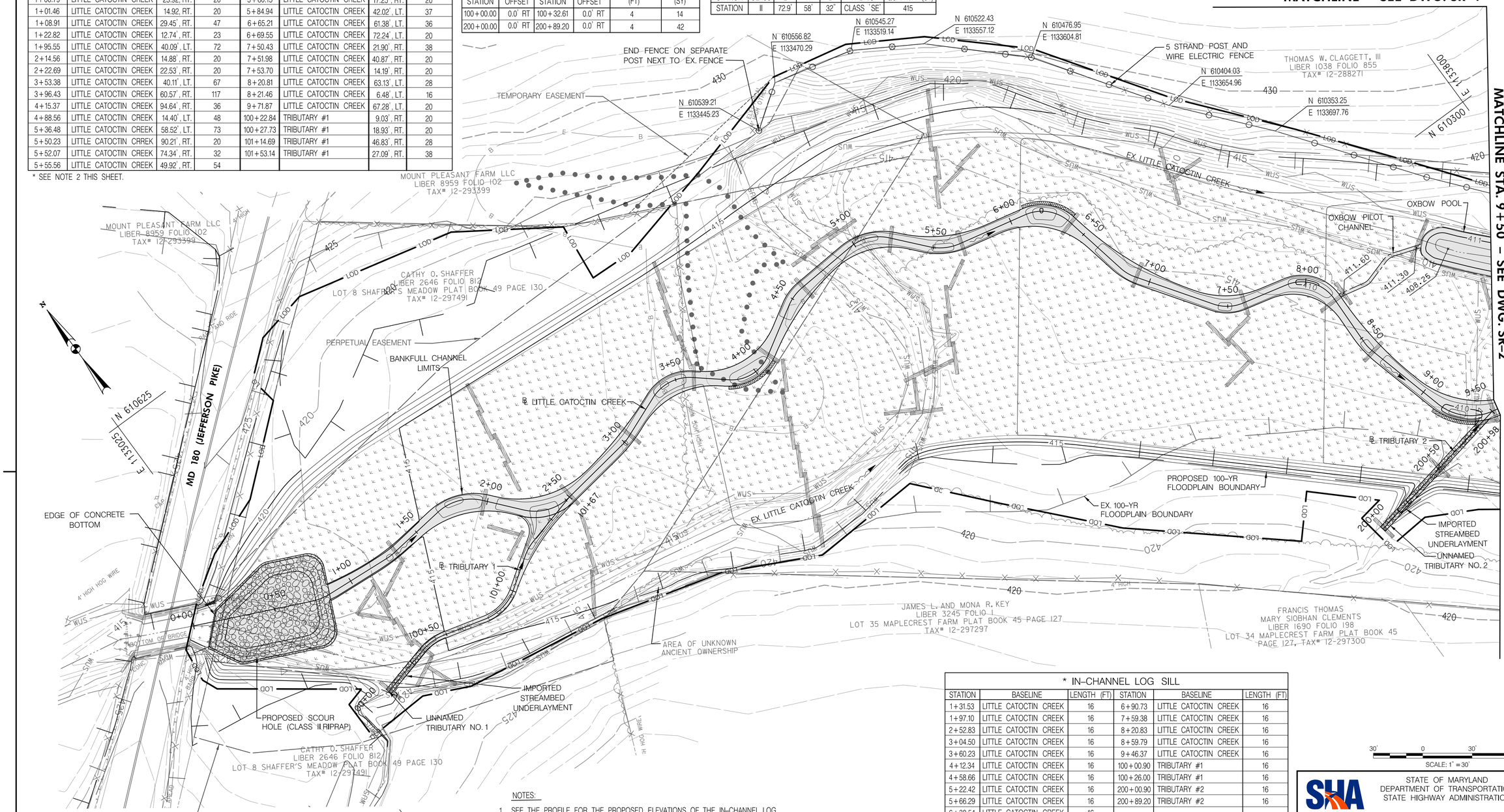
* SEE NOTE 2 THIS SHEET.

IMPORTED STREAMBED UNDERLAYMENT

FROM STATION	FROM OFFSET	TO STATION	TO OFFSET	AVG. WIDTH (FT)	QUANTITY (SY)
100+00.00	0.0' RT	100+32.61	0.0' RT	4	14
200+00.00	0.0' RT	200+89.20	0.0' RT	4	42

RIPRAP OUTFALL PROTECTION / SCOUR HOLE SCHEDULE

STATION	CLASS	L	W	D	FABRIC	QUANTITY (SY)
STATION	II	72.9'	58'	32'	CLASS 'SE'	415



* IN-CHANNEL LOG SILL

STATION	BASELINE	LENGTH (FT)	STATION	BASELINE	LENGTH (FT)
1+31.53	LITTLE CATOCTIN CREEK	16	6+90.73	LITTLE CATOCTIN CREEK	16
1+97.10	LITTLE CATOCTIN CREEK	16	7+59.38	LITTLE CATOCTIN CREEK	16
2+52.83	LITTLE CATOCTIN CREEK	16	8+20.83	LITTLE CATOCTIN CREEK	16
3+04.50	LITTLE CATOCTIN CREEK	16	8+59.79	LITTLE CATOCTIN CREEK	16
3+60.23	LITTLE CATOCTIN CREEK	16	9+46.37	LITTLE CATOCTIN CREEK	16
4+12.34	LITTLE CATOCTIN CREEK	16	100+00.90	TRIBUTARY #1	16
4+58.66	LITTLE CATOCTIN CREEK	16	100+26.00	TRIBUTARY #1	16
5+22.42	LITTLE CATOCTIN CREEK	16	200+00.90	TRIBUTARY #2	16
5+66.29	LITTLE CATOCTIN CREEK	16	200+89.20	TRIBUTARY #2	16
6+38.54	LITTLE CATOCTIN CREEK	16			

* SEE NOTE 5 THIS SHEET.

LIVE FASCINES

FROM	TO	LENGTH (FT)
3+82.83, RT.	4+11.15, RT.	35
6+09.80, LT.	6+38.14, LT.	35
9+11.24, RT.	9+35.46, RT.	28

5 STAND POST AND WIRE ELECTRIC FENCE

LENGTH (FT.) (THIS SHEET)
480

NOTES:

1. SEE THE PROFILE FOR THE PROPOSED ELEVATIONS OF THE IN-CHANNEL LOG SILLS. ALL IN-CHANNEL LOG SILLS WILL BE PLACED PERPENDICULAR TO STREAM CHANNEL.
2. STATIONS AND OFFSETS FOR FLOODPLAIN LOG SILLS ARE TO THE CENTER OF SILL STRUCTURE. TOP OF FLOODPLAIN LOG SILLS WILL BE SET AT THE PROPOSED FLOODPLAIN ELEVATION.
3. SEE THE TYPICAL SECTIONS FOR DIMENSIONS OF ALL PROPOSED CHANNELS.
4. SEE SD-1 FOR LIVE FASCINE DETAILS AND THE IN-CHANNEL AND FLOODPLAIN LOG SILL DETAILS.
5. CENTER OF IN-CHANNEL LOG SILLS IS THE BASELINE. TOP OF IN-CHANNEL LOG SILLS SHALL BE PLACED FLUSH WITH THE PROPOSED STREAMBED ELEVATION.

SCALE: 1" = 30'

DATUM: NAD 8391 Horizontal
NAVD 88 Vertical

JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future®

BY: barranger

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

CROSS REFERENCE		R / W PLAT NUMBER	REVISIONS
ITEM	SHEET NOs.		
TITLE SHEET	1		
ABBREVIATIONS /GENERAL NOTES	2		
STREAM RESTORATION GEOMETRY	3–4		
STREAM TYPICAL SECTIONS	5		
STREAM RESTORATION PROFILES	6–10		
KEY MAP	11		
STREAM RESTORATION PLANS	12–15		
STREAM RESTORATION DETAILS	16–18		
ESC NOTES & SEQUENCE OF CONSTRUCTION	19–22		
ESC PLANS	23–42		
ESC DETAILS	43–44		
LANDSCAPING PLANS	45–48		
STREAM RESTORATION CROSS SECTIONS	49–52		
MOT PLANS	53		

STREAM RESTORATION PLANS

SCALE 1" = 30' ADVERTISED DATE: JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY FAB
DRAWN BY FAB/PVC
CHECKED BY MRG/FAB
F.A.P. NO. SEE TITLE SHEET
COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. SR – 1 OF 4 SHEET NO. 12 OF 53

PLOTTED: Tuesday, April 25, 2017 AT 08:18 AM
FILE: G:\SMD\120079_017_Little_Catoctin_Cree\CADD\pSR_P001_LCC.dgn

MATCHLINE – SEE DWG. SR–4

MATCHLINE STA. 9+50 – SEE DWG. SR–1

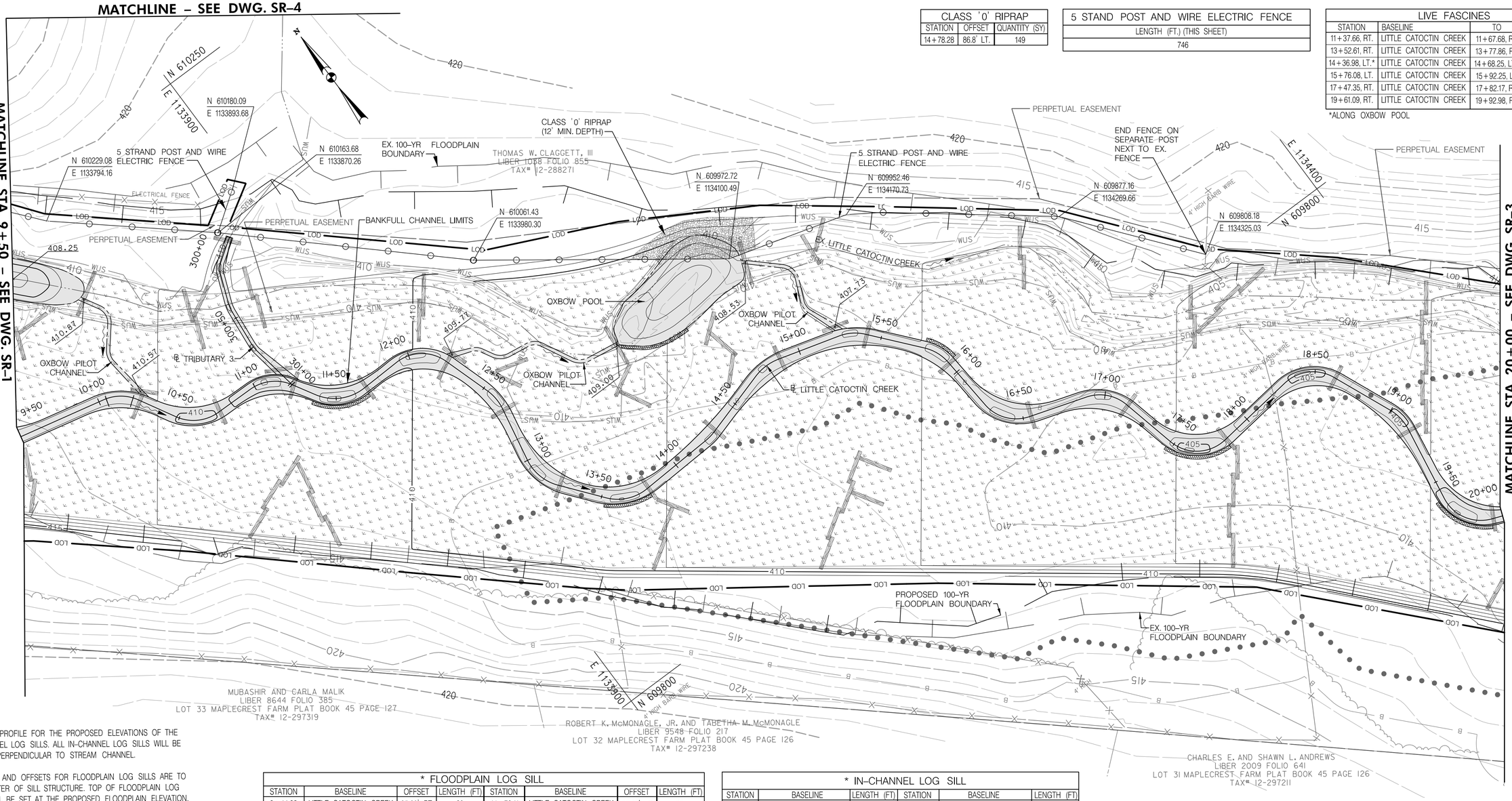
MATCHLINE STA. 20+00 – SEE DWG. SR–3

CLASS '0' RIPRAP		
STATION	OFFSET	QUANTITY (SY)
14+78.28	86.8' LT.	149

5 STAND POST AND WIRE ELECTRIC FENCE
LENGTH (FT.) (THIS SHEET)
746

LIVE FASCINES			
STATION	BASELINE	TO	LENGTH (FT)
11+37.66, RT.	LITTLE CATOCTIN CREEK	11+67.68, RT.	34
13+52.61, RT.	LITTLE CATOCTIN CREEK	13+77.86, RT.	30
14+36.98, LT.*	LITTLE CATOCTIN CREEK	14+68.25, LT.*	42
15+76.08, LT.	LITTLE CATOCTIN CREEK	15+92.25, LT.	20
17+47.35, RT.	LITTLE CATOCTIN CREEK	17+82.17, RT.	42
19+61.09, RT.	LITTLE CATOCTIN CREEK	19+92.98, RT.	38

*ALONG OXBOW POOL



NOTES

1. SEE THE PROFILE FOR THE PROPOSED ELEVATIONS OF THE IN–CHANNEL LOG SILLS. ALL IN–CHANNEL LOG SILLS WILL BE PLACED PERPENDICULAR TO STREAM CHANNEL.
2. STATIONS AND OFFSETS FOR FLOODPLAIN LOG SILLS ARE TO THE CENTER OF SILL STRUCTURE. TOP OF FLOODPLAIN LOG SILLS WILL BE SET AT THE PROPOSED FLOODPLAIN ELEVATION.
3. SEE THE TYPICAL SECTIONS FOR DIMENSIONS OF ALL PROPOSED CHANNELS.
4. SEE SD–1 FOR LIVE FASCINE DETAILS AND THE IN–CHANNEL AND FLOODPLAIN LOG SILL DETAILS.
5. CENTER OF IN–CHANNEL LOG SILLS IS THE BASELINE. TOP OF IN–CHANNEL LOG SILLS SHALL BE PLACED FLUSH WITH THE PROPOSED STREAMBED ELEVATION.

* FLOODPLAIN LOG SILL							
STATION	BASELINE	OFFSET	LENGTH (FT)	STATION	BASELINE	OFFSET	LENGTH (FT)
9+44.32	LITTLE CATOCTIN CREEK	35.20', RT.	20	14+72.11	LITTLE CATOCTIN CREEK	26.65', LT.	20
9+46.95	LITTLE CATOCTIN CREEK	16.98', RT.	20	14+73.15	LITTLE CATOCTIN CREEK	38.91', LT.	20
9+71.36	LITTLE CATOCTIN CREEK	49.67', LT.	20	14+89.04	LITTLE CATOCTIN CREEK	59.96', LT.	25
9+83.30	LITTLE CATOCTIN CREEK	57.87', LT.	20	15+24.13	LITTLE CATOCTIN CREEK	5.79', LT.	16
10+07.66	LITTLE CATOCTIN CREEK	63.63', LT.	28	15+25.64	LITTLE CATOCTIN CREEK	53.99', LT.	20
10+25.14	LITTLE CATOCTIN CREEK	5.83', LT.	16	15+28.20	LITTLE CATOCTIN CREEK	60.70', LT.	20
10+72.94	LITTLE CATOCTIN CREEK	57.18', RT.	56	15+87.60	LITTLE CATOCTIN CREEK	74.33', LT.	37
11+45.52	LITTLE CATOCTIN CREEK	63.47', RT.	55	16+08.19	LITTLE CATOCTIN CREEK	71.68', RT.	20
12+07.72	LITTLE CATOCTIN CREEK	27.26', LT.	40	16+20.58	LITTLE CATOCTIN CREEK	88.16', RT.	20
12+24.57	LITTLE CATOCTIN CREEK	5.71', LT.	16	17+12.75	LITTLE CATOCTIN CREEK	64.44', LT.	37
12+54.14	LITTLE CATOCTIN CREEK	20.48', LT.	20	17+72.54	LITTLE CATOCTIN CREEK	35.07', RT.	71
12+56.04	LITTLE CATOCTIN CREEK	11.95', LT.	20	18+33.43	LITTLE CATOCTIN CREEK	60.01', LT.	54
12+65.43	LITTLE CATOCTIN CREEK	75.67', LT.	25	19+00.38	LITTLE CATOCTIN CREEK	38.00', LT.	89
13+72.67	LITTLE CATOCTIN CREEK	29.58', RT.	38	19+89.77	LITTLE CATOCTIN CREEK	43.58', RT.	20
13+83.59	LITTLE CATOCTIN CREEK	17.36', RT.	20	300+35.14	TRIBUTARY #3	15.63', RT.	20
14+37.21	LITTLE CATOCTIN CREEK	86.56', RT.	73	300+41.73	TRIBUTARY #3	22.23', RT.	37
14+64.26	LITTLE CATOCTIN CREEK	13.69', LT.	20	300+43.47	TRIBUTARY #3	15.51', LT.	38

* SEE NOTE 2 THIS SHEET.

* IN–CHANNEL LOG SILL					
STATION	BASELINE	LENGTH (FT)	STATION	BASELINE	LENGTH (FT)
10+23.86	LITTLE CATOCTIN CREEK	16	15+40.40	LITTLE CATOCTIN CREEK	16
10+74.06	LITTLE CATOCTIN CREEK	16	15+92.36	LITTLE CATOCTIN CREEK	16
11+22.76	LITTLE CATOCTIN CREEK	16	16+53.76	LITTLE CATOCTIN CREEK	16
11+67.71	LITTLE CATOCTIN CREEK	16	17+13.74	LITTLE CATOCTIN CREEK	16
12+22.84	LITTLE CATOCTIN CREEK	16	17+82.42	LITTLE CATOCTIN CREEK	16
12+66.59	LITTLE CATOCTIN CREEK	16	18+61.51	LITTLE CATOCTIN CREEK	16
13+23.77	LITTLE CATOCTIN CREEK	16	19+15.19	LITTLE CATOCTIN CREEK	16
13+78.08	LITTLE CATOCTIN CREEK	16	19+93.30	LITTLE CATOCTIN CREEK	16
14+29.78	LITTLE CATOCTIN CREEK	16	300+02.33	TRIBUTARY #3	16
14+86.94	LITTLE CATOCTIN CREEK	16	300+88.77	TRIBUTARY #3	16

* SEE NOTE 5 THIS SHEET.

30' 0 30' 60'
SCALE: 1" = 30'

DATUM: NAD 83\91 Horizontal
NAVD 88 Vertical

JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future®

BY: barranger

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

CROSS REFERENCE		R / W PLAT NUMBER	REVISIONS
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MOT PLANS	53		

STREAM RESTORATION PLANS

SCALE 1"=30' ADVERTISED DATE: JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY FAB
DRAWN BY FAB/PVC
CHECKED BY MRG/FAB
F.A.P. NO. SEE TITLE SHEET

COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. SR – 2 OF 4 SHEET NO. 13 OF 53

PLOTTED: Tuesday, April 25, 2017 AT 08:19 AM
FILE: C:\SMD\120079_017_Little_Catoctin_Cree\CADD\pSR_P002_LCC.dgn

ROCK CROSS VANE STRUCTURE		
STATION	OFFSET	QUANTITY (LF)
29+32.16	0.00'	102

IMPORTED STREAMBED UNDERLAYMENT					
FROM		TO		AVG. WIDTH (FT)	QUANTITY (SY)
STATION	OFFSET	STATION	OFFSET		
400+00.00	0.0' RT	400+23.50	0.0' RT	4	11

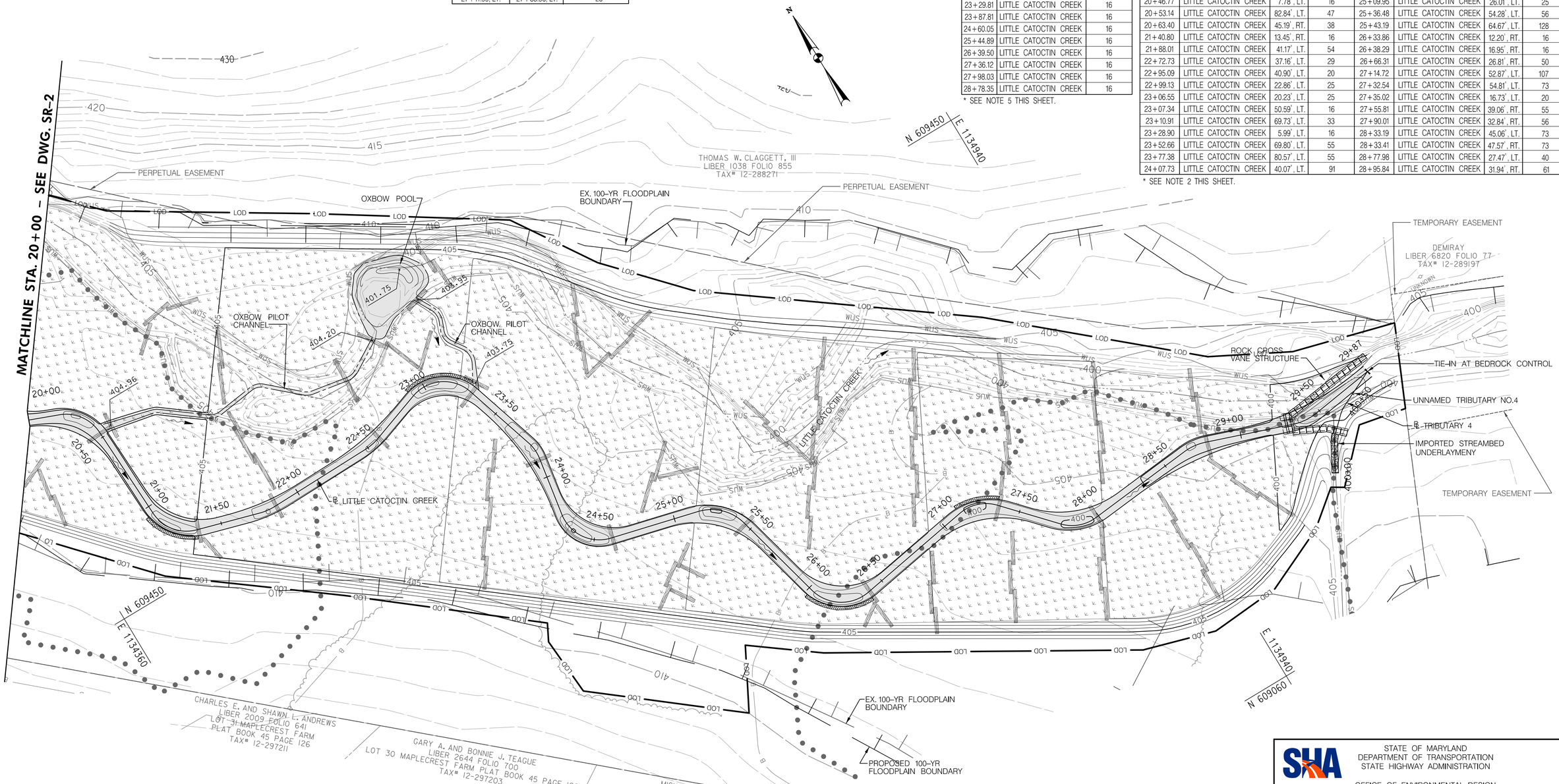
LIVE FASCINES		
FROM	TO	LENGTH (FT)
21+05.31, RT.	21+34.65, RT.	33
22+91.25, LT.	23+27.34, LT.	44
26+02.14, RT.	26+39.14, RT.	44
27+11.99, LT.	27+35.96, LT.	28

* IN-CHANNEL LOG SILL		
STATION	BASELINE	LENGTH (FT)
20+46.40	LITTLE CATOCTIN CREEK	16
21+34.79	LITTLE CATOCTIN CREEK	16
21+83.75	LITTLE CATOCTIN CREEK	16
22+57.92	LITTLE CATOCTIN CREEK	16
23+29.81	LITTLE CATOCTIN CREEK	16
23+87.81	LITTLE CATOCTIN CREEK	16
24+60.05	LITTLE CATOCTIN CREEK	16
25+44.89	LITTLE CATOCTIN CREEK	16
26+39.50	LITTLE CATOCTIN CREEK	16
27+36.12	LITTLE CATOCTIN CREEK	16
27+98.03	LITTLE CATOCTIN CREEK	16
28+78.35	LITTLE CATOCTIN CREEK	16

* SEE NOTE 5 THIS SHEET.

* FLOODPLAIN LOG SILL							
STATION	BASELINE	OFFSET	LENGTH (FT)	STATION	BASELINE	OFFSET	LENGTH (FT)
19+97.14	LITTLE CATOCTIN CREEK	32.25', RT.	20	24+88.61	LITTLE CATOCTIN CREEK	30.86', RT.	43
20+36.51	LITTLE CATOCTIN CREEK	76.88', LT.	20	24+91.13	LITTLE CATOCTIN CREEK	45.77', RT.	16
20+37.23	LITTLE CATOCTIN CREEK	60.85', LT.	20	24+95.57	LITTLE CATOCTIN CREEK	27.93', LT.	45
20+38.46	LITTLE CATOCTIN CREEK	89.84', LT.	20	25+00.53	LITTLE CATOCTIN CREEK	33.23', RT.	16
20+46.77	LITTLE CATOCTIN CREEK	7.78', LT.	16	25+09.95	LITTLE CATOCTIN CREEK	26.01', LT.	25
20+53.14	LITTLE CATOCTIN CREEK	82.84', LT.	47	25+36.48	LITTLE CATOCTIN CREEK	54.28', LT.	56
20+63.40	LITTLE CATOCTIN CREEK	45.19', RT.	38	25+43.19	LITTLE CATOCTIN CREEK	64.67', LT.	128
21+40.80	LITTLE CATOCTIN CREEK	13.45', RT.	16	26+33.86	LITTLE CATOCTIN CREEK	12.20', RT.	16
21+88.01	LITTLE CATOCTIN CREEK	41.17', LT.	54	26+38.29	LITTLE CATOCTIN CREEK	16.95', RT.	16
22+72.73	LITTLE CATOCTIN CREEK	37.16', LT.	29	26+66.31	LITTLE CATOCTIN CREEK	26.81', RT.	50
22+95.09	LITTLE CATOCTIN CREEK	40.90', LT.	20	27+14.72	LITTLE CATOCTIN CREEK	52.87', LT.	107
22+99.13	LITTLE CATOCTIN CREEK	22.86', LT.	25	27+32.54	LITTLE CATOCTIN CREEK	54.81', LT.	73
23+06.55	LITTLE CATOCTIN CREEK	20.23', LT.	25	27+35.02	LITTLE CATOCTIN CREEK	16.73', LT.	20
23+07.34	LITTLE CATOCTIN CREEK	50.59', LT.	16	27+55.81	LITTLE CATOCTIN CREEK	39.06', RT.	55
23+10.91	LITTLE CATOCTIN CREEK	69.73', LT.	33	27+90.01	LITTLE CATOCTIN CREEK	32.84', RT.	56
23+28.90	LITTLE CATOCTIN CREEK	5.99', LT.	16	28+33.19	LITTLE CATOCTIN CREEK	45.06', LT.	73
23+52.66	LITTLE CATOCTIN CREEK	69.80', LT.	55	28+33.41	LITTLE CATOCTIN CREEK	47.57', RT.	73
23+77.38	LITTLE CATOCTIN CREEK	80.57', LT.	55	28+77.98	LITTLE CATOCTIN CREEK	27.47', LT.	40
24+07.73	LITTLE CATOCTIN CREEK	40.07', LT.	91	28+95.84	LITTLE CATOCTIN CREEK	31.94', RT.	61

* SEE NOTE 2 THIS SHEET.



NOTES

1. SEE THE PROFILE FOR THE PROPOSED ELEVATIONS OF THE IN-CHANNEL LOG SILLS. ALL IN-CHANNEL LOG SILLS WILL BE PLACED PERPENDICULAR TO STREAM CHANNEL.
2. STATIONS AND OFFSETS FOR FLOODPLAIN LOG SILLS ARE TO THE CENTER OF SILL STRUCTURE. TOP OF FLOODPLAIN LOG SILLS WILL BE SET AT THE PROPOSED FLOODPLAIN ELEVATION.
3. SEE THE TYPICAL SECTIONS FOR DIMENSIONS OF ALL PROPOSED CHANNELS.
4. SEE SD-1 FOR LIVE FASCINE DETAILS AND THE IN-CHANNEL AND FLOODPLAIN LOG SILL DETAILS.
5. CENTER OF IN-CHANNEL LOG SILLS IS THE BASELINE. TOP OF IN-CHANNEL LOG SILLS SHALL BE PLACED FLUSH WITH THE PROPOSED STREAMBED ELEVATION.

30' 0 30' 60'
SCALE: 1" = 30'

DATUM: NAD 83\91 Horizontal
NAVD 88 Vertical

JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future®

BY: barranger

CROSS REFERENCE	
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ABBREVIATIONS /GENERAL NOTES	2
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R /W PLAT NUMBER

REVISIONS

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

STREAM RESTORATION PLANS

SCALE 1" = 30' ADVERTISED DATE: JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY FAB COUNTY FREDERICK COUNTY
DRAWN BY FAB/PVC LOGMILE
CHECKED BY MRG/FAB HORIZONTAL SCALE N/A
F.A.P. NO. SEE TITLE SHEET VERTICAL SCALE N/A

DRAWING NO. SR – 3 OF 4 SHEET NO. 14 OF 53

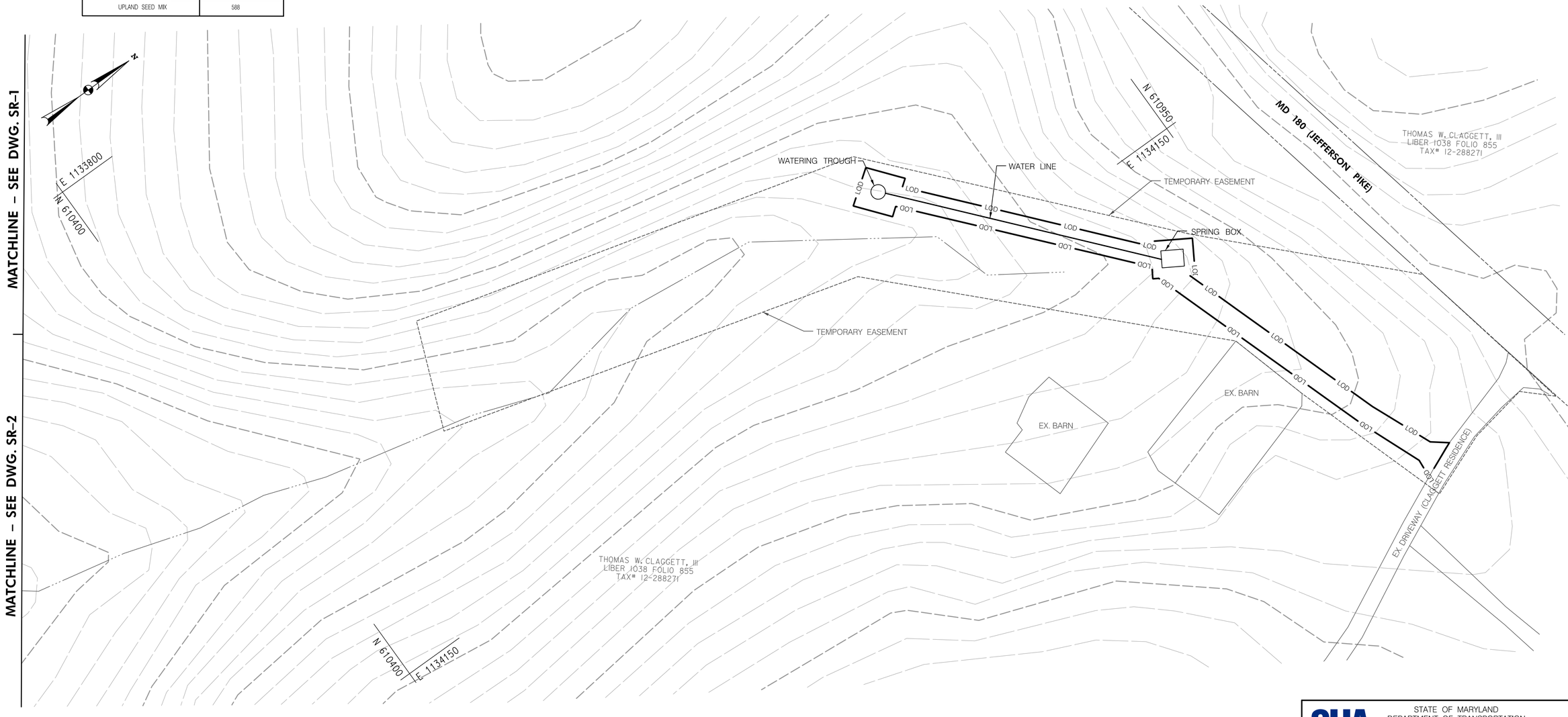
PLOTTED: Tuesday, April 25, 2017 AT 08:20 AM
FILE: G:\SMD\120079_017_Little_Catoctin_Creek\CADD\pSR_P003_LCC.dgn

SPRING BOX*	
NORTHING	EASTING
640908.06	1134214.15

WATERING TROUGH*	
NORTHING	EASTING
610781.93	1134089.30

*COSTS INCLUDED IN LUMP SUM OF WATERING TROUGH SYSTEM

SEED MIX SCHEDULE (THIS SHEET)	
SEED MIX	SQUARE YARDS (SY)
UPLAND SEED MIX	588



30' 0 30' 60'
SCALE: 1" = 30'

DATUM: NAD 83\91 Horizontal
NAVD 88 Vertical

JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future®

BY: barranger

CROSS REFERENCE		R /W PLAT NUMBER	REVISIONS
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STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

STREAM RESTORATION PLANS

SCALE 1" = 30' ADVERTISED DATE: JUNE 2017 CONTRACT NO. FR5975182

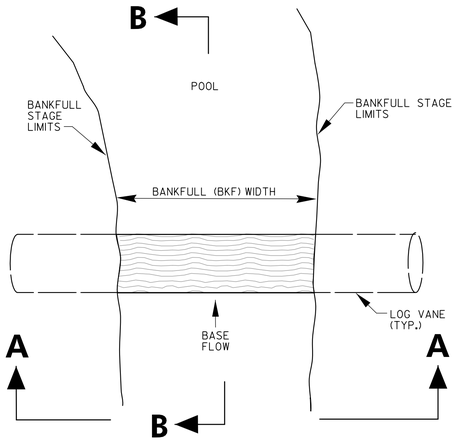
DESIGNED BY FAB COUNTY FREDERICK COUNTY
DRAWN BY FAB/PVC LOGMILE
CHECKED BY MRG/FAB HORIZONTAL SCALE N/A
F.A.P. NO. SEE TITLE SHEET VERTICAL SCALE N/A

DRAWING NO. SR – 4 OF 4 SHEET NO. 15 OF 53

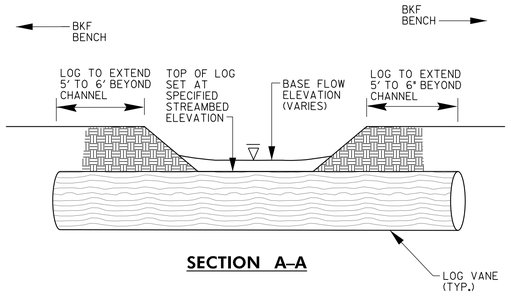
PLOTTED: Tuesday, April 25, 2017 AT 08:21 AM
FILE: O:\SMD\150079_017_Little_Catoctin_Cree\CADD\pSR_P004_LCC.dgn

IN-CHANNEL LOG SILL DETAILS

N.T.S.



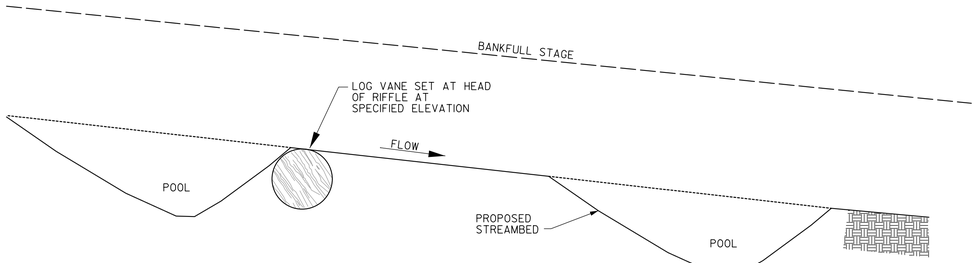
PLAN VIEW



SECTION A–A

NOTES:

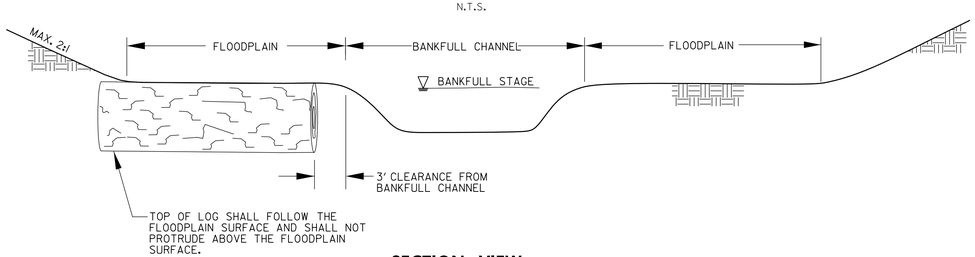
1. IN-CHANNEL LOG SILLS SHALL HAVE A MINIMUM DIAMETER OF 18".
2. TOP OF THE LOG SHALL BE FLUSH WITH THE PROPOSED STREAMBED ELEVATION.



SECTION B–B

FLOODPLAIN LOG SILL DETAIL

N.T.S.



SECTION VIEW

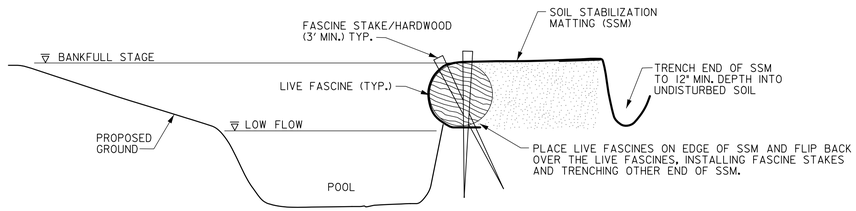
NOTES:

1. FLOODPLAIN LOG SILLS SHALL HAVE A MINIMUM DIAMETER OF 12".
2. TOP OF FLOODPLAIN LOGS WILL BE SET AT THE ELEVATION OF THE PROPOSED FLOODPLAIN.
3. THE ENDS OF MULTIPLE LOGS USED TO CONSTRUCT A FLOODPLAIN LOG SILL SHALL OVERLAP (EXTEND) PAST ONE ANOTHER BY A MINIMUM OF 2 FEET.
4. BRANCHES AND OTHER IRREGULARITIES MAY PROTRUDE ABOVE THE FLOODPLAIN SURFACE.
5. DEPRESSED AREAS OR OLD CHANNEL OXBOWS MAY CONTAIN ADDITIONAL LOGS AND/OR WOODY DEBRIS.
6. THE PLACEMENT OF ADDITIONAL MATERIALS SUCH AS TREE TOPS, BRANCHES, ROOTS AND OTHER PORTIONS OF THE HARVESTED / FURNISHED TREES (ADDITIONAL WOODY MATERIALS) SHALL BE INSTALLED UNDER THE DIRECTION OF THE DESIGNATED STREAM SPECIALIST OR STREAM RESTORATION SPECIALIST.

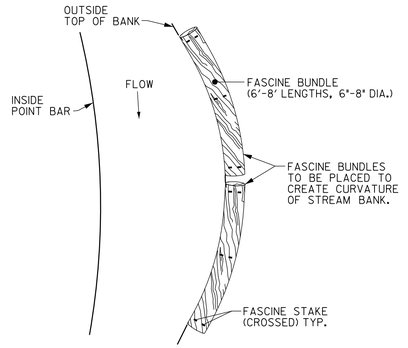
LIVE FASCINE DETAILS

N.T.S.

ORIGINAL INSTALLATION



SECTION VIEW

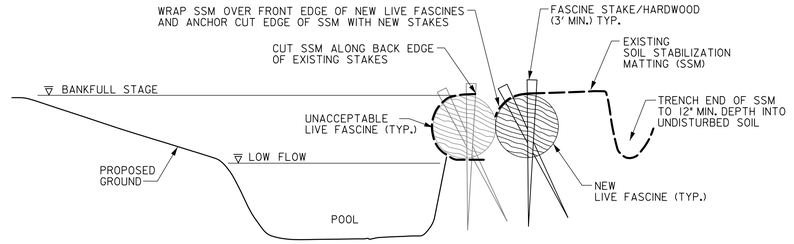


PLAN VIEW

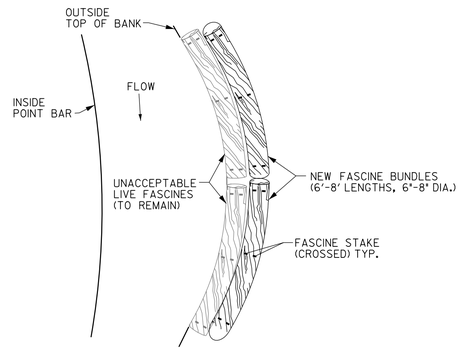
NOTES:

1. LIVE FASCINES WILL BE PLACED TO CREATE OUTSIDE STREAM BANK.
2. FASCINES WILL CONSIST OF AN EQUAL MIX OF SPECIES AS SHOWN ON SHEET LP-4.
3. FASCINES WILL CONSIST OF 6.0' TO 8.0' LENGTHS AND BUNDLED IN 8" DIAMETER BUNDLES.
4. FASCINE STAKES WILL BE CROSSED AS SHOWN AND SPACED EVERY 2.0' ALONG FASCINE.
5. SEE PLAN SHEETS FOR LOCATIONS.

LIVE FASCINE REPLACEMENT



SECTION VIEW



PLAN VIEW

NOTES:

1. CUT EDGE OF THE EXISTING SSM ALONG BACK EDGE OF EXISTING STAKES.
2. EXCAVATE A TRENCH IMMEDIATELY BEHIND THE UNACCEPTABLE LIVE FASCINES OR BRUSH BUNDLES, THAT WILL ACCOMODATE THE NEW LIVE FASCINES.
3. WRAP THE CUT SSM OVER THE FRONT OF THE NEW LIVE FASCINES AND SECURE WITH FASCINE STAKES.
4. NEW LIVE FASCINES SHALL BE THE SAME SIZE AND SPECIES OF THE UNNACEPTABLE LIVE FASCINES OR BRUSH BUNDLES.
5. FASCINE STAKES WILL BE CROSSED AS SHOWN AND SPACED EVERY 2.0' ALONG FASCINE.

JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future®

BY: bubczyk

DATUM: NAD 8391 Horizontal
NAVD 88 Vertical

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

CROSS REFERENCE

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TITLE SHEET	1
ABBREVIATIONS /GENERAL NOTES	2
STREAM RESTORATION GEOMETRY	3-4
STREAM TYPICAL SECTIONS	5
STREAM RESTORATION PROFILES	6-10
KEY MAP	11
STREAM RESTORATION PLANS	12-15
STREAM RESTORATION DETAILS	16-18
ESC NOTES & SEQUENCE OF CONSTRUCTION	19-22
ESC PLANS	23-42
ESC DETAILS	43-44
LANDSCAPING PLANS	45-48
STREAM RESTORATION CROSS SECTIONS	49-52
MOT PLANS	53

R /W PLAT NUMBER

REVISIONS

STREAM RESTORATION DETAILS

SCALE AS SHOWN ADVERTISED DATE: JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY FAB
DRAWN BY FAB/PVC
CHECKED BY MRG/FAB
F.A.P. NO. SEE TITLE SHEET

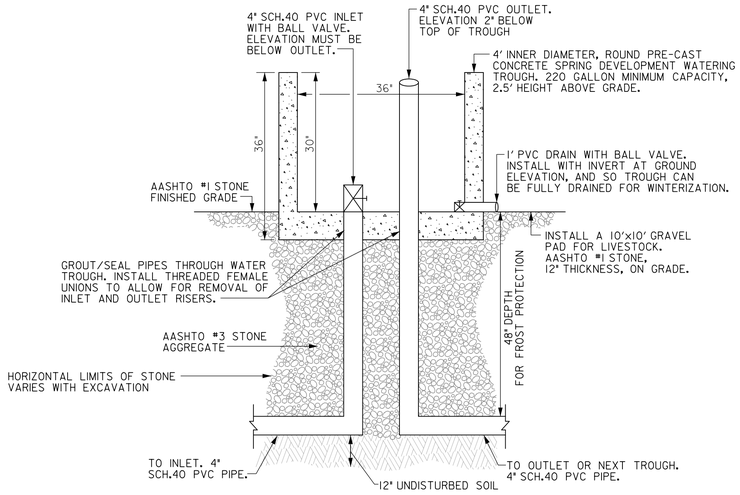
COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. SD – 1 OF 3 SHEET NO. 16 OF 53

PLOTTED: Friday, May 12, 2017 AT 01:09 PM
FILE: G:\SMD\120079_017_Little_Catoctin_Cree\CADD\pSD_P001_LCC.dgn

WATERING TROUGH SYSTEM DETAILS

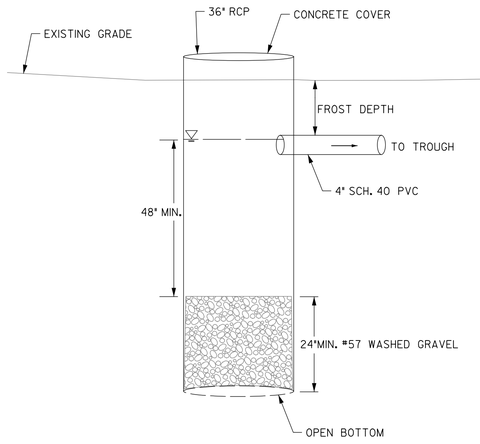
N.T.S.



SECTION VIEW

WATERING TROUGH DETAIL

N.T.S.



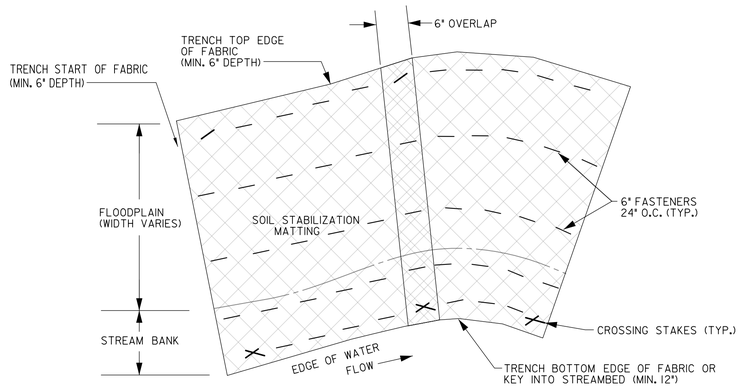
SECTION VIEW

SPRING BOX DETAIL

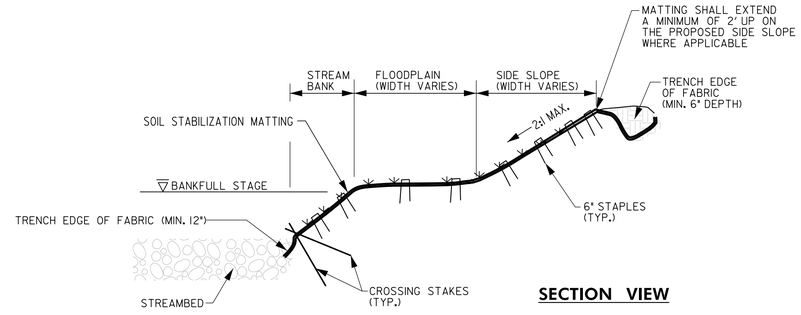
N.T.S.

STREAMBANK/FLOODPLAIN STABILIZATION DETAILS

N.T.S.



PLAN VIEW

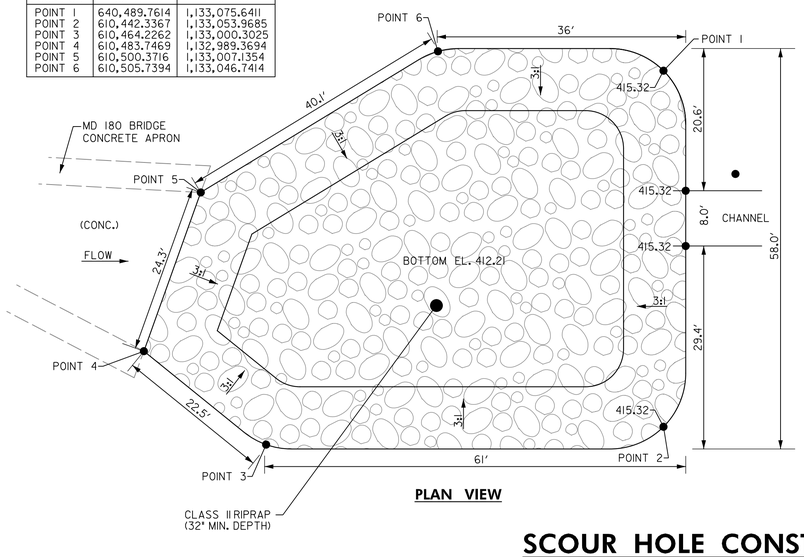


SECTION VIEW

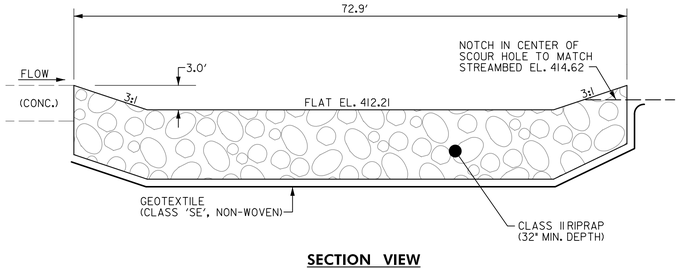
NOTES:

1. SOIL STABILIZATION MATTING (SSM) SHALL BE OVERLAPPED 'SHINGLE' STYLE OR PERPENDICULAR TO THE CHANNEL, WITH THE UPSTREAM SECTION OF MATTING OVERLAPPING THE NEXT DOWNSTREAM SECTION OF MATTING.
2. THE STREAMBANK/FLOODPLAIN STABILIZATION DETAILS SHALL APPLY TO ALL AREAS SPECIFIED TO RECIEVE SOIL STABILIZATION MATTING AND SHALL ALSO INCLUDE THE STABILIZATION OF AREAS DISTURBED IN THE CONSTRUCTION OF THE FOUR UNNAMED TRIBUTARIES.
3. THE SSM SHALL BE PLACED ACROSS BOTTOM OF OXBOW PILOT CHANNELS.
4. SPECIFIED SEED MIX SHALL BE APPLIED FIRST AND IMMEDIATELY COVERED WITH THE SSM.
5. THE SSM SHALL BE 100 PERCENT BIODEGRADABLE COIR FIBER MATTING.
6. THE SSM SHALL CONFORM TO THE SPECIFICATIONS.
7. WOOD CROSSING STAKES SHALL BE UTILIZED TO SECURE THE END OF THE FABRIC ALONG THE TOE OF THE PROPOSED CHANNEL.
8. WOOD STAKES SHALL BE UNTREATED HARDWOOD OR SOUTHERN YELLOW PINE WITH A SAW-FORMED POINT ON ONE END, 1 INCH BY 2 INCHES IN SIZE AND A MINIMUM OF 18 INCHES IN LENGTH.
9. FASTENERS SHALL BE 6" U-SHAPED STAPLES PLACED 24" ON-CENTER AND SHALL CONFORM TO SECTION 920.05.02 OF THE STANDARD SPECIFICATIONS FOR CONSTRUCTION AND MATERIALS.

LOCATION	NORTHING	EASTING
POINT 1	640,489.7614	1,133,075.6411
POINT 2	610,442.3367	1,133,053.9685
POINT 3	610,464.2262	1,133,000.3025
POINT 4	610,483.7469	1,132,989.3694
POINT 5	610,500.3716	1,133,007.1354
POINT 6	610,505.7394	1,133,046.7414



PLAN VIEW



SECTION VIEW

SCOUR HOLE CONSTRUCTION DETAILS

STA. 0+11.95 STA. 0+84.86

N.T.S.

DATUM: NAD 8391 Horizontal
NAVD 88 Vertical

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future®

BY: barranger

CROSS REFERENCE

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ABBREVIATIONS /GENERAL NOTES	2
STREAM RESTORATION GEOMETRY	3-4
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R /W PLAT NUMBER

REVISIONS

STREAM RESTORATION DETAILS

SCALE AS SHOWN ADVERTISED DATE: JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY FAB
DRAWN BY FAB/PVC
CHECKED BY MRG/FAB
F.A.P. NO. SEE TITLE SHEET

COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

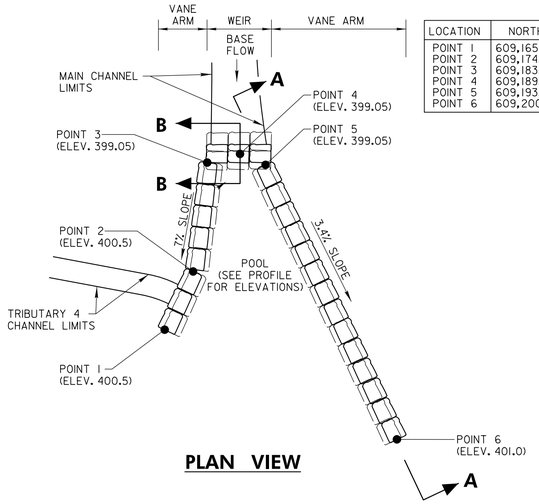
DRAWING NO. SD – 2 OF 3

SHEET NO. 17 OF 53

PLOTTED: Tuesday, April 25, 2017 AT 08:23 AM
FILE: G:\SMD\120079_017_Little_Catoctin_Cree\CADD\pSD_P002_LCC.dgn

ROCK CROSS VANE CONSTRUCTION DETAILS

N.T.S.

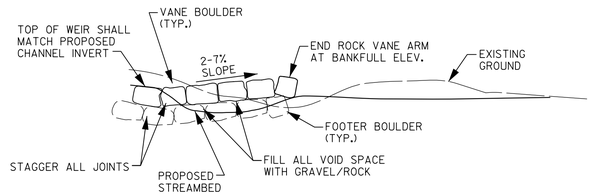


LOCATION	NORTHING	EASTING
POINT 1	609,165.7145	1,135,046.2261
POINT 2	609,174.2957	1,135,037.0045
POINT 3	609,183.3940	1,135,019.1037
POINT 4	609,189.7570	1,135,019.2215
POINT 5	609,193.6271	1,135,023.0373
POINT 6	609,200.9176	1,135,079.7175

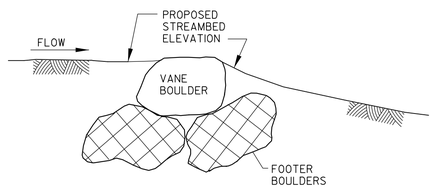
PLAN VIEW

CONSTRUCTION PROCEDURES FOR ROCK STRUCTURES

1. CUT A TRENCH, FOR THE GRADE CONTROL VANE ARM, FROM THE OUTWARD LIMIT OF THE STRUCTURE, EXTENDING INTO THE STREAM AT THE SPECIFIED ANGLE UPSTREAM (AT LEAST TWO (2)). FIRST PLACE THE BOTTOM MOST FOOTER BOULDERS ON EXISTING GROUND & WORKING HIGHER, PLACE SECOND ROW OF FOOTER BOULDERS AND THEN PLACE VANE ROCKS TO ACHIEVE THE CORRECT PROPOSED ELEVATION OF EACH STRUCTURE. EXCAVATION OF THE TRENCH SHALL BE CONDUCTED IN CONJUCTION WITH THE PLACEMENT OF THE FOOTER AND THE VANE ROCKS TO ACHIEVE PROPER ELEVATIONS AT THE TOP OF THE VANE ROCKS.
2. FOOTER ROCKS SHALL BE PLACED IN THE EXCAVATED TRENCH SUCH THAT THEY BUTT AGAINST ONE ANOTHER, WHICH WILL ALLOW THE VANE ROCKS TO INTERLOCK WITH THE FOOTER ROCKS. ADDITIONAL FOOTER ROCKS MAY BE REQUIRED FOR PLACEMENT OF THE VANE ROCKS TO ACHIEVE THE PROPOSED ELEVATION.
3. THE DEPTH OF EXCAVATION SHALL BE TO THE DEPTH OF THE DEEPEST FOOTER ROCK. THE WIDTH OF EXCAVATION IN THE DIRECTION OF FLOW SHALL ONLY BE THE WIDTH OF THE ROCKS.
4. THE VANE ROCKS SHALL BE PLACED ON TOP OF THE FOOTER ROCKS SUCH THAT THEY ARE CONTINUOUS, STAGGERED OVER THE TWO (2) ADJACENT FOOTER ROCKS, AND PLACED SKEWED UPSTREAM OF THE FOOTER ROCKS.
5. THE DESIGNATED SPECIALIST/ENGINEER RESERVES THE RIGHT TO ADJUST THE ANGLE OR ELEVATION OF THE PROPOSED STRUCTURE IN THE FIELD TO MEET THE SITE CONDITIONS.



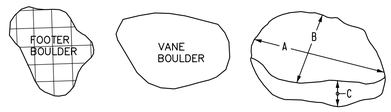
SECTION A–A



SECTION B–B

N.T.S.

ROCK DIMENSION DETAILS



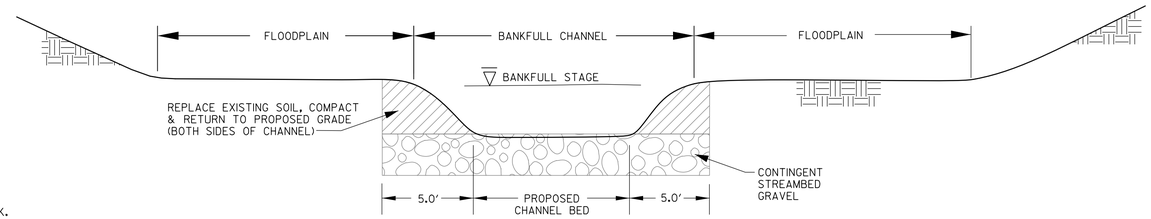
VANE AND FOOTER BOULDERS SHALL HAVE A MINIMUM INTERMEDIATE AXIS DIMENSION OF 3.5' (42"). TYPICAL SIZE OF THE BOULDERS WIL BE 4.0'x3.5'x3.0'.

ALL BOULDERS USED SHALL HAVE A MINIMUM DENSITY OF 160 POUNDS PER CUBIC FOOT.

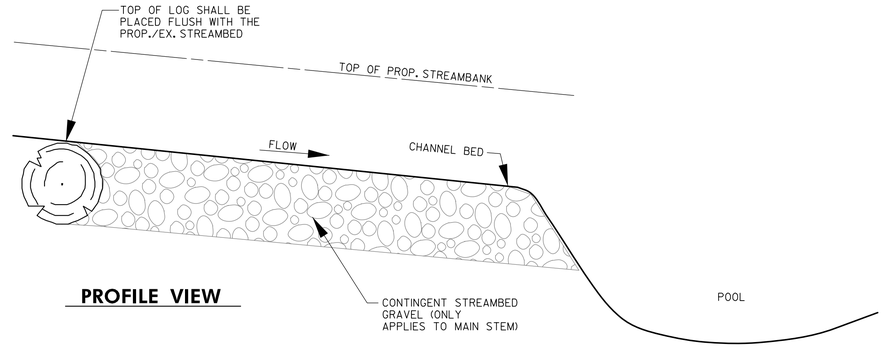
SPECIFIED ROCK SIZES FOR IN–STREAM ROCK CROSS VANES			
	AXIS A (FT)	AXIS B (FT)	AXIS C (FT)
MINIMUM LENGTH	3.0	3.0	2.0
MAXIMUM LENGTH	5.0	4.0	4.0

CONTINGENT STREAMBED GRAVEL CONSTRUCTION DETAILS

N.T.S.



SECTION VIEW



PROFILE VIEW

NOTES:

1. SALVAGED STREAMBED GRAVEL SHALL ONLY BE HARVESTED FOR APPROVED LOCATIONS WITHIN THE PERMITTED LIMIT OF DISTURBANCE. SEE THE E&S PLAN SHEETS FOR LOCATIONS.
2. SALVAGED STREAMBED GRAVEL MAY BE STOCKPILED IN APPROVED LOCATIONS WITH E&S CONTROLS.
3. THE SALVAGED STREAMBED GRAVEL SHALL BE PLACED A MINIMUM THICKNESS OF 12".
4. UNUSED STREAMED GRAVEL SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR TO REMOVE FROM THE SITE.

BY: barranger

JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future®

DATUM: NAD 83\91 Horizontal
NAVD 88 Vertical

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

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LITTLE CATOCTIN CREEK STREAM RESTORATION

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TITLE SHEET	1
ABBREVIATIONS /GENERAL NOTES	2
STREAM RESTORATION GEOMETRY	3–4
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STREAM RESTORATION DETAILS

SCALE AS SHOWN ADVERTISED DATE: JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY FAB
DRAWN BY FAB/PVC
CHECKED BY MRG/FAB
F.A.P. NO. SEE TITLE SHEET

COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N./A
VERTICAL SCALE N./A

DRAWING NO. SD – 3 OF 3 SHEET NO. 18 OF 53

PLOTTED: Tuesday, April 25, 2017 AT 08:23 AM
FILE: G:\SMD\120079_017_Little_Catoctin_Cree\CADD\pSD_P003_LCC.dgn

EROSION AND SEDIMENT CONTROL – GENERAL NOTES

1. NOTIFICATION

NOTIFY THE REGIONAL ENVIRONMENTAL COORDINATOR(REC) IN WRITING AND/OR BY TELEPHONE AT (410) 365-0164 PRIOR TO THE FOLLOWING POINTS:
- PRE-CONSTRUCTION MEETING
- EROSION AND SEDIMENT CONTROL MEETING (MINIMUM 7 WORKING DAYS PRIOR TO COMMENCING EARTH DISTURBING ACTIVITIES)
- UPON INSTALLATION OF INITIAL SEDIMENT CONTROL MEASURES
- INSTALLATION OF MAJOR SEDIMENT CONTROL BASINS/TRAPS
- REMOVAL OR MODIFICATION OF ANY SEDIMENT CONTROL STRUCTURE(S)
- REMOVAL OF ALL SEDIMENT CONTROL DEVICES
- FINAL ACCEPTANCE BY SHA

2. STANDARDS AND SPECIFICATIONS

CONSTRUCT THIS PLAN IN ACCORDANCE TO THE 2011 MARYLAND STANDARDS AND SPECIFICATIONS FOR SOIL EROSION AND SEDIMENT CONTROL, THE 2000 MARYLAND STORMWATER DESIGN MANUAL, VOLUMES I & II AND THE MARYLAND DEPARTMENT OF ENVIRONMENT EROSION AND SEDIMENT CONTROL AND STORMWATER MANAGEMENT REGULATIONS, AND ALL REVISIONS THERE OF, AND AS SPECIFIED. KEEP A COPY OF THE 2011 'MARYLAND STANDARDS AND SPECIFICATIONS FOR SOIL EROSION AND SEDIMENT CONTROL' ON THE SITE AT ALL TIMES. PERFORM VEGETATIVE STABILIZATION ACCORDING TO THOSE STANDARDS AND ACCORDING TO THE CONTRACT DOCUMENTS.

3. INGRESS / EGRESS CONTROLS

PROTECT ALL POINTS OF CONSTRUCTION INGRESS AND EGRESS TO PREVENT THE DEPOSITION OF MATERIALS ON PUBLIC ROADS. MECHANICALLY REMOVE ALL MATERIALS DEPOSITED ON PUBLIC ROADS IMMEDIATELY. THE FLUSHING OF ROAD SURFACES IS PROHIBITED.

THE LOCATIONS OF 'STABILIZED CONSTRUCTION ENTRANCES' SHOWN ON THE PLANS ARE APPROXIMATE. DETERMINE THE EXACT LOCATION IN THE FIELD AND SUBMIT ACTUAL LOCATIONS FOR APPROVAL BY THE REGIONAL ENVIRONMENTAL COORDINATOR.

4. INSPECTION

INSPECT DAILY ALL EROSION AND SEDIMENT CONTROL MEASURES AND MAINTAIN CONTINUOUSLY IN AN EFFECTIVE OPERATING CONDITION UNTIL REMOVED UPON APPROVAL OF THE REC AND THE ENGINEER.

5. SHUTDOWNS AND OR PENALTIES

TOTAL COMPLIANCE WITH THE APPROVED EROSION AND SEDIMENT CONTROL PLAN IS EXPECTED AT ALL TIMES. IN CASES WHERE THE CONTRACTOR IS FOUND TO BE IN NON-COMPLIANCE SHA MAY TAKE STEPS TO IMPOSE SELECTED OR TOTAL SHUTDOWNS AND IMPOSE LIQUIDATED DAMAGES FOR NON-COMPLIANCE.

THE DISTRICT ENGINEER CAN IMPOSE A TOTAL OR PARTIAL SHUTDOWN IF THE PROJECT MAY ADVERSELY IMPACT THE WATERS OF THE STATE.

6. RECORD KEEPING

THE PROJECTS' APPROVAL LETTER, APPROVED EROSION AND SEDIMENT CONTROL PLANS, APPROVED CHANGE REQUESTS, DAILY LOG BOOKS AND TEST REPORTS WILL BE AVAILABLE AT THE SITE FOR INSPECTION BY DULY AUTHORIZED OFFICIALS.

7. DEWATERING PRACTICES

THE DEWATERING PRACTICES SHOWN ARE CONSIDERED TO BE ELECTIVE IN NATURE. LOCATE AND OPERATE DEWATERING PRACTICES IN A MANNER THAT DOES NOT DISCHARGE SEDIMENT INTO ANY WATERWAY. NO VISIBLE CHANGES TO STREAM CLARITY ARE PERMITTED.

8. EROSION AND SEDIMENT CONTROL EXCAVATION

PLACE SILT REMOVED FROM CONTROL DEVICES IN AN APPROVED WASTE SITE EITHER ON OR OFF THE PROJECT. MATERIAL STORED ON SITE MAY BE REUSED ONCE IT IS DRIED AND IF IT MEETS SHA REQUIREMENTS FOR EMBANKMENT OR ANY UNSPECIFIED NEED.

9. OFF-SITE UTILITY WORK

FOLLOW THESE ADDITIONAL BEST MANAGEMENT SEDIMENT CONTROL PRACTICES FOR UTILITY CONSTRUCTION IN AREAS OUTSIDE OF DESIGNED CONTROLS:

(a) CALL 'MISS UTILITY' AT 1-800-257-7777 48 HOURS PRIOR TO THE START OF WORK.
(b) PLACE EXCAVATED MATERIAL ON THE HIGH SIDE OF THE TRENCH.
(c) BACKFILL, COMPACT AND STABILIZE TRENCHES FOR UTILITY INSTALLATIONS AT THE END OF EACH WORKING DAY. WHEN THIS IS NOT POSSIBLE, CONFORM TO (d).
(d) PLACE TEMPORARY SILT FENCES IMMEDIATELY DOWNSTREAM OF ANY DISTURBED AREA INTENDED TO REMAIN DISTURBED FOR MORE THAN ONE DAY.

10. SENSITIVE AREAS

OBTAIN APPROVAL FROM THE ENGINEER AND COORDINATE WITH THE PERMIT HOLDERS WHO WILL COORDINATE WITH THE APPROPRIATE REGULATORY AGENCIES TO ENSURE THAT ALL PERMIT CONDITIONS ARE MET PRIOR TO COMMENCING ANY CONSTRUCTION ACTIVITY WITHIN SPECIFIED SENSITIVE AREAS OF THE PROJECT. DESIGNATE A RESPONSIBLE PARTY TO MONITOR ALL WORK IN THESE AREAS TO ASSURE THAT REASONABLE CARE IS TAKEN IN OR ADJACENT TO THESE AREAS. SENSITIVE AREAS ARE DEFINED AS: FLOODPLAINS, WETLANDS (TIDAL, NONTIDAL AND ASSOCIATED BUFFERS) CRITICAL AREAS, FORESTED AREAS, ARCHEOLOGICAL SITES, HISTORIC SITES, PARKLAND AND OPEN WATER.

11. STANDARD STABILIZATION NOTE

FOLLOWING INITIAL SOIL DISTURBANCE OR REDISTURBANCE, COMPLETE PERMANENT OR TEMPORARY STABILIZATION WITHIN THREE (3) CALENDAR DAYS AS TO THE SURFACE OF ALL PERIMETER CONTROLS, DIKES, SWALES, DITCHES, PERIMETER SLOPES, AND ALL SLOPES GREATER THAN 3 HORIZONTAL TO 1 VERTICAL (3:1); AND SEVEN DAYS (7) AS TO ALL OTHER DISTURBED OR GRADED AREAS ON THE PROJECT SITE.

12. SITE INFORMATION

TOTAL AREA OF SITE	17.87	ACRES
AREA DISTURBED	12.54	ACRES
AREA TO BE ROOFED OR PAVED	0	ACRES
TOTAL CUT	46,850	CU. YDS.
TOTAL FILL	4,370	CU. YDS.
OFFSITE WASTE/BORROW AREA LOCATION (IF KNOWN)	TBD	

• (NOT FOR BIDDING PURPOSES)

13. INCREMENTAL STABILIZATION

REFER TO THE CURRENT MARYLAND STANDARDS AND SPECIFICATIONS FOR SOIL EROSION AND SEDIMENT CONTROL FOR THE INCREMENTAL STABILIZATION OF CUT AND FILLS.

14. MODIFICATIONS

SUBMIT MODIFICATIONS TO THE EROSION AND SEDIMENT CONTROLS TO SHA FOR APPROVAL AND SUBMISSION TO MDE. OBTAIN ALL APPROVALS FROM SHA PRIOR TO IMPLEMENTING ANY MODIFICATION.

15. SEDIMENT TRAPS AND BASINS

PLAN DIMENSIONS ARE RELATIVE TO THE OUTLET ELEVATION. INFLOW AND OUTFLOW LOCATIONS FOR TRAPS AND BASINS MUST BE MAINTAINED IN STABLE CONDITION.

STANDARD SYMBOLS

AT-GRADE INLET PROTECTION	AGIP	ROCK OUTLET PROTECTION II	ROPII	SANDBAG DIKE	
BAFFLE BOARDS	BB	ROCK OUTLET PROTECTION III	ROPIII	HARDWOOD CONSTRUCTION MATS	
CATCH BASIN INSERT	CBI	SILT FENCE	SF	TEMPORARY TIMBER MAT STREAM CROSSING	
CLEAR WATER DIVERSION PIPE	CWD - 12 (NOTE: DESIGNATION CWD-12 REFERS TO CLEAR WATER DIVERSION WITH 12 INCH PIPE.)	SILT FENCE ON PAVEMENT	SFOP	TEMPORARY MULCH ACCESS ROAD	
COMBINATION INLET PROTECTION	COIP	SOD		TEMPORARY ACCESS BRIDGE	TB
CURB INLET PROTECTION	CIP	STABILIZED CONSTRUCTION ENTRANCE	SCE	FABRIC BASED STREAM DIVERSION	
DIVERSION FENCE	DF	STANDARD INLET PROTECTION	SIP	CLEAN WATER PUMP	CWP
EARTH DIKE	A-1 PLACE DESIGNATION (A-1, B-2, ETC.) ON FLOW CHANNEL SIDE OF DIKE.	STOCKPILE AREA		DIRTY WATER PUMP	DWP
EMERGENCY SPILLWAY	ES	STONE CHECK DAM	CD	5 STRAND POST AND WIRE ELECTRIC FENCE	
FILTER BAG	FB	STONE/RIPRAP OUTLET SEDIMENT TRAP ST II	ST-II	LIMIT OF PLANTING (LOP)	LOP
FILTER BERM	FB-A / FB-B	SUBSURFACE DRAINS	SSD	MAJOR CONTOUR (TEMPORARY)	
FILTER LOG	FL-18 (NOTE: DESIGNATION FL-18 REFERS TO FILTER LOG WITH 18 INCH DIAMETER.)	SUMP PIT	SP	MINOR CONTOUR (TEMPORARY)	
GABION INFLOW PROTECTION	GP	SUPER SILT FENCE	SSF	TEMPORARY GRADE LIMIT LINE	
GABION INLET PROTECTION	GIP	TEMPORARY ACCESS CULVERT		ORANGE CONSTRUCTION FENCE (OCF)	OCF
LIMIT OF DISTURBANCE	LOD	TEMPORARY ASPHALT BERM	TAB		
MEDIAN INLET PROTECTION	MIP	TEMPORARY BARRIER DIVERSION	TBD		
MEDIAN SUMP INLET PROTECTION	MSIP	TEMPORARY GABION OUTLET STRUCTURE	TGOS		
MOUNTABLE BERM	MB	TEMPORARY SOIL STABILIZATION MATTING-TYPE A			
PERIMETER DIKE/SWALE	PDS-1	TEMPORARY SOIL STABILIZATION MATTING-TYPE E			
PERMANENT SOIL STABILIZATION MATTING-TYPE B		TEMPORARY SOIL STABILIZATION MATTING-TYPE D			
PERMANENT SOIL STABILIZATION MATTING-TYPE C		TEMPORARY STONE OUTLET STRUCTURE	TSOS		
PIPE OUTLET SEDIMENT TRAP ST I	ST-I	TEMPORARY SWALE	A-1 PLACE DESIGNATION (A-1,B-2, ETC.) ON FLOW CHANNEL SIDE OF SWALE.		
PIPE SLOPE DRAIN	PSD - 12 (NOTE: DESIGNATION PSD-12 REFERS TO PIPE SLOPE DRAIN WITH 12 IN PIPE	WASH RACK OPTION	WR		
PLUNGE POOL	PP	CHESAPEAKE BAY CRITICAL AREA	CBCA		
PORTABLE SEDIMENT TANK	PST	DRAINAGE BOUNDARY	DA		
REMOVABLE PUMPING STATION	RPS	EXISTING CONTOURS	100		
RIPRAP INFLOW PROTECTION	RRP	PROPOSED CONTOURS	100		
RIPRAP OUTLET SEDIMENT TRAP ST III	ST-III	TREE PROTECTION FENCE	TPF		
ROCK OUTLET PROTECTION I	ROPI	WETLAND			
OUTLET PROTECTION (SEE DETAIL ON EN-01)	OP	WETLAND BUFFER	B		
		100-YEAR FLOODPLAIN			

DESIGN CERTIFICATION

ELIZABETH TANE KANNER — NAME

SIGNATURE

33330 — MARYLAND REGISTRATION NUMBER. (P.E.) R.L.S. OR R.L.A. (circle)

03-12-2017 — DATE

"PROFESSIONAL CERTIFICATION. I HEREBY CERTIFY THAT THESE DOCUMENTS WERE PREPARED OR APPROVED BY ME, AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MARYLAND, LICENSE NO. 33330, EXPIRATION DATE: 06/29/18."

DESIGN CERTIFICATION

I HEREBY CERTIFY THAT THIS PLAN HAS BEEN DESIGNED IN ACCORDANCE WITH THE 2011 MARYLAND STANDARDS AND SPECIFICATIONS FOR SOIL EROSION AND SEDIMENT CONTROL, THE 2000 MARYLAND STORMWATER DESIGN MANUAL, VOLUMES I & II INCLUDING SUPPLEMENTS, THE ENVIRONMENT ARTICLE SECTIONS 4-101 THROUGH 116 AND SECTIONS 4-201 AND 215, AND THE CODE OF MARYLAND REGULATIONS (COMAR) 26.17.01 AND COMAR 26.17.02 FOR EROSION AND SEDIMENT CONTROL AND STORMWATER MANAGEMENT, RESPECTIVELY.

COASTAL RESOURCES INC.

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

EROSION & SEDIMENT CONTROL NOTES

SCALE N.T.S. ADVERTISED DATE JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY MJD — COUNTY FREDERICK COUNTY
DRAWN BY MJD — LOGMILE
CHECKED BY ETK — HORIZONTAL SCALE N/A
F.A.P. NO. SEE TITLE SHEET — VERTICAL SCALE N/A

DRAWING NO. EN-1 OF 6 — SHEET NO. 19 OF 53

BY: matthewd –

PLOTTED: Thursday, April 20, 2017 AT 03:42 PM
FILE: G:\Active\2014-16 BCS 2012-030 EPD Env Design-Permitting, EA-JMT\Task 17 Little Catoctin Creek\CAD\pES-N001.dgn

BEST MANAGEMENT PRACTICES FOR WORKING IN NONTIDAL WETLANDS, WETLAND BUFFERS, WATERWAYS, AND 100–YEAR FLOODPLAINS

1. NO EXCESS FILL, CONSTRUCTION MATERIAL, OR DEBRIS SHALL BE STOCKPILED OR STORED IN NONTIDAL WETLANDS, NONTIDAL WETLAND BUFFERS, WATERWAYS, OR THE 100–YEAR FLOODPLAIN.

2. PLACE MATERIALS IN A LOCATION AND MANNER WHICH DOES NOT ADVERSELY IMPACT SURFACE OR SUBSURFACE WATER FLOW INTO OR OUT OF NONTIDAL WETLANDS, NONTIDAL WETLAND BUFFERS, WATERWAYS, OR THE 100–YEAR FLOODPLAIN.

3. DO NOT USE THE EXCAVATED MATERIAL AS BACKFILL IF IT CONTAINS WASTE METAL PRODUCTS, UNSIGHTLY DEBRIS, TOXIC MATERIAL, OR ANY OTHER DELETERIOUS SUBSTANCE. IF ADDITIONAL BACKFILL IS REQUIRED, USE CLEAN MATERIAL FREE OF WASTE METAL PRODUCTS, UNSIGHTLY DEBRIS, TOXIC MATERIAL, OR ANY OTHER DELETERIOUS SUBSTANCE.

4. PLACE HEAVY EQUIPMENT ON MATS OR SUITABLY OPERATE THE EQUIPMENT TO PREVENT DAMAGE TO NONTIDAL WETLANDS, NONTIDAL WETLAND BUFFERS, WATERWAYS, OR THE 100–YEAR FLOODPLAIN.

5. REPAIR AND MAINTAIN ANY SERVICEABLE STRUCTURE OR FILL SO THERE IS NO PERMANENT LOSS OF NONTIDAL WETLANDS, NONTIDAL WETLAND BUFFERS, OR WATERWAYS, OR PERMANENT MODIFICATION OF THE 100–YEAR FLOODPLAIN IN EXCESS OF THAT LOST UNDER THE ORIGINALLY AUTHORIZED STRUCTURE OR FILL.

6. RECTIFY ANY NONTIDAL WETLANDS, WETLAND BUFFERS, WATERWAYS, OR 100–YEAR FLOODPLAIN TEMPORARILY IMPACTED BY ANY CONSTRUCTION.

7. ALL STABILIZATION IN THE NONTIDAL WETLAND AND NONTIDAL WETLAND BUFFER SHALL CONSIST OF THE FOLLOWING SPECIES: ANNUAL RYEGRASS (LOLIUM MULTIFLORUM), MILLET (SETARIA ITALICA), BARLEY (HORDEUM SP.), OATS (UNIOLA SP.), AND/OR RYE (SECALE CEREALE). THESE SPECIES WILL ALLOW FOR THE STABILIZATION OF THE SITE WHILE ALSO ALLOWING FOR THE VOLUNTARY REVEGETATION OF NATURAL WETLAND SPECIES.
OTHER NONPERSISTENT VEGETATION MAY BE ACCEPTABLE, BUT MUST BE APPROVED BY THE NONTIDAL WETLANDS AND WATERWAYS DIVISION. KENTUCKY 31 FESCUE SHALL NOT BE UTILIZED IN WETLAND OR BUFFER AREAS. THE AREA SHOULD BE SEEDED AND MULCHED TO REDUCE EROSION AFTER CONSTRUCTION ACTIVITIES HAVE BEEN COMPLETED.

8. AFTER INSTALLATION HAS BEEN COMPLETED, MAKE POST–CONSTRUCTION GRADES AND ELEVATIONS THE SAME AS THE ORIGINAL GRADES AND ELEVATIONS IN TEMPORARILY IMPACTED AREAS.

9. TO PROTECT AQUATIC SPECIES, IN–STREAM WORK IS PROHIBITED AS DETERMINED BY THE CLASSIFICATION OF THE STREAM:
USE I WATERS: IN–STREAM WORK SHALL NOT BE CONDUCTED DURING THE PERIOD MARCH 1 THROUGH JUNE 15, INCLUSIVE, DURING ANY YEAR.
USE III WATERS: IN–STREAM WORK SHALL NOT BE CONDUCTED DURING THE PERIOD OCTOBER 1 THROUGH APRIL 30, INCLUSIVE, DURING ANY YEAR.
USE IV WATERS: IN–STREAM WORK SHALL NOT BE CONDUCTED DURING THE PERIOD MARCH 1 THROUGH MAY 31, INCLUSIVE, DURING ANY YEAR.

10. STORMWATER RUNOFF FROM IMPERVIOUS SURFACES SHALL BE CONTROLLED TO PREVENT THE WASHING OF DEBRIS INTO THE WATERWAY.

11. CULVERTS SHALL BE CONSTRUCTED AND ANY RIPRAP PLACED SO AS NOT TO OBSTRUCT THE MOVEMENT OF AQUATIC SPECIES, UNLESS THE PURPOSE OF THE ACTIVITY IS TO IMPOUND WATER.

12. MATERIAL STOCKPILED ON THE EXISTING FLOODPLAIN FOR USE IN FILLING THE OLD CHANNEL MUST BE USED WITHIN 72 HOURS. THE PERIMETER OF THE STOCKPILED MATERIAL MUST BE SURROUNDED BY 18" FILTER LOGS. IF A RAIN EVENT OF MORE THAN 1.0" OF RAINFALL IS FORECAST WITHIN THE 72 HOUR TIME PERIOD THE MATERIAL MUST BE USED OR REMOVED FROM THE FLOODPLAIN.

SEQUENCE OF CONSTRUCTION

1. THE CONTRACTOR SHALL NOTIFY THE REGIONAL ENVIRONMENTAL COORDINATOR AT (410) 365–0164 AT LEAST SEVEN (7) DAYS BEFORE ANY LAND DISTURBING ACTIVITY AND HOLD A PRE–CONSTRUCTION MEETING BETWEEN PROJECT REPRESENTATIVES AND ADJACENT LANDOWNERS.

2. LOD, ACCESS ROUTES, AND STAGING AREAS SHALL BE STAKED AND REVIEWED IN THE FIELD WITH THE ENGINEER PRIOR TO CONSTRUCTION TO ALLOW FOR ADJUSTMENTS. ANY ADJUSTMENT MUST BE APPROVED BY THE ENGINEER AND PRD PRIOR TO CONSTRUCTION. ALL PROTECTED RESOURCES WITHIN THE PROPOSED LOD ARE CONSIDERED TO BE IMPACTED DURING CONSTRUCTION. PROTECTED RESOURCES OUTSIDE OF THE LOD SHOULD BE FLAGGED TO 25 FEET BEYOND THE LOD AND REVIEWED BY THE ENGINEER BEFORE CONSTRUCTION.

3. ORANGE CONSTRUCTION FENCING (OCF) SHALL BE INSTALLED ALONG THE ENTIRE LIMITS OF DISTURBANCE PRIOR TO EACH CONSTRUCTION PHASE TO PROTECT WETLANDS, WATERWAYS, AND RESIDENTIAL PROPERTY FROM ACCIDENTAL ENCROACHMENT AND IMPACT. INSTALL OCF IMMEDIATELY AFTER CONSTRUCTION PHASE LOD STAKEOUT AND PRIOR TO THE INSTALLATION OF SEDIMENT AND EROSION CONTROLS. LOCATION OF THE FENCING MUST BE APPROVED BY THE INSPECTOR.

4. CLEAR AND GRUB FOR THE MINIMUM AREA REQUIRED FOR INSTALLATION OF THE STABILIZED CONSTRUCTION ENTRANCE (SCE), DIVERSION FENCE (DF), OUTLET PROTECTION (OP), AND SUPER SILT FENCE (SSF). INSTALL SCE, SSF, ACCESS ROAD, AND STAGING/STOCKPILE AREAS.

5. THE CONTRACTOR SHALL STABILIZE ALL DISTURBED AREAS BY THE END OF EACH WORK DAY.

6. WHERE PUMP AROUND PRACTICES ARE UTILIZED, THE EXACT LOCATION OF THE HOSES AND FILTER BAG MAY BE MODIFIED IN THE FIELD BASED ON EXISTING CONDITIONS. ANY ADJUSTMENTS MUST BE APPROVED BY THE ENGINEER.

7. WHERE FILTER LOGS ARE UTILIZED, THE ELEVATION OF THE FILTER LOGS SHALL BE ADJUSTED TO MEET GRADE AT ALL TIMES DURING THE FLOODPLAIN EXCAVATION. THE FILTER LOGS SHALL BE REMOVED AFTER EACH WORK AREA IS PERMANENTLY STABILIZED.

8. WORK WITHIN THE FLOODPLAIN SHALL BE CONDUCTED IN AN ORDER WHICH DOES NOT REQUIRE THE CONTRACTOR TO TRACK OVER FINISHED GRADING OR CROSS OVER THE STREAM IN ANY AREAS OTHER THAN THOSE SHOWN ON THE PLANS. THE ACCESS ROAD AND ANY STOCKPILE AREAS WILL BE REMOVED DURING THE FLOODPLAIN GRADING WORK IN EACH CONSTRUCTION PHASE.

9. THE STREAM WORK IS DIVIDED INTO 7 PHASES AS SHOWN ON THE EROSION AND SEDIMENT CONTROL PLANS. WORK IN THE STREAM AREAS MUST OCCUR IN ORDER FROM DOWNSTREAM TO UPSTREAM UNLESS OTHERWISE SPECIFIED.

10. BEGIN WORK IN ACCORDANCE WITH THE INDIVIDUAL SEQUENCES FOR EACH WORK AREA.

11. CONTINGENT STREAMBED MATERIAL SHALL BE HARVESTED DURING THE PHASE IN WHICH IT IS LOCATED ON THE PLANS, UTILIZING AN APPROVED PUMP–AROUND PRACTICE

12. UPON COMPLETION OF HEAVY CONSTRUCTION INSTALL PERMANENT PLANTINGS. PERMANENT LANDSCAPING MAY BE PHASED AND COMPLETED AT THE END OF EACH CONSTRUCTION PHASE BEFORE OR AFTER PHASES 1–6 ARE COMPLETE AND THEN AGAIN AFTER PHASE 7 IS COMPLETE. THE AREA WITHIN THE LIMIT OF PLANTING (LOP) MAY ONLY BE ACCESSED BY ALL–TERRAIN VEHICLES AND HAND–TOOLS AND NO SOIL DISTURBANCE OTHER THAN THAT REQUESTED DURING PLANTING IS AUTHORIZED.

13. THE ACCESS PATH WITHIN EACH PHASE SHALL BE REMOVED UPON COMPLETION.

14. UPON APPROVAL OF THE INSPECTOR, REMOVE REMAINING EROSION AND SEDIMENT CONTROL MEASURES AND STABILIZE ANY AREAS DISTURBED BY THEIR REMOVAL.

STREAM CONSTRUCTION PHASE 1 – WATERING TROUGH, 5 STRAND POST AND WIRE ELECTRIC FENCE, AND STA. 28+50 – STA. 29+87 (SHEETS ES–1 – ES–4)

15. INSTALL WATERING TROUGH SYSTEM AS LOCATED ON THE PLANS AND UNDER THE DIRECTION OF THE DESIGNATED STREAM SPECIALIST (SEE PLAN SHEET ES–4).

16. INSTALL 5 STRAND POST AND WIRE ELECTRIC FENCE WHERE SHOWN ON PLANS WITH THE EXCEPTION FROM STA. 12+59, LEFT TO STA 15+33, LEFT. IN THIS LOCATION ORANGE CONSTRUCTION FENCE SHALL BE INSTALLED TO ALLOW FOR THE FUTURE CONSTRUCTION OF THE OXBOW POOL AND CLASS 0 RIPRAP INSTALLATION (SEE PLAN SHEET ES–01 AND ES–02).

17. INSTALL PUMP–AROUND 1A (PA–1A), AS SHOWN ON THE PLANS. PA–1A SHALL BE MAINTAINED THROUGHOUT PHASE 1. IF 24–HOUR PUMPING IS REQUIRED, IT MUST BE PRE–APPROVED BY THE ENGINEER AND THE INSPECTOR. THE PUMPS MUST BE MANNED AT ALL TIMES OF OPERATION.

18. GRADE THE PROPOSED CHANNEL TO STA 28+50. GRADE THE UNNAMED TRIBUTARY NO.4 (UT–4) (SEE PLAN SHEET SR–03). INSTALL ALL IN–STREAM STRUCTURES WITHIN THIS REACH. BEGIN GRADING THE PROPOSED FLOODPLAIN AND FILL THE EXISTING CHANNEL TO STA. 29+00.

19. INSTALL THE FABRIC BASED STREAM DIVERSION (FBSD–1) AND SANDBAG DIKE 1 (SD–1) AT THE LOCATIONS SHOWN ON THE PLANS.

20. FINISH THE FLOODPLAIN GRADING AND BACK–FILL THE EXISTING CHANNEL TO SD–1. INSTALL THE FLOODPLAIN STRUCTURES WITHIN WORK AREA 1.

21. REMOVE PA–1A BY HAND AFTER THE WORK IN THIS AREA IS COMPLETE.

22. PERMANENTLY STABILIZE THE WORK AREA WITH PERMANENT SEEDING AND TYPE "D" SOIL STABILIZATION MATTING (SEE DETAIL SHEET SD–2 FOR STREAMBANK /FLOODPLAIN STABILIZATION DETAILS). INSTALL THE 18" FILTER LOGS AT THE UPSTREAM END OF WORK AREA 1 AS SHOWN ON THE PLANS.

STREAM CONSTRUCTION PHASE 2 – STA. 22+18 – STA. 28+50 (SHEETS ES–5 – ES–7)

23. INSTALL PA–1B, AS SHOWN ON THE PLANS. EXCAVATE THE PROPOSED STREAM AND FLOODPLAIN TO STA. 22+18 AND GRADE TO THE TEMPORARY GRADE LIMIT LINE (8' MIN FROM THE TOP OF THE EXISTING BANK) AS SHOWN ON THE PLANS AND INSTALL ALL STRUCTURES WITHIN THE TEMPORARY GRADE LIMITS.

24. INSTALL THE TEMPORARY FLOODPLAIN STOCKPILES WHEN THE LOCATIONS SHOWN ON THE PLANS ARE AT FINAL GRADE. EXCAVATED MATERIAL MAY ONLY BE STOCKPILED TEMPORARILY (72 HOURS MAX) IN THESE DESIGNATED AREAS.

25. INSTALL PA–2A IN THE LOCATION SHOWN ON THE PLANS. WHEN PA–2A IS PROPERLY INSTALLED, INSTALL TEMPORARY BRIDGE 2 IN THE LOCATION SHOWN ON THE PLANS.

26. INSTALL FBSD–2 AND SD–2 IN THE LOCATIONS SHOWN ON THE PLANS. WHEN FBSD–2 IS PROPERLY INSTALLED, REMOVE PA–2A, FBSD–1, AND SD–1. MAINTAIN PA–1B FOR THE FIRST FLUSH. REMOVE PA–1B WHEN THE FLOW THROUGH THE NEWLY CONSTRUCTED CHANNEL IS CLEAR.

27. GRADE THE FLOODPLAIN IN THE WORK AREA AND BACK–FILL THE EXISTING CHANNEL DOWNSTREAM OF SD–2. A DEWATERING SET–UP MAY BE NEEDED IN ORDER TO KEEP THE WORK AREA DRY. GRADE THE OXBOW POOL AND ASSOCIATED TRIBUTARIES WITHIN THE WORK AREA. INSTALL REMAINING FLOODPLAIN STRUCTURES. REMOVE THE STOCKPILE AREA LAST DURING THE FLOODPLAIN GRADING.

28. PERMANENTLY STABILIZE THE WORK AREA WITH PERMANENT SEEDING AND TYPE "D" SOIL STABILIZATION MATTING. REMOVE THE 18" FILTER LOGS IN WORK AREA 1 AND INSTALL 18" FILTER LOGS AT THE UPSTREAM END OF WORK AREA 2 AS SHOWN ON THE PLANS.

STREAM CONSTRUCTION PHASE 3 – STA. 16+75 – STA. 22+18 (SHEETS ES–8 – ES–10)

29. INSTALL PA–2B, AS SHOWN ON THE PLANS. EXCAVATE THE PROPOSED STREAM AND FLOODPLAIN TO STA. 16+75 AND GRADE TO THE TEMPORARY GRADE LIMIT LINE SHOWN ON THE PLANS. INSTALL ALL STRUCTURES WITHIN THE TEMPORARY GRADE LIMITS.

30. INSTALL THE TEMPORARY FLOODPLAIN STOCKPILE WHEN THE LOCATION SHOWN ON THE PLANS IS AT FINAL GRADE. EXCAVATED MATERIAL MAY ONLY BE STOCKPILED TEMPORARILY (72 HOURS MAX) IN THESE DESIGNATED AREAS.

31. INSTALL HARDWOOD CONSTRUCTION MATS AND TTMSC–2 FOR ACCESS AS SHOWN ON THE PLANS. INSTALL PA–3A IN THE LOCATIONS SHOWN ON THE PLANS. THE LOCATION OF PA–3A US SHOULD BE ACCESSED BY FOOT AND SANDBAGS AND PUMP PLACED BY HAND.

32. INSTALL FBSD–3 AND SD–3 IN THE LOCATIONS SHOWN ON THE PLANS. WHEN FBSD–3 IS PROPERLY INSTALLED, REMOVE PA–3A, FBSD–2, AND SD–2. MAINTAIN PA–2B FOR THE FIRST FLUSH. REMOVE PA–2B WHEN THE FLOW THROUGH THE NEWLY CONSTRUCTED CHANNEL IS CLEAR.

33. GRADE THE FLOODPLAIN IN THE WORK AREA AND BACK–FILL THE EXISTING CHANNEL DOWNSTREAM OF SD–3. A DEWATERING SET–UP MAY BE NEEDED IN ORDER TO KEEP THE WORK AREA DRY. INSTALL ALL REMAINING FLOODPLAIN STRUCTURES.

34. REMOVE TTMSC–2 AND THE ASSOCIATED HARDWOOD CONSTRUCTION MATS. PERMANENTLY STABILIZE THE WORK AREA WITH OERMANENT SEEDING AND TYPE "D" SOIL STABILIZATION MATTING. REMOVE THE 18" FILTER LOGS IN WORK AREA 2 AND INSTALL 18" FILTER LOGS AT THE UPSTREAM END OF WORK AREA 3 AS SHOWN ON THE PLANS.

STREAM CONSTRUCTION PHASE 4 – STA. 11+50 – STA. 16+75 (SHEETS ES–11 – ES–13)

35. INSTALL PA–3B, AS SHOWN ON THE PLANS. EXCAVATE THE PROPOSED STREAM AND FLOODPLAIN TO STA. 11+50 AND GRADE TO THE TEMPORARY GRADE LIMIT LINE SHOWN ON THE PLANS. INSTALL ALL STRUCTURES WITHIN THE TEMPORARY GRADE LIMIT.

36. INSTALL THE TEMPORARY FLOODPLAIN STOCKPILES WHEN THE LOCATIONS SHOWN ON THE PLANS ARE AT FINAL GRADE. EXCAVATED MATERIAL MAY ONLY BE STOCKPILED TEMPORARILY (72 HOURS MAX) IN THESE DESIGNATED AREAS.

37. INSTALL HARDWOOD CONSTRUCTION MATS AND TTMSC–3 FOR ACCESS AS SHOWN ON THE PLANS. INSTALL PA–4A IN THE LOCATIONS SHOWN ON THE PLANS.

38. INSTALL FBSD–4 AND SD–4 IN THE LOCATIONS SHOWN ON THE PLANS. WHEN FBSD–4 IS PROPERLY INSTALLED, REMOVE PA–4A, FBSD–3, AND SD–3. MAINTAIN PA–3B FOR THE FIRST FLUSH. REMOVE PA–3B WHEN THE FLOW THROUGH THE NEWLY CONSTRUCTED CHANNEL IS CLEAR.

39. GRADE THE REMAINING FLOODPLAIN IN THE WORK AREA AND BACK–FILL THE EXISTING CHANNEL DOWNSTREAM OF SD–4. A DEWATERING SET–UP MAY BE NEEDED IN ORDER TO KEEP THE WORK AREA DRY. GRADE THE OXBOW POOL AND ASSOCIATED TRIBUTARIES WITHIN THE WORK AREA. INSTALL ALL REMAINING FLOODPLAIN STRUCTURES.

40. INSTALL REMAINING 5 STRAND POST AND WIRE ELECTRIC FENCE FROM STATION 12+59, LEFT TO STATION 15+33, LEFT.

41. REMOVE TTMSC–3 AND THE ASSOCIATED HARDWOOD CONSTRUCTION MATS. PERMANENTLY STABILIZE THE WORK AREA WITH PERMANENT SEEDING AND TYPE "D" SOIL STABILIZATION MATTING. REMOVE THE 18" FILTER LOGS IN WORK AREA 3 AND INSTALL 18" FILTER LOGS AT THE UPSTREAM END OF WORK AREA 4 AS SHOWN ON THE PLANS.

STREAM CONSTRUCTION PHASE 5 – STA. 7+50 – STA. 11+50 (SHEETS ES–14 – ES–16)

42. INSTALL PA–4B, AS SHOWN ON THE PLANS. EXCAVATE THE PROPOSED STREAM AND FLOODPLAIN TO STA. 7+50 AND GRADE TO THE TEMPORARY GRADE LIMIT LINE SHOWN ON THE PLANS. INSTALL ALL STRUCTURES WITHIN THE TEMPORARY GRADE LIMITS.

43. INSTALL THE TEMPORARY FLOODPLAIN STOCKPILE WHEN THE LOCATION SHOWN ON THE PLANS IS AT FINAL GRADE. EXCAVATED MATERIAL MAY ONLY BE STOCKPILED TEMPORARILY (72 HOURS MAX) IN THESE DESIGNATED AREAS.

44. INSTALL TRIB–PA–3 IN UT–2 AND REMOVE TTMSC–1.

45. INSTALL INSTREAM STRUCTURES AND COMPLETE THE PROPOSED GRADING IN UT–2 (SEE SHEET SR–1). REPLACE THE CROSSING WHEN COMPLETE.

46. CONTINUE GRADING THE PROPOSED CHANNEL AND FLOODPLAIN FROM 9+50 TO 7+50 AND GRADING THE FLOODPLAIN TO THE TEMPORARY GRADE LIMIT LINE. REMOVE TRIB–PA–3 WHEN UT–2 IS TIED IN TO THE PROPOSED CHANNEL.

47. INSTALL TTMSC–4 AND PA–5A IN THE LOCATIONS SHOWN ON THE PLANS.

48. INSTALL FBSD–5 AND SD–5 IN THE LOCATIONS SHOWN ON THE PLANS. WHEN FBSD–5 IS PROPERLY INSTALLED, REMOVE PA–5A, FBSD–4, AND SD–4. MAINTAIN PA–4B FOR THE FIRST FLUSH. REMOVE PA–4B WHEN THE FLOW THROUGH THE NEWLY CONSTRUCTED CHANNEL IS CLEAR.

49. GRADE PROPOSED UT–3 AND INSTALL THE INSTREAM STRUCTURE (SEE SHEET SR–2).

50. GRADE THE REMAINING FLOODPLAIN IN THE WORK AREA AND BACK–FILL THE EXISTING CHANNEL DOWNSTREAM OF SD–5. A DEWATERING SET–UP MAY BE NEEDED IN ORDER TO KEEP THE WORK AREA DRY. GRADE THE OXBOW POOL AND ASSOCIATED TRIBUTARIES WITHIN THE WORK AREA. INSTALL ALL REMAINING FLOODPLAIN STRUCTURES.

51. REMOVE TTMSC–4 AND THE ASSOCIATED HARDWOOD CONSTRUCTION MATS. PERMANENTLY STABILIZE THE WORK AREA WITH PERMANENT SEEDING AND TYPE "D" SOIL STABILIZATION MATTING. REMOVE THE 18" FILTER LOGS IN WORK AREA 4 AND INSTALL 18" FILTER LOGS AT THE UPSTREAM END OF WORK AREA 5 AS SHOWN ON THE PLANS.

STREAM CONSTRUCTION PHASE 6 – STA. 4+67 – STA. 7+50 (SHEETS ES–17 – ES–19)

52. INSTALL PA–5B, AS SHOWN ON THE PLANS. EXCAVATE THE PROPOSED STREAM AND FLOODPLAIN TO STA. 5+25 AND GRADE THE FLOODPLAIN TO THE TEMPORARY GRADE LIMIT LINE SHOWN ON THE PLANS. INSTALL ALL STRUCTURES WITHIN THE TEMPORARY GRADE LIMITS.

53. INSTALL THE TEMPORARY FLOODPLAIN STOCKPILES WHEN THE LOCATIONS SHOWN ON THE PLANS ARE AT FINAL GRADE. EXCAVATED MATERIAL MAY ONLY BE STOCKPILED TEMPORARILY (72 HOURS MAX) IN THESE DESIGNATED AREAS.

54. INSTALL PA–6A IN THE LOCATION SHOWN ON THE PLANS.

55. INSTALL FBSD–6 AND SD–6 IN THE LOCATIONS SHOWN ON THE PLANS. WHEN FBSD–6 IS PROPERLY INSTALLED, REMOVE PA–6A, FBSD–5, AND SD–5. MAINTAIN PA–5B FOR THE FIRST FLUSH. REMOVE PA–5B WHEN THE FLOW THROUGH THE NEWLY CONSTRUCTED CHANNEL IS CLEAR.

56. GRADE THE REMAINING FLOODPLAIN IN THE WORK AREA AND BACK–FILL THE EXISTING CHANNEL DOWNSTREAM OF SD–6. A DEWATERING SET–UP MAY BE NEEDED IN ORDER TO KEEP THE WORK AREA DRY. REMOVE THE STOCKPILE AREA LAST DURING THE FLOODPLAIN GRADING.

57. CONTINUE GRADING THE PROPOSED CHANNEL TO STA 4+67 AND INSTALL ALL REMAINING INSTREAM AND FLOODPLAIN STRUCTURES.

58. PERMANENTLY STABILIZE THE WORK AREA WITH PERMANENT SEEDING AND TYPE "D" SOIL STABILIZATION MATTING. INSTALL ALL REMAINING PERMANENT PLANTINGS IN WORK AREAS 1–6.

59. REMOVE THE 18" FILTER LOGS IN WORK AREA 5 AND INSTALL 18" FILTER LOGS AT THE UPSTREAM END OF WORK AREA 6 AS SHOWN ON THE PLANS AND REMOVE THE TEMPORARY BRIDGE.

STREAM CONSTRUCTION PHASE 7 – STA. 1+00 – STA. 4+50 (SHEET ES–20)

60. INSTALL PA–6B, AS SHOWN ON THE PLANS. EXCAVATE THE PROPOSED STREAM AND FLOODPLAIN FROM STA. 5+25 TO STA. 1+00 AND GRADE THE FLOODPLAIN TO THE TEMPORARY GRADE LIMIT LINE AS SHOWN ON THE PLANS. INSTALL ALL STRUCTURES WITHIN THE TEMPORARY GRADE LIMITS. EXCAVATE UT–1 TO STA. 101+00 (SEE SHEET SR–1).

61. INSTALL THE TEMPORARY FLOODPLAIN STOCKPILE WHEN THE LOCATION SHOWN ON THE PLANS IS AT FINAL GRADE. EXCAVATED MATERIAL MAY ONLY BE STOCKPILED TEMPORARILY (72 HOURS MAX) IN THESE DESIGNATED AREAS.

62. INSTALL TTMSC–5 AND PA–7A IN THE LOCATION SHOWN ON THE PLANS.

63. THE WORK IN THIS STEP SHALL BE DONE IN A SINGLE WORK DAY. GRADE THE REMAINING PROPOSED CHANNEL AND INSTALL THE CLASS II RIPRAP SCOUR PROTECTION. INSTALL REMAINING INSTREAM STRUCTURES. REMOVE PA–7A WHEN THE WORK IS COMPLETE.

64. INSTALL TRIB–PA–4 IN UT–1. WHEN TRIB–PA–3 IS PROPERLY INSTALLED REMOVE FBSD–6 AND SD–6. MAINTAIN PA–6B FOR THE FIRST FLUSH. REMOVE PA–6B WHEN THE FLOW THROUGH THE NEWLY CONSTRUCTED CHANNEL IS CLEAR.

65. GRADE THE REMAINING FLOODPLAIN AND BACK–FILL THE EXISTING CHANNEL. GRADE UT–1 AND INSTALL ALL INSTREAM STRUCTURES (SEE SHEET SR–1). INSTALL ALL REMAINING FLOODPLAIN STRUCTURES.

66. REMOVE TTMSC–5, PERMANENTLY STABILIZE THE WORK AREA WITH PERMANENT SEEDING AND TYPE "D" SOIL STABILIZATION MATTING, AND REMOVE THE 18" FILTER LOGS IN WORK AREA 6.

67. INSTALL ALL REMAINING PLANTINGS IN WORK AREA 7.

COASTAL RESOURCES INC.

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

EROSION & SEDIMENT CONTROL NOTES

SCALE N.T.S. ADVERTISED DATE JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY MJD
DRAWN BY MJD
CHECKED BY ETK
F.A.P. NO. SEE TITLE SHEET

COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. EN-2 OF 6 SHEET NO. 20 OF 53

PLOTTED: Thursday, April 20, 2017 AT 03:42 PM
FILE: G:\Active\2014-16 BCS 2012-03D EPD Env Design-Permitting, EA-JMT\Task 17 Little Catoctin Creek\CAD\pES-N002.dgn

BY: matthewd –

FENCE - LIMIT OF DISTURBANCE				
NO	STATION	OFFSET(FT)	NORTHING	EASTING
1001	4+94.45	92.00 LT	610540.9433	1133438.8844
1002	4+97.62	85.11 LT	610534.4244	1133445.5751
1003	5+02.96	112.57 LT	610560.2122	1133471.3765
1004	5+03.45	106.21 LT	610553.5329	1133472.6995
1005	5+12.39	118.35 LT	610550.2121	1133518.7458
1006	5+13.12	111.14 LT	610542.0924	1133518.5140
1007	5+95.03	116.19 LT	610518.8495	1133555.9214
1008	5+97.50	123.75 LT	610525.6976	1133559.9610
1009	6+18.64	89.50 LT	610473.9640	1133602.0303
1010	6+18.93	98.92 LT	610481.0955	1133608.3258
1011	6+37.65	97.56 LT	610406.5099	1133659.0231
1012	6+38.20	90.52 LT	610402.3812	1133652.7438
1013	7+91.12	96.05 LT	610362.8852	1133684.6600
1014	7+96.91	92.69 LT	610346.7197	1133708.3693
1015	7+98.93	81.98 LT	610332.5463	1133709.4277
1016	8+10.88	91.58 LT	610294.1482	1133749.3082
1017	10+03.04	112.03 LT	610234.5580	1133783.9457
1018	10+05.14	113.96 LT	610233.3011	1133795.6511
1019	11+04.48	97.43 LT	610170.5146	1133868.1250
1020	11+06.76	93.45 LT	610162.9320	1133876.9735
1021	11+07.82	120.62 LT	610185.3332	1133893.3253
1022	11+09.60	116.63 LT	610177.0424	1133900.5371
1023	11+10.29	81.74 LT	610145.2630	1133885.7392
1024	11+96.69	69.12 LT	610108.3345	1133925.1281
1025	12+17.66	56.48 LT	610056.9093	1133978.8260
1026	12+17.76	67.94 LT	610062.3116	1133988.9485
1027	14+74.89	120.52 LT	610028.9901	1134061.3158
1028	14+75.38	110.61 LT	610019.4275	1134064.8490
1029	14+86.77	86.99 LT	609992.4078	1134111.4442
1030	15+06.58	81.82 LT	609981.9089	1134129.5494
1031	15+08.70	87.99 LT	609987.2669	1134133.2671
1032	15+32.92	65.96 LT	609949.9606	1134168.4418
1033	15+38.92	75.34 LT	609942.8019	1134191.4945
1034	15+39.53	69.54 LT	609937.1749	1134188.7867
1035	15+87.72	109.44 LT	609879.7635	1134272.0054
1036	16+92.53	102.63 LT	609873.8626	1134267.9788
1037	18+33.91	84.31 LT	609804.7408	1134322.0016
1038	18+35.10	90.11 LT	609810.2976	1134327.7260

WATER TROUGH - LIMIT OF DISTURBANCE				
NO	STATION	OFFSET(FT)	NORTHING	EASTING
1039	6+26.48	840.84 LT	610924.5435	1134211.2458
1040	6+26.73	817.17 LT	610903.0252	1134198.1962
1041	6+26.81	818.13 LT	610901.5872	1134200.5674
1042	6+26.84	668.26 LT	610807.7696	1134083.6914
1043	6+26.85	644.22 LT	610792.6490	1134064.9953
1044	6+26.91	742.77 LT	610852.3318	1134143.4417
1045	6+27.03	668.12 LT	610803.4234	1134086.9159
1046	6+27.07	848.49 LT	610913.1035	1134230.1098
1047	6+27.11	845.60 LT	610910.4559	1134228.5041
1048	6+27.15	822.58 LT	610895.2913	1134211.1331
1049	6+27.30	828.26 LT	610894.5503	1134218.8583
1050	6+27.34	825.03 LT	610891.5853	1134217.0602
1051	6+27.42	878.24 LT	610921.4501	1134261.1869
1052	6+27.47	667.62 LT	610793.5446	1134093.8421
1053	6+27.70	667.73 LT	610788.5441	1134097.6937
1054	6+27.74	643.71 LT	610773.4235	1134078.9976
1055	6+27.76	877.44 LT	610911.0499	1134267.9071
1056	6+27.82	924.46 LT	610936.9387	1134307.2303
1057	6+28.19	971.51 LT	610952.6288	1134353.8724
1058	6+28.32	1,021.33 LT	610976.9540	1134397.6723
1059	6+28.40	1,010.48 LT	610968.0676	1134390.6444
1060	6+28.49	969.12 LT	610941.5821	1134358.6707
1061	6+28.70	1,008.09 LT	610956.4029	1134395.7250
1062	8+02.28	1,016.01 LT	610955.4923	1134406.9117

PHASE 1 - LIMIT OF DISTURBANCE				
NO	STATION	OFFSET(FT)	NORTHING	EASTING
1	1+14.20	135.09 LT	610599.1667	1133107.6437
2	1+40.74	116.61 LT	610580.6258	1133110.5777
3	1+62.05	149.95 LT	610616.1778	1133127.9437
4	1+70.76	70.30 LT	610538.3448	1133152.7483
5	1+72.21	155.29 LT	610623.2328	1133160.5400
6	3+35.15	158.45 LT	610600.2032	1133258.0256
7	3+36.97	60.57 LT	610507.2367	1133289.8948
8	3+37.37	50.10 LT	610497.1930	1133293.1055
9	3+37.88	78.08 LT	610525.0591	1133290.0364
10	3+39.31	38.57 LT	610486.5620	1133299.9772
11	3+43.16	78.42 LT	610526.7184	1133311.1050
12	3+43.18	50.46 LT	610498.7748	1133310.0576
13	3+43.60	114.20 LT	610562.3534	1133314.8475
14	3+46.60	40.76 LT	610488.1580	1133318.3969
15	3+51.15	14.49 LT	610460.4629	1133320.7508
16	28+50.27	28.96 LT	609234.5140	1134940.3747
17	28+70.04	68.22 LT	609275.1126	1134968.3696
18	28+90.10	50.08 LT	609248.6744	1134998.7755
19	29+60.13	37.62 LT	609224.9290	1135044.0568
20	29+87.32	33.51 LT	609208.1504	1135105.3388
21	4+05.64	114.90 RT	610312.1351	1133392.0405
22	4+08.64	46.76 RT	610380.7872	1133382.9036
23	4+12.10	108.01 RT	610332.4337	1133422.9983
24	4+16.75	42.33 RT	610391.7116	1133394.1530
25	4+20.18	63.76 RT	610375.0859	1133408.0985
26	5+58.97	100.75 RT	610323.7550	1133451.1545
27	6+85.80	109.67 RT	610293.3919	1133473.5076
28	7+34.00	146.54 RT	610213.6308	1133480.4398
29	7+41.68	90.77 RT	610237.1882	1133531.9605
30	8+82.79	91.49 RT	610165.5432	1133583.4642
31	8+99.45	117.01 RT	610142.9546	1133563.0017
32	9+09.20	56.20 RT	610148.9577	1133624.3033
33	9+14.33	68.35 RT	610135.0532	1133615.8065
34	9+32.35	38.97 RT	610113.1450	1133666.6348
35	9+41.37	59.84 RT	610083.8624	1133676.2187
36	10+46.74	65.98 RT	610061.2324	1133727.9966
37	10+57.86	76.58 RT	610024.4535	1133745.4786
38	10+66.48	68.45 RT	610015.7383	1133778.7308
39	13+06.65	93.22 RT	609936.6183	1133842.1515
40	13+08.39	66.31 RT	609932.4138	1133869.5564
41	13+44.04	40.80 RT	609885.2848	1133921.9357
42	13+53.05	54.28 RT	609869.1150	1133917.5914
43	13+57.97	38.09 RT	609871.0088	1133938.4091
44	13+61.86	53.43 RT	609852.4617	1133937.9246
45	13+66.87	40.10 RT	609858.2404	1133956.0766
46	13+78.83	55.12 RT	609838.8136	1133984.7990
47	16+29.70	109.80 RT	609782.7243	1134063.7778
48	16+37.03	104.58 RT	609748.1641	1134084.4094
49	16+46.90	80.60 RT	609730.2429	1134134.3605
50	17+61.85	63.25 RT	609673.8965	1134207.7016
51	17+70.72	67.05 RT	609653.4904	1134233.6149
52	17+72.02	85.21 RT	609634.5810	1134232.6048
53	17+73.69	72.57 RT	609644.7365	1134242.9951
54	17+76.47	81.12 RT	609634.1767	1134252.8698
55	19+69.00	60.46 RT	609591.1914	1134292.1148
56	19+78.03	49.26 RT	609567.7334	1134313.1355
57	20+82.71	63.18 RT	609514.9275	1134343.6081
58	20+94.32	32.32 RT	609504.6008	1134374.9214
59	21+11.73	17.60 RT	609483.0182	1134392.2370
60	21+22.65	28.59 RT	609459.3067	1134394.3422
61	21+25.08	13.23 RT	609467.6110	1134408.0157
62	21+90.76	67.57 RT	609393.7355	1134480.5539
63	22+11.07	64.05 RT	609397.6516	1134500.7913
64	24+33.37	54.38 RT	609347.3773	1134564.5666
65	24+43.41	56.23 RT	609316.5712	1134576.3936
66	24+44.75	66.57 RT	609306.4819	1134571.1385
67	24+50.98	91.26 RT	609270.3959	1134573.7771
68	25+97.07	51.65 RT	609243.7233	1134671.2801
69	26+03.63	24.11 RT	609242.7241	1134700.0153
70	26+08.11	82.03 RT	609207.6468	1134652.1347
71	26+10.79	16.95 RT	609234.0825	1134712.0396
72	26+16.95	31.43 RT	609215.5318	1134709.1083
73	26+27.51	14.62 RT	609219.7556	1134734.7459
74	26+39.01	25.44 RT	609207.5972	1134754.3650
75	27+92.47	83.63 RT	609117.8362	1134874.4580
76	27+95.75	69.59 RT	609130.9053	1134889.0883
77	28+13.18	78.60 RT	609123.8528	1134913.9251
78	28+15.12	97.70 RT	609105.0360	1134917.7208
79	28+31.69	82.21 RT	609122.0677	1134932.7023
80	28+49.31	81.48 RT	609124.5095	1134950.1690

PHASE 1 - LIMIT OF DISTURBANCE (CONT.)				
NO	STATION	OFFSET(FT)	NORTHING	EASTING
81	29+01.45	94.70 RT	609108.4062	1134961.1706
82	29+32.29	64.71 RT	609126.2989	1135000.4940
83	29+38.42	43.11 RT	609143.2701	1135021.5715
84	29+41.50	46.67 RT	609139.0175	1135028.6053
85	29+63.31	21.76 RT	609166.5818	1135055.5429
86	29+87.32	31.83 RT	609160.6988	1135084.3192

PHASE 2 - LIMIT OF DISTURBANCE				
NO	STATION	OFFSET(FT)	NORTHING	EASTING
1	1+14.20	135.09 LT	610599.1667	1133107.6437
2	1+40.74	116.61 LT	610580.6258	1133110.5777
3	1+62.05	149.95 LT	610616.1778	1133127.9437
4	1+70.76	70.30 LT	610538.3448	1133152.7483
5	1+72.21	155.29 LT	610623.2328	1133160.5400
6	3+35.15	158.45 LT	610600.2032	1133258.0256
7	3+36.97	60.57 LT	610507.2367	1133289.8948
8	3+37.37	50.10 LT	610497.1930	1133293.1055
9	3+37.88	78.08 LT	610525.0591	1133290.0364
10	3+39.31	38.57 LT	610486.5620	1133299.9772
11	3+43.16	78.42 LT	610526.7184	1133311.1050
12	3+43.18	50.46 LT	610498.7748	1133310.0576
13	3+43.60	114.20 LT	610562.3534	1133314.8475
14	3+46.60	40.76 LT	610488.1580	1133318.3969
15	3+51.15	14.49 LT	610460.4629	1133320.7508
17	28+70.04	68.22 LT	609275.1126	1134968.3696
18	28+90.10	50.08 LT	609248.6744	1134998.7755
21	4+05.64	114.90 RT	610312.1351	1133392.0405
22	4+08.64	46.76 RT	610380.7872	1133382.9036
23	4+12.10	108.01 RT	610332.4337	1133422.9983
24	4+16.75	42.33 RT	610391.7116	1133394.1530
25	4+20.18	63.76 RT	610375.0859	1133408.0985
26	5+58.97	100.75 RT	610323.7550	1133451.1545
27	6+85.80	109.67 RT	610293.3919	1133473.5076
28	7+34.00	146.54 RT	610213.6308	1133480.4398
29	7+41.68	90.77 RT	610237.1882	1133531.9605
30	8+82.79	91.49 RT	610165.5432	1133583.4642
31	8+99.45	117.01 RT	610142.9546	1133563.0017
32	9+09.20	56.20 RT	610148.9577	1133624.3033
33	9+14.33	68.35 RT	610135.0532	1133615.8065
34	9+32.35	38.97 RT	610113.1450	1133666.6348
35	9+41.37	59.84 RT	610083.8624	1133676.2187
36	10+46.74	65.98 RT	610061.2324	1133727.9966
37	10+57.86	76.58 RT	610024.4535	1133745.4786
38	10+66.48	68.45 RT	610015.7383	1133778.7308
39	13+06.65	93.22 RT	609936.6183	1133842.1515
40	13+08.39	66.31 RT	609932.4138	1133869.5564
41	13+44.04	40.80 RT	609885.2848	1133921.9357
42	13+53.05	54.28 RT	609869.1150	1133917.5914
43	13+57.97	38.09 RT	609871.0088	1133938.4091
44	13+61.86	53.43 RT	609852.4617	1133937.9246
45	13+66.87	40.10 RT	609858.2404	1133956.0766
46	13+78.83	55.12 RT	609838.8136	1133984.7990
47	16+29.70	109.80 RT	609782.7243	1134063.7778
48	16+37.03	104.58 RT	609748.1641	1134084.4094
49	16+46.90	80.60 RT	609730.2429	1134134.3605
50	17+61.85	63.25 RT	609673.8965	1134207.7016
51	17+70.72	67.05 RT	609653.4904	1134233.6149
52	17+72.02	85.21 RT	609634.5810	1134232.6048
53	17+73.69	72.57 RT	609644.7365	1134242.9951
54	17+76.47	81.12 RT	609634.1767	1134252.8698
55	19+69.00	60.46 RT	609591.1914	1134292.1148
56	19+78.03	49.26 RT	609567.7334	1134313.1355
57	20+82.71	63.18 RT	609514.9275	1134343.6081
58	20+94.32	32.32 RT	609504.6008	1134374.9214
59	21+11.73	17.60 RT	609483.0182	1134392.2370
60	21+22.65	28.59 RT	609459.3067	1134394.3422
61	21+25.08	13.23 RT	609467.6110	1134408.0157
62	21+90.76	67.57 RT	609393.7355	1134480.5539
65	24+43.41	56.23 RT	609316.5712	1134576.3936
66	24+44.75	66.57 RT	609306.4819	1134571.1385
67	24+50.98	91.26 RT	609270.3959	1134573.7771
68	25+97.07	51.65 RT	609243.7233	1134671.2801
70	26+08.11	82.03 RT	609207.6468	1134652.1347
72	26+16.95	31.43 RT	609215.5318	1134709.1083
75	27+92.47	83.63 RT	609117.8362	1134874.4580
78	28+15.12	97.70 RT	609105.0360	1134917.7208
81	29+01.45	94.70 RT	609108.4062	1134961.1706
88	20+77.10	58.60 LT	609525.5677	1134465.0506
89	21+73.41	33.16 LT	609494.4599	1134471.2639

PHASE 2 - LIMIT OF DISTURBANCE (CONT.)				
NO	STATION	OFFSET(FT)	NORTHING	EASTING
90	22+32.53	95.88 LT	609557.9634	1134519.1323
91	22+95.01	143.79 LT	609617.3122	1134555.0221
92	22+99.05	123.35 LT	609599.6835	1134583.3817
93	23+20.04	103.43 LT	609535.6046	1134682.2013
94	23+35.75	108.64 LT	609486.5101	1134714.0258
95	25+21.11	131.99 LT	609442.3521	1134754.6992
96	25+36.00	141.52 LT	609390.6924	1134824.7780
97	27+28.78	111.96 LT	609339.0327	1134894.8568
98	29+11.50	6.62 LT	609200.5623	1135004.4544
99	21+76.40	32.73 RT	609429.8463	1134458.0967
100	21+83.94	11.49 RT	609449.6681	1134472.6415
101	29+12.41	84.13 RT	609114.7104	1134975.0255
102	29+18.23	25.82 RT	609167.7382	1134999.9730

COASTAL RESOURCES INC.

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

LOD STAKEOUT (PHASES 1 & 2)

SCALE NTS ADVERTISED DATE JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY MJD
DRAWN BY MJD
CHECKED BY ETK
F.A.P. NO. SEE TITLE SHEET

COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. EN-3 OF 6 SHEET NO. 21 OF 53

SHEET REVISION DATE: NOVEMBER 24, 2020

BY: matthewd -

PLOTTED: Thursday, April 20, 2017 AT 03:42 PM
FILE: G:\Active\2014-16 BCS 2012-03D EPD Env Design-Permitting, EA-JMT\Task 17 Little Catoctin Creek\CAD\pES-N003.dgn

PHASE 3 - LIMIT OF DISTURBANCE					
NO	STATION	OFFSET(FT)		NORTHING	EASTING
1	1+14.20	135.09	LT	610599.1667	1133107.6437
2	1+40.74	116.61	LT	610580.6258	1133110.5777
3	1+62.05	149.95	LT	610616.1778	1133127.9437
4	1+70.76	70.30	LT	610538.3448	1133152.7483
5	1+72.21	155.29	LT	610623.2328	1133160.5400
6	3+35.15	158.45	LT	610600.2032	1133258.0256
7	3+36.97	60.57	LT	610507.2367	1133289.8948
8	3+37.37	50.10	LT	610497.1930	1133293.1055
9	3+37.88	78.08	LT	610525.0591	1133290.0364
10	3+39.31	38.57	LT	610486.5620	1133299.9772
11	3+43.16	78.42	LT	610526.7184	1133311.1050
12	3+43.18	50.46	LT	610498.7748	1133310.0576
13	3+43.60	114.20	LT	610562.3534	1133314.8475
14	3+46.60	40.76	LT	610488.1580	1133318.3969
15	3+51.15	14.49	LT	610460.4629	1133320.7508
21	4+05.64	114.90	RT	610312.1351	1133392.0405
22	4+08.64	46.76	RT	610380.7872	1133382.9036
23	4+12.10	108.01	RT	610332.4337	1133422.9983
24	4+16.75	42.33	RT	610391.7116	1133394.1530
25	4+20.18	63.76	RT	610375.0859	1133408.0985
26	5+58.97	100.75	RT	610323.7550	1133451.1545
27	6+85.80	109.67	RT	610293.3919	1133473.5076
28	7+34.00	146.54	RT	610213.6308	1133480.4398
29	7+41.68	90.77	RT	610237.1882	1133531.9605
30	8+82.79	91.49	RT	610165.5432	1133583.4642
31	8+99.45	117.01	RT	610142.9546	1133563.0017
32	9+09.20	56.20	RT	610148.9577	1133624.3033
33	9+14.33	68.35	RT	610135.0532	1133615.8065
34	9+32.35	38.97	RT	610113.1450	1133666.6348
35	9+41.37	59.84	RT	610083.8624	1133676.2187
36	10+46.74	65.98	RT	610061.2324	1133727.9966
37	10+57.86	76.58	RT	610024.4535	1133745.4786
38	10+66.48	68.45	RT	610015.7383	1133778.7308
39	13+06.65	93.22	RT	609936.6183	1133842.1515
40	13+08.39	66.31	RT	609932.4138	1133869.5564
41	13+44.04	40.80	RT	609885.2848	1133921.9357
42	13+53.05	54.28	RT	609869.1150	1133917.5914
43	13+57.97	38.09	RT	609871.0088	1133938.4091
44	13+61.86	53.43	RT	609852.4617	1133937.9246
45	13+66.87	40.10	RT	609858.2404	1133956.0766
46	13+78.83	55.12	RT	609838.8136	1133984.7990
47	16+29.70	109.80	RT	609782.7243	1134063.7778
48	16+37.03	104.58	RT	609748.1641	1134084.4094
49	16+46.90	80.60	RT	609730.2429	1134134.3605
52	17+72.02	85.21	RT	609634.5810	1134232.6048
57	20+82.71	63.18	RT	609514.9275	1134343.6081
60	21+22.65	28.59	RT	609459.3067	1134394.3422
62	21+90.76	67.57	RT	609393.7355	1134480.5539
91	22+95.01	143.79	LT	609617.3122	1134555.0221
92	22+99.05	123.35	LT	609599.6835	1134583.3817
103	15+81.13	90.74	LT	609902.5025	1134242.9637
104	15+86.05	56.91	LT	609871.7327	1134219.6407
105	15+87.72	109.44	LT	609879.7635	1134272.0054
106	18+35.10	90.11	LT	609810.2976	1134327.7260
107	18+52.66	67.86	LT	609760.4709	1134385.8574
108	19+09.61	118.44	LT	609665.5234	1134477.4638
109	23+15.53	98.91	LT	609548.6224	1134662.1259
110	16+48.68	81.34	RT	609725.4830	1134140.5560
111	16+56.21	17.33	RT	609776.6458	1134182.8599
112	22+24.18	23.50	RT	609438.4451	1134513.1075
113	23+49.01	20.82	RT	609435.0003	1134594.5179

PHASE 4 - LIMIT OF DISTURBANCE					
NO	STATION	OFFSET(FT)		NORTHING	EASTING
1	1+14.20	135.09	LT	610599.1667	1133107.6437
2	1+40.74	116.61	LT	610580.6258	1133110.5777
3	1+62.05	149.95	LT	610616.1778	1133127.9437
4	1+70.76	70.30	LT	610538.3448	1133152.7483
5	1+72.21	155.29	LT	610623.2328	1133160.5400
6	3+35.15	158.45	LT	610600.2032	1133258.0256
7	3+36.97	60.57	LT	610507.2367	1133289.8948
8	3+37.37	50.10	LT	610497.1930	1133293.1055
9	3+37.88	78.08	LT	610525.0591	1133290.0364
10	3+39.31	38.57	LT	610486.5620	1133299.9772
11	3+43.16	78.42	LT	610526.7184	1133311.1050
12	3+43.18	50.46	LT	610498.7748	1133310.0576
13	3+43.60	114.20	LT	610562.3534	1133314.8475
14	3+46.60	40.76	LT	610488.1580	1133318.3969
15	3+51.15	14.49	LT	610460.4629	1133320.7508
21	4+05.64	114.90	RT	610312.1351	1133392.0405
22	4+08.64	46.76	RT	610380.7872	1133382.9036
23	4+12.10	108.01	RT	610332.4337	1133422.9983
24	4+16.75	42.33	RT	610391.7116	1133394.1530
25	4+20.18	63.76	RT	610375.0859	1133408.0985
26	5+58.97	100.75	RT	610323.7550	1133451.1545
27	6+85.80	109.67	RT	610293.3919	1133473.5076
28	7+34.00	146.54	RT	610213.6308	1133480.4398
29	7+41.68	90.77	RT	610237.1882	1133531.9605
30	8+82.79	91.49	RT	610165.5432	1133583.4642
31	8+99.45	117.01	RT	610142.9546	1133563.0017
32	9+09.20	56.20	RT	610148.9577	1133624.3033
33	9+14.33	68.35	RT	610135.0532	1133615.8065
34	9+32.35	38.97	RT	610113.1450	1133666.6348
35	9+41.37	59.84	RT	610083.8624	1133676.2187
36	10+46.74	65.98	RT	610061.2324	1133727.9966
37	10+57.86	76.58	RT	610024.4535	1133745.4786
38	10+66.48	68.45	RT	610015.7383	1133778.7308
39	13+06.65	93.22	RT	609936.6183	1133842.1515
42	13+53.05	54.28	RT	609869.1150	1133917.5914
44	13+61.86	53.43	RT	609852.4617	1133937.9246
48	16+37.03	104.58	RT	609748.1641	1134084.4094
103	15+81.13	90.74	LT	609902.5025	1134242.9637
105	15+87.72	109.44	LT	609879.7635	1134272.0054
114	11+05.80	33.67	LT	610108.8584	1133851.2899
115	11+07.20	61.08	LT	610132.5727	1133865.5967
116	11+09.74	89.65	LT	610153.3108	1133887.6803
117	11+51.82	17.44	LT	610058.7649	1133878.0940
118	12+17.76	67.94	LT	610062.3116	1133988.9485
119	14+74.89	120.52	LT	610028.9901	1134061.3158
120	15+08.70	87.99	LT	609987.2669	1134133.2671
121	15+38.92	75.34	LT	609942.8019	1134191.4945
122	16+98.70	99.55	LT	609853.5689	1134293.0169
123	18+35.83	27.58	LT	609747.7856	1134325.0481
124	11+49.18	81.89	RT	609979.1414	1133818.6223
125	17+55.70	85.29	RT	609678.9071	1134174.7712

PHASE 5 - LIMIT OF DISTURBANCE					
NO	STATION	OFFSET(FT)		NORTHING	EASTING
1	1+14.20	135.09	LT	610599.1667	1133107.6437
2	1+40.74	116.61	LT	610580.6258	1133110.5777
3	1+62.05	149.95	LT	610616.1778	1133127.9437
4	1+70.76	70.30	LT	610538.3448	1133152.7483
5	1+72.21	155.29	LT	610623.2328	1133160.5400
6	3+35.15	158.45	LT	610600.2032	1133258.0256
7	3+36.97	60.57	LT	610507.2367	1133289.8948
8	3+37.37	50.10	LT	610497.1930	1133293.1055
9	3+37.88	78.08	LT	610525.0591	1133290.0364
10	3+39.31	38.57	LT	610486.5620	1133299.9772
11	3+43.16	78.42	LT	610526.7184	1133311.1050
12	3+43.18	50.46	LT	610498.7748	1133310.0576
13	3+43.60	114.20	LT	610562.3534	1133314.8475
14	3+46.60	40.76	LT	610488.1580	1133318.3969
15	3+51.15	14.49	LT	610460.4629	1133320.7508
21	4+05.64	114.90	RT	610312.1351	1133392.0405
22	4+08.64	46.76	RT	610380.7872	1133382.9036
23	4+12.10	108.01	RT	610332.4337	1133422.9983
24	4+16.75	42.33	RT	610391.7116	1133394.1530
25	4+20.18	63.76	RT	610375.0859	1133408.0985
26	5+58.97	100.75	RT	610323.7550	1133451.1545
27	6+85.80	109.67	RT	610293.3919	1133473.5076
28	7+34.00	146.54	RT	610213.6308	1133480.4398
29	7+41.68	90.77	RT	610237.1882	1133531.9605
30	8+82.79	91.49	RT	610165.5432	1133583.4642
31	8+99.45	117.01	RT	610142.9546	1133563.0017
33	9+14.33	68.35	RT	610135.0532	1133615.8065
35	9+41.37	59.84	RT	610083.8624	1133676.2187
37	10+57.86	76.58	RT	610024.4535	1133745.4786
126	7+13.94	92.20	LT	610365.4223	1133665.8023
127	7+17.94	51.81	LT	610339.2414	1133634.7792
128	7+66.22	28.70	LT	610306.9485	1133633.3282
129	7+91.50	104.11	LT	610369.6795	1133689.4201
130	8+10.88	91.58	LT	610294.1482	1133749.3082
131	10+05.14	113.96	LT	610233.3011	1133795.6511
132	11+06.76	93.45	LT	610162.9320	1133876.9735
133	12+14.94	65.11	LT	610069.6744	1133980.7548
134	7+46.22	88.71	RT	610222.8436	1133547.1570
135	9+13.56	83.37	RT	610132.5638	1133600.7721
136	9+19.98	90.00	RT	610108.1822	1133604.5197
137	9+23.89	65.82	RT	610110.3149	1133632.0535
138	9+34.82	57.08	RT	610094.8366	1133661.1139
139	11+63.01	19.73	RT	610020.5559	1133876.9452
140	12+34.67	16.73	RT	610007.5300	1133919.7043
141	13+07.74	88.83	RT	609932.3679	1133846.9017

PHASE 6 - LIMIT OF DISTURBANCE					
NO	STATION	OFFSET(FT)		NORTHING	EASTING
1	1+14.20	135.09	LT	610599.1667	1133107.6437
2	1+40.74	116.61	LT	610580.6258	1133110.5777
3	1+62.05	149.95	LT	610616.1778	1133127.9437
4	1+70.76	70.30	LT	610538.3448	1133152.7483
5	1+72.21	155.29	LT	610623.2328	1133160.5400
6	3+35.15	158.45	LT	610600.2032	1133258.0256
7	3+36.97	60.57	LT	610507.2367	1133289.8948
8	3+37.37	50.10	LT	610497.1930	1133293.1055
9	3+37.88	78.08	LT	610525.0591	1133290.0364
10	3+39.31	38.57	LT	610486.5620	1133299.9772
11	3+43.16	78.42	LT	610526.7184	1133311.1050
12	3+43.18	50.46	LT	610498.7748	1133310.0576
13	3+43.60	114.20	LT	610562.3534	1133314.8475
14	3+46.60	40.76	LT	610488.1580	1133318.3969
15	3+51.15	14.49	LT	610460.4629	1133320.7508
21	4+05.64	114.90	RT	610312.1351	1133392.0405
22	4+08.64	46.76	RT	610380.7872	1133382.9036
23	4+12.10	108.01	RT	610332.4337	1133422.9983
24	4+16.75	42.33	RT	610391.7116	1133394.1530
28	7+34.00	146.54	RT	610213.6308	1133480.4398
30	8+82.79	91.49	RT	610165.5432	1133583.4642
31	8+99.45	117.01	RT	610142.9546	1133563.0017
142	4+50.53	93.74	LT	610532.7357	1133368.6476
143	4+58.47	94.39	LT	610540.8072	1133402.1686
144	5+02.96	112.57	LT	610560.2122	1133471.3765
145	5+12.39	118.35	LT	610550.2121	1133518.7458
146	5+97.50	123.75	LT	610525.6976	1133559.9610
147	6+18.93	98.92	LT	610481.0955	1133608.3258
148	6+37.65	97.56	LT	610406.5099	1133659.0231
149	7+94.62	96.52	LT	610355.9318	1133700.7663
150	8+39.92	15.51	LT	610230.3774	1133681.2075
151	4+67.34	34.77	RT	610412.6136	1133420.5649
152	7+57.03	43.95	RT	610239.7709	1133603.3769
153	7+60.44	25.39	RT	610255.7406	1133614.9944
154	8+39.51	15.08	RT	610231.6479	1133650.6458
155	8+67.09	58.51	RT	610189.0988	1133611.3707
156	8+88.45	87.95	RT	610160.9675	1133588.3179

PHASE 7 - LIMIT OF DISTURBANCE					
NO	STATION	OFFSET(FT)		NORTHING	EASTING
1	1+14.20	135.09	LT	610599.1667	1133107.6437
3	1+62.05	149.95	LT	610616.1778	1133127.9437
5	1+72.21	155.29	LT	610623.2328	1133160.5400
6	3+35.15	158.45	LT	610600.2032	1133258.0256
11	3+43.16	78.42	LT	610526.7184	1133311.1050
13	3+43.60	114.20	LT	610562.3534	1133314.8475
21	4+05.64	114.90	RT	610312.1351	1133392.0405
157	+4.85	13.92	LT	610510.7012	1133000.5925
158	+21.44	40.29	LT	610527.7957	1133026.6344
159	+49.11	68.14	LT	610541.6209	1133063.3820
160	1+40.70	117.71	LT	610581.7168	1133110.4051
161	3+50.02	82.23	LT	610525.6693	1133339.3009
162	4+55.43	92.98	LT	610537.7049	1133389.2847
163	4+91.64	33.17	LT	610482.0661	1133440.1337
164	5+98.07	14.94	LT	610419.3178	1133537.0956
165	+.00	15.39	RT	610491.0417	1132977.9173
166	+.00	33.43	RT	610470.2921	1132975.1602
167	+6.15	40.40	RT	610460.7518	1132979.1919
168	+76.50	66.47	RT	610405.6411	1133038.0599
169	+78.64	89.50	RT	610381.4876	1133038.2020
170	+79.96	60.23	RT	610408.7609	1133049.6821
171	1+00.20	82.44	RT	610383.3123	1133077.2456
172	1+26.20	93.00	RT	610370.6889	1133104.5277
173	2+41.50	73.70	RT	610356.7530	1133192.3850
174	2+86.75	97.79	RT	610336.1182	1133268.3420
175	3+93.80	117.66	RT	610308.5251	1133323.5890
176	6+00.42	20.58	RT	610384.1201	1133531.7350
177	6+85.27	135.52	RT	610286.3365	1133448.4447

COASTAL RESOURCES INC.

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

LOD STAKEOUT (PHASES 3, 4, 5, 6, & 7)

SCALE NTS ADVERTISED DATE JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY MJD
DRAWN BY MJD
CHECKED BY ETK
F.A.P. NO. SEE TITLE SHEET

COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

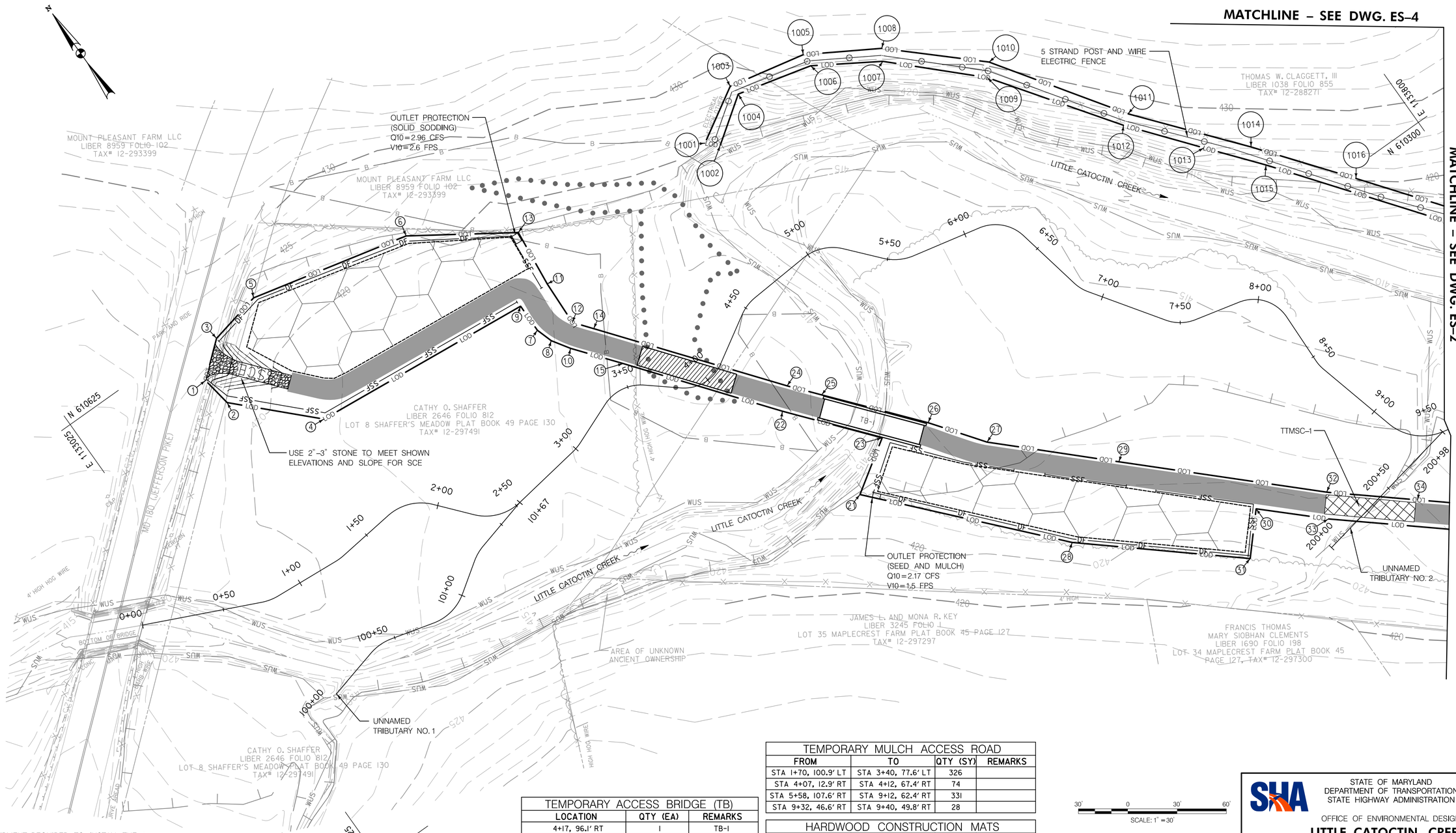
DRAWING NO. EN-4 OF 6

SHEET NO. 22 OF 53

SHEET REVISION DATE: NOVEMBER 24, 2018

BY: matthewd –

PLOTTED: Thursday, April 20, 2017 AT 03:42 PM
FILE: G:\Active\2014-16 BCS 2012-030 EPD Env Design-Permitting, EA-JMT\Task 17 Little Catoctin Creek\CAD\pES-N004.dgn



NOTE:
ALL EQUIPMENT REQUIRED TO INSTALL THE 5 STRAND POST AND WIRE ELECTRIC FENCE MUST BE WALKED IN.

PHASE 1 EXCAVATION	
CUT	FILL
4,124 CY	210 CY

SUPER SILT FENCE (SSF)			
FROM	TO	QTY (LF)	REMARKS
STA 1+15, 135.6' LT	STA 3+38, 81.4' LT	212'	
STA 3+43, 114.8' LT	STA 3+42, 78.3' LT	37'	
STA 4+07, 120.5' RT	STA 6+90, 117.6' RT	109'	
STA 7+04, 113.4' RT	STA 7+43, 103.5' RT	50'	
STA 7+47, 103.2' RT	STA 8+97, 116.4' RT	91'	

TEMPORARY ACCESS BRIDGE (TB)		
LOCATION	QTY (EA)	REMARKS
4+17, 96.1' RT	1	TB-1

DIVERSION FENCE (DF)			
FROM	TO	QTY (LF)	REMARKS
STA 1+62, 147.7' LT	STA 3+43, 114.8' LT	196'	
STA 4+07, 120.5' RT	STA 8+97, 116.4' RT	232'	

STABILIZED CONSTRUCTION ENTRANCE (SCE)			
FROM	TO	QTY (EA)	REMARKS
STA 1+50, 142.1 LT	STA 1+70, 100.71 LT	1	

TEMPORARY TIMBER MAT STREAM CROSSING (TTMSC)		
LOCATION	QTY (EA)	REMARKS
9+21, 50.7' RT	1	TTMSC-1

TEMPORARY MULCH ACCESS ROAD			
FROM	TO	QTY (SY)	REMARKS
STA 1+70, 100.9' LT	STA 3+40, 77.6' LT	326	
STA 4+07, 12.9' RT	STA 4+12, 67.4' RT	74	
STA 5+58, 107.6' RT	STA 9+12, 62.4' RT	331	
STA 9+32, 46.6' RT	STA 9+40, 49.8' RT	28	

HARDWOOD CONSTRUCTION MATS			
FROM	TO	QTY (SY)	REMARKS
STA 3+58, 17.8' LT	STA 4+07, 12.9' RT	80	

30' 0 30' 60'
SCALE: 1" = 30'

DATUM: NAD 83\91 Horizontal
NAVD 88 Vertical

COASTAL RESOURCES INC.

BY: matthewd –

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

E&S CONTROL PLAN (PHASE 1)

CROSS REFERENCE

ITEM	SHEET NOs.
ABBREVIATIONS /GENERAL NOTES	2
STREAM RESTORATION PROFILES	4 – 8
KEY MAP	11
STREAM RESTORATION PLANS	12 – 15
STREAM RESTORATION DETAILS	16 – 18
ESC NOTES	19
ESC SEQUENCE OF CONSTRUCTION	20
LOD STAKEOUT	21 – 22
ESC DETAILS	43 – 44
LANDSCAPING PLANS	45 – 47
LANDSCAPING DETAILS	48
STREAM RESTORATION CROSS SECTIONS	49 – 52
MOT PLANS	53

R /W PLAT NUMBER

REVISIONS

SCALE 1" = 30' ADVERTISED DATE JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY MJD
DRAWN BY MJD
CHECKED BY ETK
F.A.P. NO. SEE TITLE SHEET

COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. ES-1 OF 20 SHEET NO. 23 OF 53

PLOTTED: Thursday, April 20, 2017 AT 03:42 PM
FILE: G:\Active\2014-16 BCS 2012-030 EPD Env Design-Permitting, EA-JMT\Task 17 Little Catoctin Creek\CAD\pES_P101_LittleCatoctin_CRR.dgn

MATCHLINE – SEE DWG. ES–4

MATCHLINE – SEE DWG. ES–1

MATCHLINE – SEE DWG. ES–3

5 STRAND POST AND WIRE ELECTRIC FENCE

5 STRAND POST AND WIRE ELECTRIC FENCE

THOMAS W. CLAGGETT, III
LIBER 1038 FOLIO 855
TAX# 12-288271

UNNAMED TRIBUTARY NO. 3

LITTLE CATOCTIN CREEK

TEMPORARY ACCESS ROAD

MUBASHIR AND CARLA MALIK
LIBER 8644 FOLIO 385
LOT 33 MAPLECREST FARM PLAT BOOK 45 PAGE 127
TAX# 12-297319

ROBERT K. McMONAGLE, JR. AND TABETHA M. McMONAGLE
LIBER 9548 FOLIO 217
LOT 32 MAPLECREST FARM PLAT BOOK 45 PAGE 126
TAX# 12-297238

CHARLES E. AND SHAWN L. ANDREWS
LIBER 2009 FOLIO 641
LOT 31 MAPLECREST FARM PLAT BOOK 45 PAGE 126
TAX# 12-297211

NOTE:
ALL EQUIPMENT REQUIRED TO INSTALL THE 5 STRAND POST AND WIRE ELECTRIC FENCE MUST BE WALKED IN.

SCALE: 1" = 30'

DATUM: NAD 83\91 Horizontal
NAVD 88 Vertical

BY: matthewd –

COASTAL RESOURCES INC.

TEMPORARY MULCH ACCESS ROAD			
FROM	TO	QTY (SY)	REMARKS
STA 9+40, 49.5' RT	STA 13+10, 72.0' RT	335	

HARDWOOD CONSTRUCTION MATS			
FROM	TO	QTY (SY)	REMARKS
STA 13+10, 72.0' RT	STA 19+91, 59.0' RT	822	

TEMPORARY ORANGE CONSTRUCTION FENCE			
FROM	TO	QTY (LF)	REMARKS
STA 12+17, 60.1' LT	STA 15+33, 69.3' LT	221	

CROSS REFERENCE

ITEM	SHEET NOs.
ABBREVIATIONS /GENERAL NOTES	2
STREAM RESTORATION PROFILES	4 – 8
KEY MAP	11
STREAM RESTORATION PLANS	12 – 15
STREAM RESTORATION DETAILS	16 – 18
ESC NOTES	19
ESC SEQUENCE OF CONSTRUCTION	20
LOD STAKEOUT	21 – 22
ESC DETAILS	43 – 44
LANDSCAPING PLANS	45 – 47
LANDSCAPING DETAILS	48
STREAM RESTORATION CROSS SECTIONS	49 – 52
MOT PLANS	53

R /W PLAT NUMBER

REVISIONS

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

E&S CONTROL PLAN (PHASE 1)

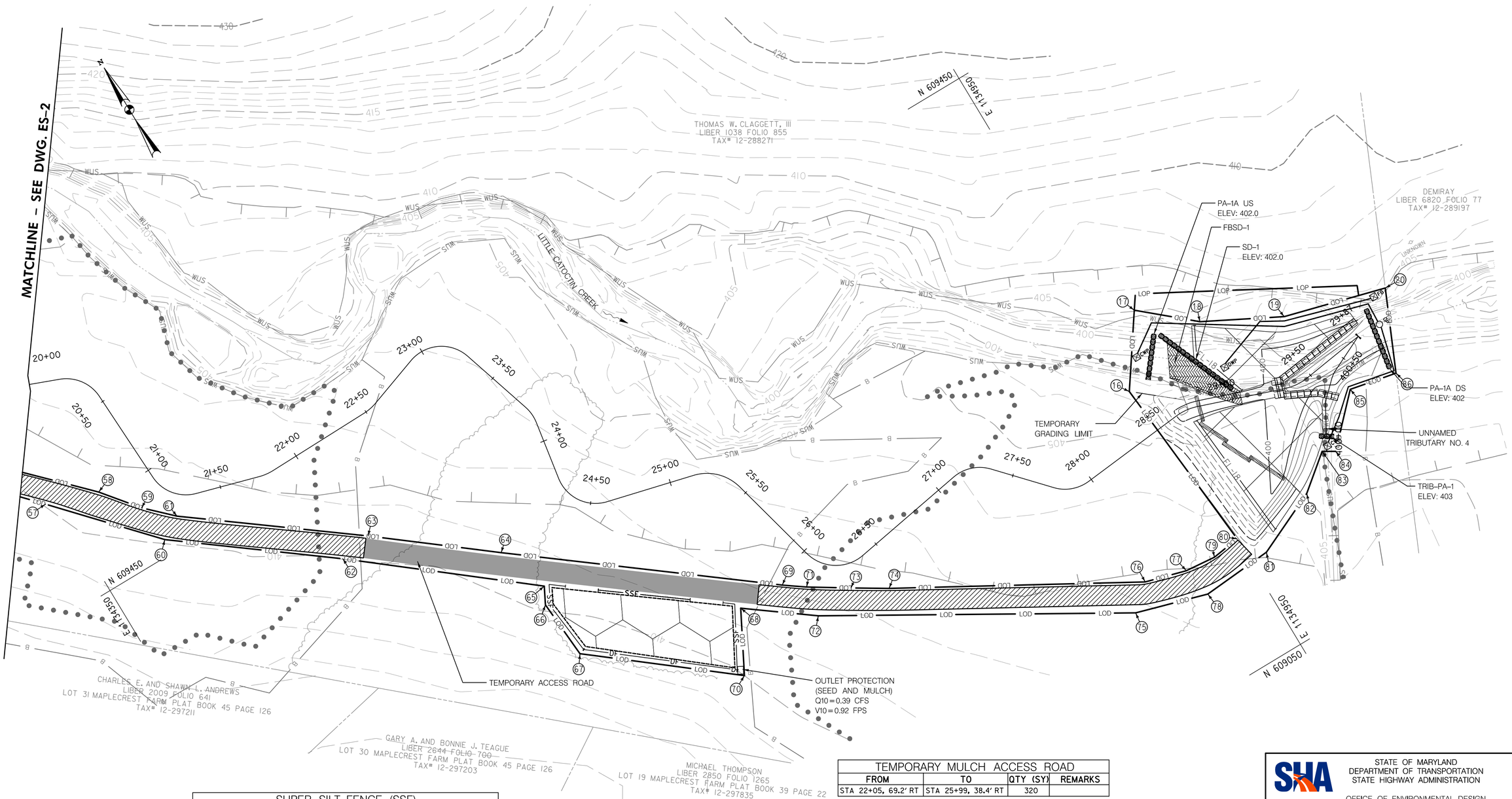
SCALE 1" = 30' ADVERTISED DATE JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY MJD
DRAWN BY MJD
CHECKED BY ETK
F.A.P. NO. SEE TITLE SHEET

COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. ES-2 OF 20 SHEET NO. 24 OF 53

PLOTTED: Thursday, April 20, 2017 AT 03:42 PM
FILE: G:\Active\2014-16 BCS 2012-03D EPD Env Design-Permitting, EA-JMT\Task 17 Little Catoctin Creek\CAD\pES_P102_LittleCatoctin_CRit.dgn



SUPER SILT FENCE (SSF)			
FROM	TO	QTY (LF)	REMARKS
STA 24+47, 52.3' RT	STA 24+51, 88.6' RT	56'	
STA 24+53, 52.4' RT	STA 25+72, 69.5' RT	56'	
STA 25+87, 56.8' RT	STA 26+07, 81.4' RT	47'	

DIVERSION FENCE (DF)			
FROM	TO	QTY (LF)	REMARKS
STA 24+51, 88.6' RT	STA 26+07, 81.4' RT	95'	

18 INCH FILTER LOG			
FROM	TO	QTY (LF)	REMARKS
STA 29+10, 82.2' RT	STA 28+76, 8.1' RT	81'	
STA 29+07, 4.3' LT	STA 28+86, 48.5' RT	52'	

TYPE 'D' SOIL STABILIZATION MATTING
QTY
665 SY

FABRIC BASED STREAM DIVERSION (FBSD)		
FROM	TO	REMARKS
STA 28+73, 32.0' LT	STA 29+05, 0.0'	FBSD-1

HARDWOOD CONSTRUCTION MATS			
FROM	TO	QTY (SY)	REMARKS
STA 19+91, 59.0' RT	STA 22+05, 69.2' RT	284	
STA 25+99, 38.4' RT	STA 28+50, 88.3' RT	403	

TEMPORARY MULCH ACCESS ROAD			
FROM	TO	QTY (SY)	REMARKS
STA 22+05, 69.2' RT	STA 25+99, 38.4' RT	320	

30' 0 30' 60'
SCALE: 1" = 30'

DATUM: NAD 83/91 Horizontal
NAVD 88 Vertical

COASTAL RESOURCES INC.

BY: matthewd –

CROSS REFERENCE		R /W PLAT NUMBER	REVISIONS
ITEM	SHEET NOs.		
ABBREVIATIONS /GENERAL NOTES	2		
STREAM RESTORATION PROFILES	4 – 8		
KEY MAP	11		
STREAM RESTORATION PLANS	12 – 15		
STREAM RESTORATION DETAILS	16 – 18		
ESC NOTES	19		
ESC SEQUENCE OF CONSTRUCTION	20		
LOD STAKEOUT	21 – 22		
ESC DETAILS	43 – 44		
LANDSCAPING PLANS	45 – 47		
LANDSCAPING DETAILS	48		
STREAM RESTORATION CROSS SECTIONS	49 – 52		
MOT PLANS	53		

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

E&S CONTROL PLAN (PHASE 1)

SCALE 1" = 30' ADVERTISED DATE JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY MJD
DRAWN BY MJD
CHECKED BY ETK
F.A.P. NO. SEE TITLE SHEET

COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. ES-3 OF 20 SHEET NO. 25 OF 53

PLOTTED: Thursday, April 20, 2017 AT 03:42 PM
FILE: G:\Active\2014-16 BCS 2012-03D EPD Env Design-Permitting, EA-JMT\Task 17 Little Catoctin Creek\CAD\pES_Pt03_LittleCatoctin_CRI.dgn

MATCHLINE – SEE DWG. ES–1

MATCHLINE – SEE DWG. ES–2

N

E 1133800
N 610400

N 610950
E 1134150

N 610400
E 1134150

MD 180 (JEFFERSON PIKE)

THOMAS W. CLAGGETT, III
LIBER 1038 FOLIO 855
TAX# 12-28827I

THOMAS W. CLAGGETT, III
LIBER 1038 FOLIO 855
TAX# 12-28827I

WATER LINE

SPRING BOX

WATERING TROUGH

TEMPORARY ACCESS ROAD

EX. BARN

EX. BARN

STABILIZED CONSTRUCTION ENTRANCE (SCE)

EX. DRIVEWAY

1039 1040 1041 1042 1043 1044 1045 1046 1047 1048 1049 1050 1051 1052 1053 1054 1055 1056 1057 1058 1059 1060 1061 1062

LOD

420 430 440 450 460 470

30' 0 30' 60'
SCALE: 1" = 30'

DATUM: NAD 83\91 Horizontal
NAVD 88 Vertical

COASTAL RESOURCES INC.

LEGEND

SAME DAY STABILIZATION

TEMPORARY MULCH ACCESS ROAD			
FROM	TO	QTY (SY)	REMARKS
STA 6+27, 836.9' LT	STA 6+28, 970.3' LT	187	

STABILIZED CONSTRUCTION ENTRANCE (SCE)			
FROM	TO	QTY (EA)	REMARKS
STA 6+29, 1019' LT	STA 6+28, 970' LT	1	OFF DRIVEWAY

CROSS REFERENCE

ITEM	SHEET NOs.
ABBREVIATIONS /GENERAL NOTES	2
STREAM RESTORATION PROFILES	4 – 8
KEY MAP	11
STREAM RESTORATION PLANS	12 – 15
STREAM RESTORATION DETAILS	16 – 18
ESC NOTES	19
ESC SEQUENCE OF CONSTRUCTION	20
LOD STAKEOUT	21 – 22
ESC DETAILS	43 – 44
LANDSCAPING PLANS	45 – 47
LANDSCAPING DETAILS	48
STREAM RESTORATION CROSS SECTIONS	49 – 52
MOT PLANS	53

R /W PLAT NUMBER

REVISIONS

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

E&S CONTROL PLAN (PHASE 1)

SCALE 1" = 30' ADVERTISED DATE JUNE 2017 CONTRACT NO. FR5975182

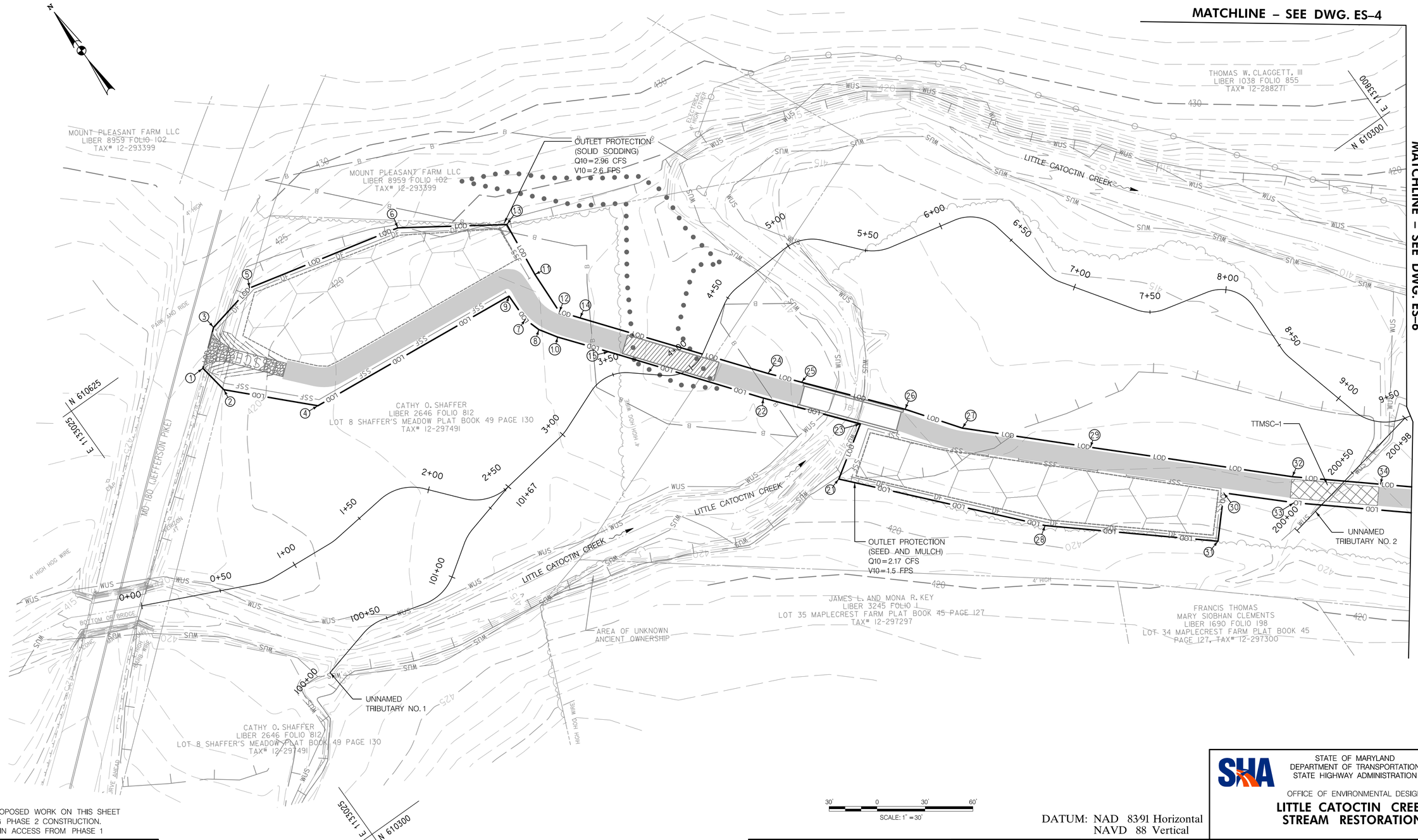
DESIGNED BY MJD
DRAWN BY MJD
CHECKED BY ETK
F.A.P. NO. SEE TITLE SHEET

COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. ES-4 OF 20 SHEET NO. 26 OF 53

PLOTTED: Thursday, April 20, 2017 AT 03:42 PM
FILE: G:\Active\2014-16 BCS 2012-030 EPD Env Design-Permitting, EA-JMT\Task 17 Little Catoctin Creek\CAD\pES_P004_LittleCatoctin_CRI.dgn

BY: matthewd –



NOTE:
NO PROPOSED WORK ON THIS SHEET DURING PHASE 2 CONSTRUCTION.
MAINTAIN ACCESS FROM PHASE 1

30' 0 30' 60'
SCALE: 1" = 30'

DATUM: NAD 83\91 Horizontal
NAVD 88 Vertical

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

COASTAL RESOURCES INC.

PHASE 2 EXCAVATION	
CUT	FILL
12,153 CY	1,049 CY

CROSS REFERENCE

ITEM	SHEET NOs.
ABBREVIATIONS /GENERAL NOTES	2
STREAM RESTORATION PROFILES	4 – 8
KEY MAP	11
STREAM RESTORATION PLANS	12 – 15
STREAM RESTORATION DETAILS	16 – 18
ESC NOTES	19
ESC SEQUENCE OF CONSTRUCTION	20
LOD STAKEOUT	21 – 22
ESC DETAILS	43 – 44
LANDSCAPING PLANS	45 – 47
LANDSCAPING DETAILS	48
STREAM RESTORATION CROSS SECTIONS	49 – 52
MOT PLANS	53

R /W PLAT NUMBER

REVISIONS

E&S CONTROL PLAN (PHASE 2)

SCALE 1" = 30' ADVERTISED DATE JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY MJD
DRAWN BY MJD
CHECKED BY ETK
F.A.P. NO. SEE TITLE SHEET
COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. ES-5 OF 20 SHEET NO. 27 OF 53

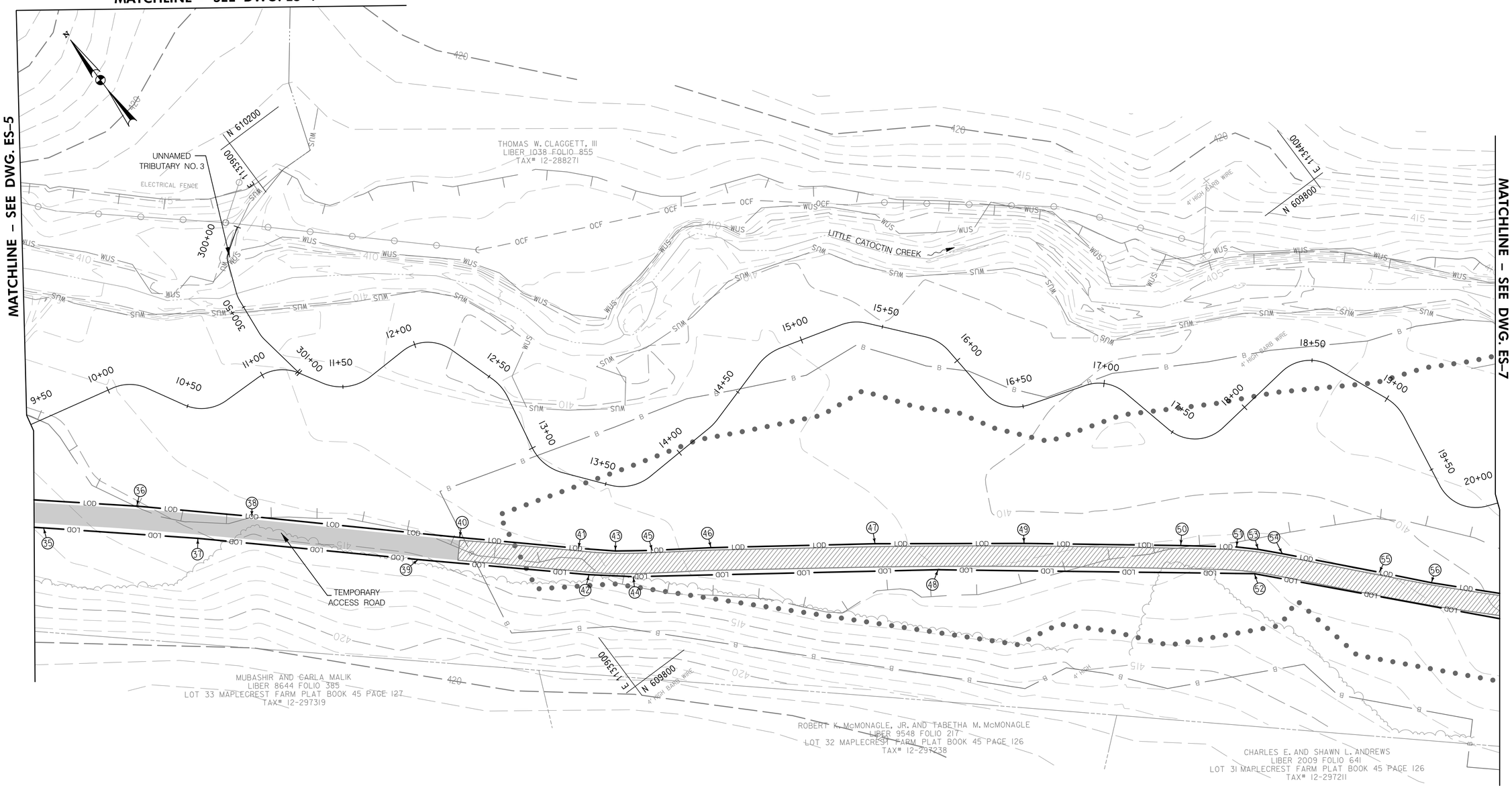
PLOTTED: Thursday, April 20, 2017 AT 03:42 PM
FILE: G:\Active\2014-16 BCS 2012-03D EPD Env Design-Permitting, EA-JMT\Task 17 Little Catoctin Creek\CAD\pES_P201_LittleCatoctin_CRII.dgn

BY: matthewd –

MATCHLINE – SEE DWG. ES–4

MATCHLINE – SEE DWG. ES–5

MATCHLINE – SEE DWG. ES–7



NOTE:
NO PROPOSED WORK ON THIS SHEET DURING PHASE 2 OF CONSTRUCTION. MAINTAIN ACCESS FROM PHASE 1

30' 0 30' 60'
SCALE: 1" = 30'

DATUM: NAD 8391 Horizontal
NAVD 88 Vertical

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

E&S CONTROL PLAN (PHASE 2)

SCALE 1" = 30' ADVERTISED DATE JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY MJD
DRAWN BY MJD
CHECKED BY ETK
F.A.P. NO. SEE TITLE SHEET

COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. ES-6 OF 20 SHEET NO. 28 OF 53

CROSS REFERENCE

ITEM	SHEET NOs.
ABBREVIATIONS /GENERAL NOTES	2
STREAM RESTORATION PROFILES	4 – 8
KEY MAP	11
STREAM RESTORATION PLANS	12 – 15
STREAM RESTORATION DETAILS	16 – 18
ESC NOTES	19
ESC SEQUENCE OF CONSTRUCTION	20
LOD STAKEOUT	21 – 22
ESC DETAILS	43 – 44
LANDSCAPING PLANS	45 – 47
LANDSCAPING DETAILS	48
STREAM RESTORATION CROSS SECTIONS	49 – 52
MOT PLANS	53

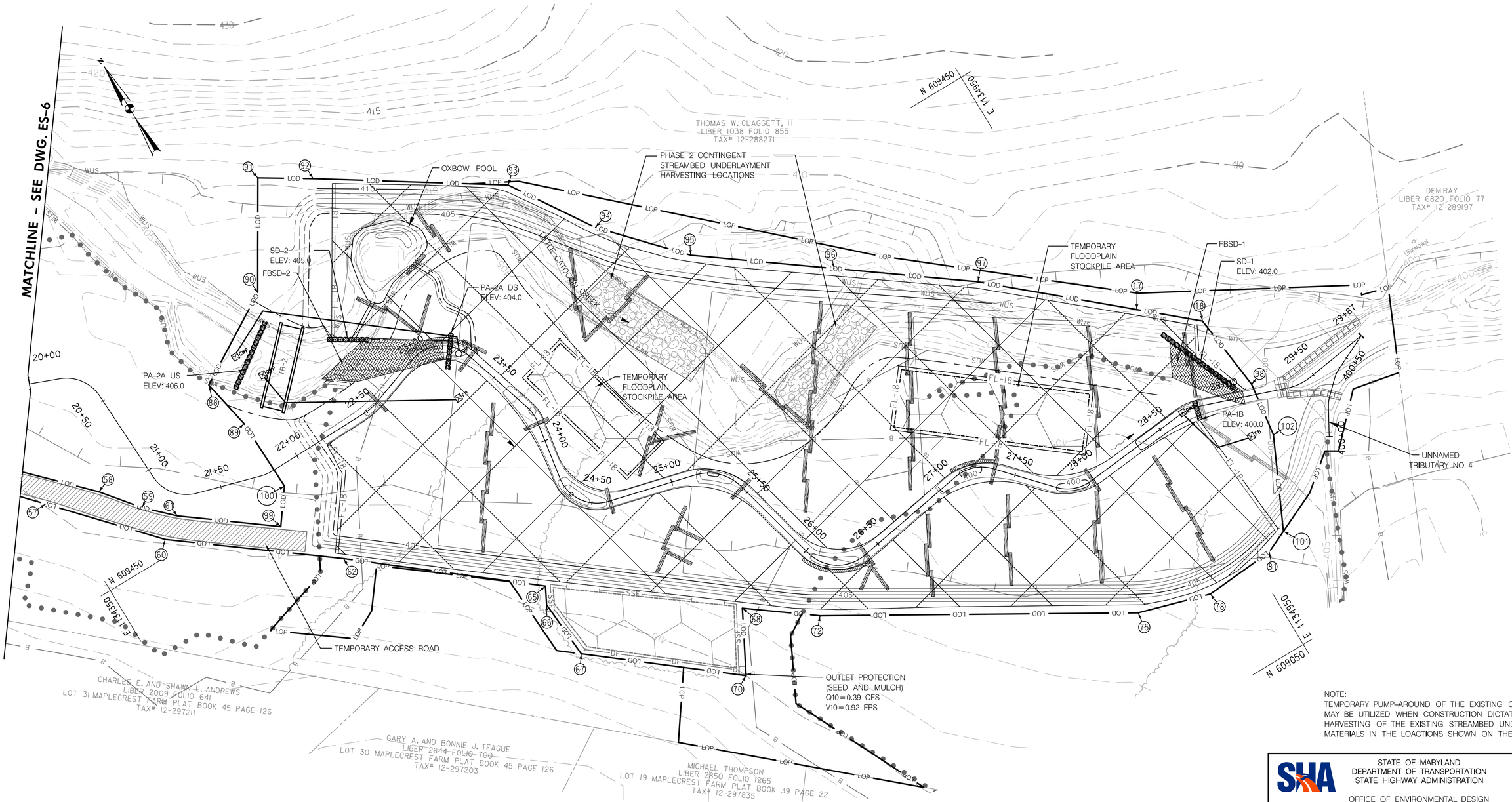
R /W PLAT NUMBER

REVISIONS

COASTAL RESOURCES INC.

BY: matthewd –

PLOTTED: Thursday, April 20, 2017 AT 03:42 PM
FILE: G:\Active\2014-16 BCS 2012-03D EPD Env Design-Permitting, EA-JMT\Task 17 Little Catoctin Creek\CAD\pES_P202_LittleCatoctin_CRI.dgn



NOTE:
TEMPORARY PUMP-AROUND OF THE EXISTING CHANNEL MAY BE UTILIZED WHEN CONSTRUCTION DICTATES THE HARVESTING OF THE EXISTING STREAMBED UNDERLAYMENT MATERIALS IN THE LOACTIONS SHOWN ON THE PLANS.

DATUM: NAD 83\91 Horizontal
NAVD 88 Vertical

COASTAL RESOURCES INC.

BY: matthewd –

18 INCH FILTER LOG

FROM	TO	QTY (LF)	REMARKS
STA 21+90, 63.3' RT	STA 22+21, 4.0' RT	70'	
STA 22+72, 44.7' LT	STA 23+01, 114.2' LT	93'	
STA 23+64, 43.7' LT	STA 24+75, 9.5' LT	241'	
STA 27+16, 74.9' LT	STA 28+04, 14.7' LT	315'	

TEMPORARY TIMBER MAT STREAM CROSSING (TTMSC)

LOCATION	QTY (EA)	REMARKS
STA 17+42, 0.0'	1	TTMSC-2

FABRIC BASED STREAM DIVERSION (FBSD)

FROM	TO	REMARKS
STA 22+65, 32.4' LT	STA 23+13, 0.0'	FBSD-2

TEMPORARY ACCESS BRIDGE (TB)

LOCATION	QTY (EA)	REMARKS
STA 22+22, 49.9' LT	1	TB-2

TYPE 'D' SOIL STABILIZATION MATTING

QTY
11,082 SY

CROSS REFERENCE

ITEM	SHEET NOs.
ABBREVIATIONS /GENERAL NOTES	2
STREAM RESTORATION PROFILES	4 – 8
KEY MAP	11
STREAM RESTORATION PLANS	12 – 15
STREAM RESTORATION DETAILS	16 – 18
ESC NOTES	19
ESC SEQUENCE OF CONSTRUCTION	20
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ESC DETAILS	43 – 44
LANDSCAPING PLANS	45 – 47
LANDSCAPING DETAILS	48
STREAM RESTORATION CROSS SECTIONS	49 – 52
MOT PLANS	53

R /W PLAT NUMBER

REVISIONS

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

E&S CONTROL PLAN (PHASE 2)

SCALE 1" = 30' ADVERTISED DATE JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY MJD
DRAWN BY MJD
CHECKED BY ETK
F.A.P. NO. SEE TITLE SHEET

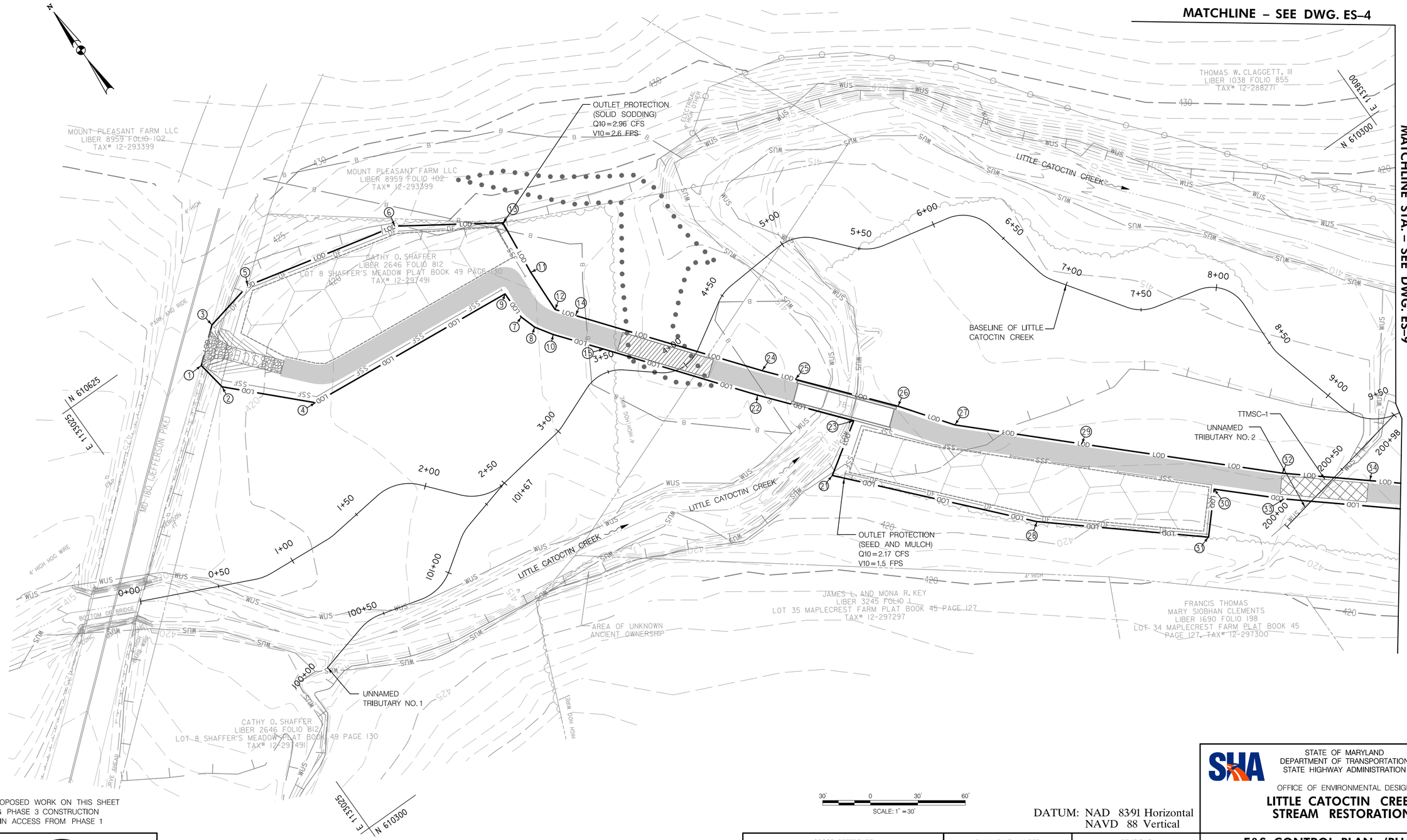
COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. ES-7 OF 20 SHEET NO. 29 OF 53

PLOTTED: Thursday, April 20, 2017 AT 03:42 PM
FILE: G:\Active\2014-16 BCS 2012-03D EPD Env Design-Permitting, EA-JMT\Task 17 Little Catoctin Creek\CAD\pES_P203_LittleCatoctin_CRI.dgn

MATCHLINE – SEE DWG. ES–4

MATCHLINE STA. – SEE DWG. ES–9



NOTE:
NO PROPOSED WORK ON THIS SHEET
DURING PHASE 3 CONSTRUCTION
MAINTAIN ACCESS FROM PHASE 1

SCALE: 1" = 30'

DATUM: NAD 83\91 Horizontal
NAVD 88 Vertical

COASTAL RESOURCES INC.

PHASE 3 EXCAVATION	
CUT	FILL
7,295 CY	629 CY

CROSS REFERENCE	
ITEM	SHEET NOs.
ABBREVIATIONS /GENERAL NOTES	2
STREAM RESTORATION PROFILES	4 – 8
KEY MAP	11
STREAM RESTORATION PLANS	12 – 15
STREAM RESTORATION DETAILS	16 – 18
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LANDSCAPING DETAILS	48
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MOT PLANS	53

R /W PLAT NUMBER

REVISIONS

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

E&S CONTROL PLAN (PHASE 3)

SCALE 1" = 30' ADVERTISED DATE JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY MJD
DRAWN BY MJD
CHECKED BY ETK
F.A.P. NO. SEE TITLE SHEET

COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. ES-8 OF 20

SHEET NO. 30 OF 53

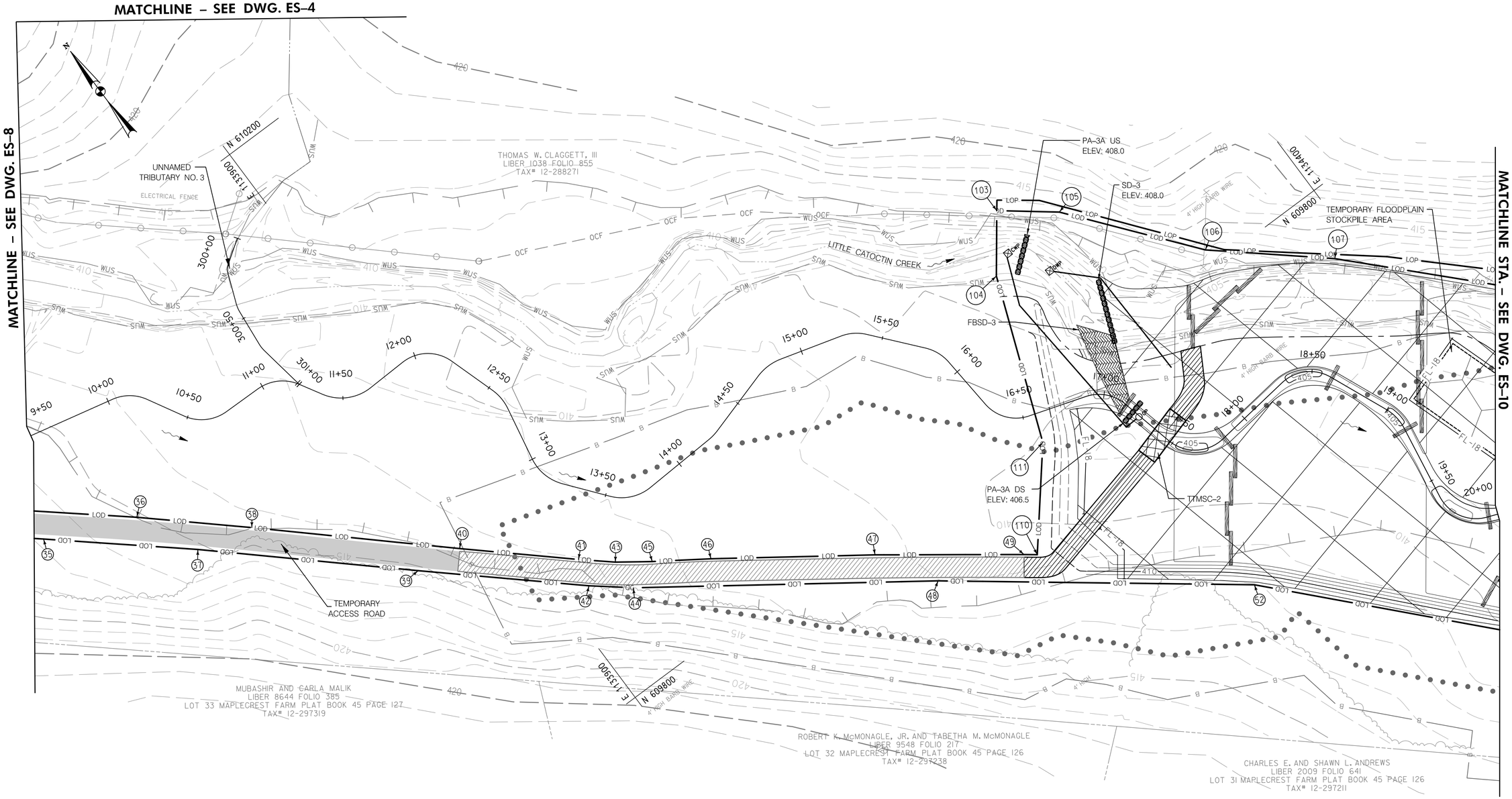
PLOTTED: Thursday, April 20, 2017 AT 03:42 PM
FILE: G:\Active\2014-16 BCS 2012-03D EPD Env Design-Permitting, EA-JMT\Task 17 Little Catoctin Creek\CAD\pES_P301_LittleCatoctin_CRI.dgn

BY: matthewd –

MATCHLINE – SEE DWG. ES–4

MATCHLINE – SEE DWG. ES–8

MATCHLINE STA. – SEE DWG. ES–10



NOTE:
TEMPORARY PUMP–AROUND OF THE EXISTING CHANNEL MAY BE UTILIZED WHEN CONSTRUCTION DICTATES STREAMBED UNDERLAYMENT HARVESTING AT SPECIFIED LOCATIONS

HARDWOOD CONSTRUCTION MATS			
FROM	TO	QTY (SY)	REMARKS
STA 16+46, 88.2' RT	STA 17+43, 15.5' RT	134	
STA 17+22, 49.9' LT	STA 17+42, 15.2' LT	55	

18 INCH FILTER LOG			
FROM	TO	QTY (LF)	REMARKS
STA 16+66, 65.2' RT	STA 16+82, 5.1' RT	63'	
STA 17+48, 67.9' RT	STA 17+55, 84.8' RT	36'	
STA 19+04, 56.5' LT	STA 20+27, 6.4 LT	281'	

TEMPORARY TIMBER MAT STREAM CROSSING (TTMSC)		
TO	QTY (EA)	REMARKS
STA 17+42, 0.0'	1	TTMSC-2

FABRIC BASED STREAM DIVERSION (FBSD)		
FROM	TO	REMARKS
STA 16+96, 37.9' LT	STA 17+14, 0.0'	FBSD-3

TYPE 'D' SOIL STABILIZATION MATTING
QTY
4,603 SY

30' 0 30' 60'
SCALE: 1" = 30'

DATUM: NAD 83\91 Horizontal
NAVD 88 Vertical

COASTAL RESOURCES INC.

CROSS REFERENCE		R /W PLAT NUMBER	REVISIONS
ITEM	SHEET NOs.		
ABBREVIATIONS /GENERAL NOTES	2		
STREAM RESTORATION PROFILES	4 – 8		
KEY MAP	11		
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ESC DETAILS	43 – 44		
LANDSCAPING PLANS	45 – 47		
LANDSCAPING DETAILS	48		
STREAM RESTORATION CROSS SECTIONS	49 – 52		
MOT PLANS	53		

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

E&S CONTROL PLAN (PHASE 3)

SCALE 1" = 30' ADVERTISED DATE JUNE 2017 CONTRACT NO. FR5975182

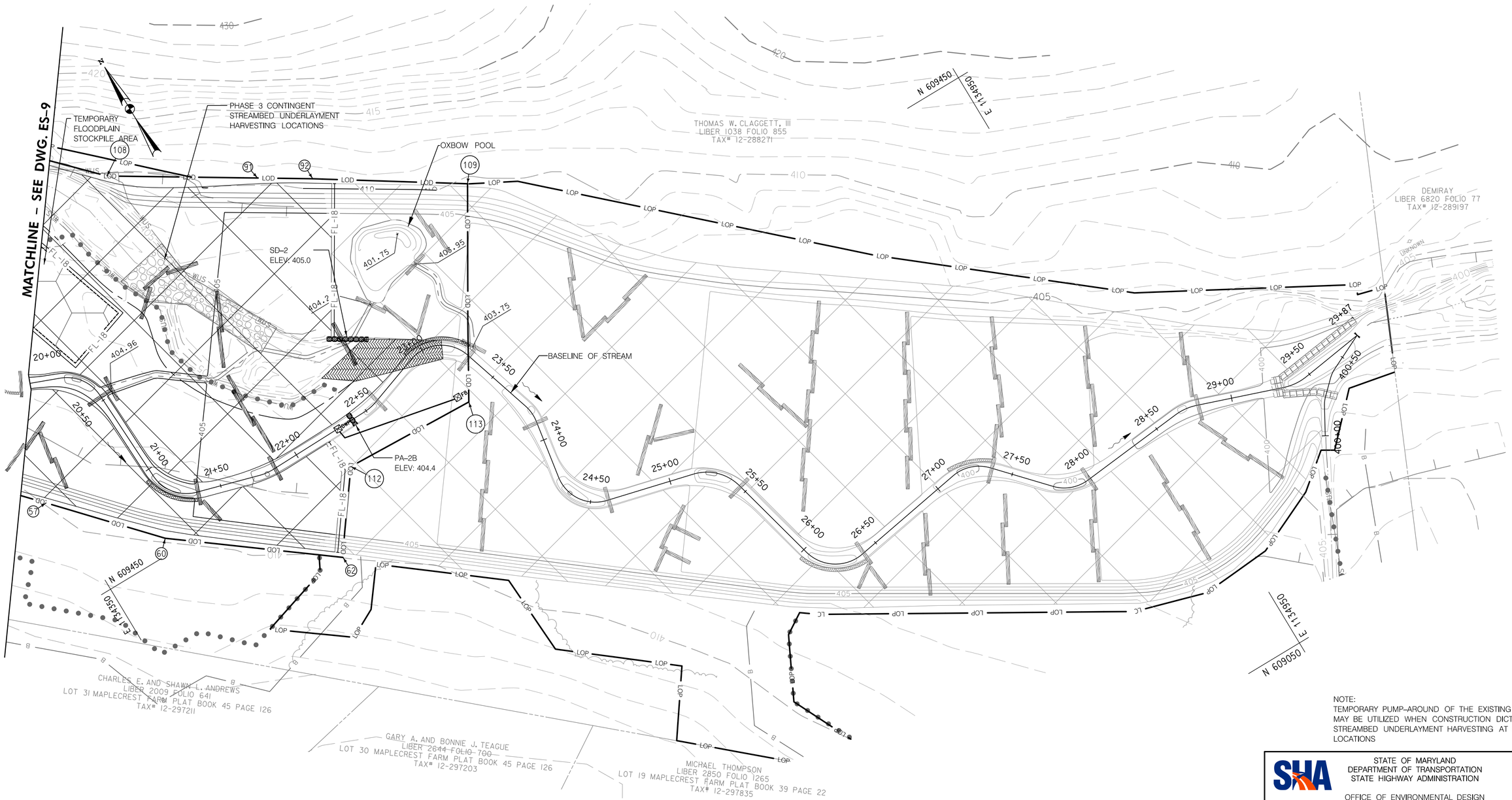
DESIGNED BY MJD
DRAWN BY MJD
CHECKED BY ETK
F.A.P. NO. SEE TITLE SHEET

COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. ES-9 OF 20 SHEET NO. 31 OF 53

PLOTTED: Thursday, April 20, 2017 AT 03:42 PM
FILE: G:\Active\2014-16 BCS 2012-03D EPD Env Design-Permitting, EA-JMT\Task 17 Little Catoctin Creek\CAD\pES_P302_LittleCatoctin_CRI.dgn

BY: matthewd –



NOTE:
TEMPORARY PUMP-AROUND OF THE EXISTING CHANNEL MAY BE UTILIZED WHEN CONSTRUCTION DICTATES STREAMBED UNDERLAYMENT HARVESTING AT SPECIFIED LOCATIONS

DATUM: NAD 83\91 Horizontal
NAVD 88 Vertical

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

COASTAL RESOURCES INC.

TYPE 'D' SOIL STABILIZATION MATTING
QTY
4,186 SY

CROSS REFERENCE

ITEM	SHEET NOs.
ABBREVIATIONS /GENERAL NOTES	2
STREAM RESTORATION PROFILES	4 – 8
KEY MAP	11
STREAM RESTORATION PLANS	12 – 15
STREAM RESTORATION DETAILS	16 – 18
ESC NOTES	19
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ESC DETAILS	43 – 44
LANDSCAPING PLANS	45 – 47
LANDSCAPING DETAILS	48
STREAM RESTORATION CROSS SECTIONS	49 – 52
MOT PLANS	53

R /W PLAT NUMBER

REVISIONS

E&S CONTROL PLAN (PHASE 3)

SCALE 1" = 30' ADVERTISED DATE JUNE 2017 CONTRACT NO. FR5975182

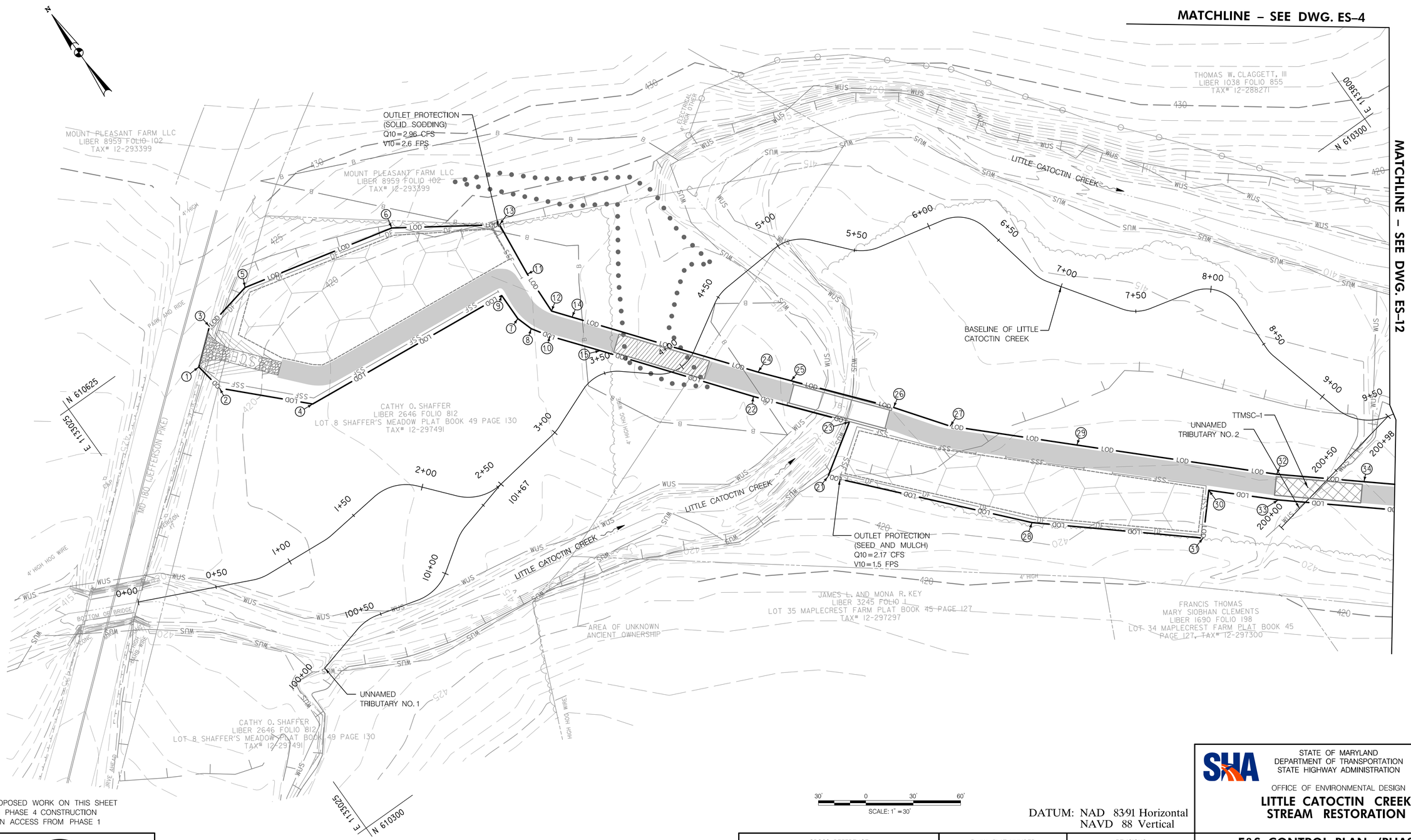
DESIGNED BY MJD
DRAWN BY MJD
CHECKED BY ETK
F.A.P. NO. SEE TITLE SHEET

COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. ES-10 OF 20
SHEET NO. 32 OF 53

PLOTTED: Thursday, April 20, 2017 AT 03:42 PM
FILE: G:\Active\2014-16 BCS 2012-030 EPD Env Design-Permitting, EA-JMT\Task 17 Little Catoctin Creek\CAD\pES_P303_LittleCatoctin_CRI.dgn

BY: matthewd –



NOTE:
NO PROPOSED WORK ON THIS SHEET
DURING PHASE 4 CONSTRUCTION
MAINTAIN ACCESS FROM PHASE 1

DATUM: NAD 83/91 Horizontal
NAVD 88 Vertical

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

COASTAL RESOURCES INC.

PHASE 4 EXCAVATION	
CUT	FILL
5,878 CY	497 CY

CROSS REFERENCE	
ITEM	SHEET NOs.
ABBREVIATIONS /GENERAL NOTES	2
STREAM RESTORATION PROFILES	4 – 8
KEY MAP	11
STREAM RESTORATION PLANS	12 – 15
STREAM RESTORATION DETAILS	16 – 18
ESC NOTES	19
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LOD STAKEOUT	21 – 22
ESC DETAILS	43 – 44
LANDSCAPING PLANS	45 – 47
LANDSCAPING DETAILS	48
STREAM RESTORATION CROSS SECTIONS	49 – 52
MOT PLANS	53

R / W PLAT NUMBER

REVISIONS

E&S CONTROL PLAN (PHASE 4)

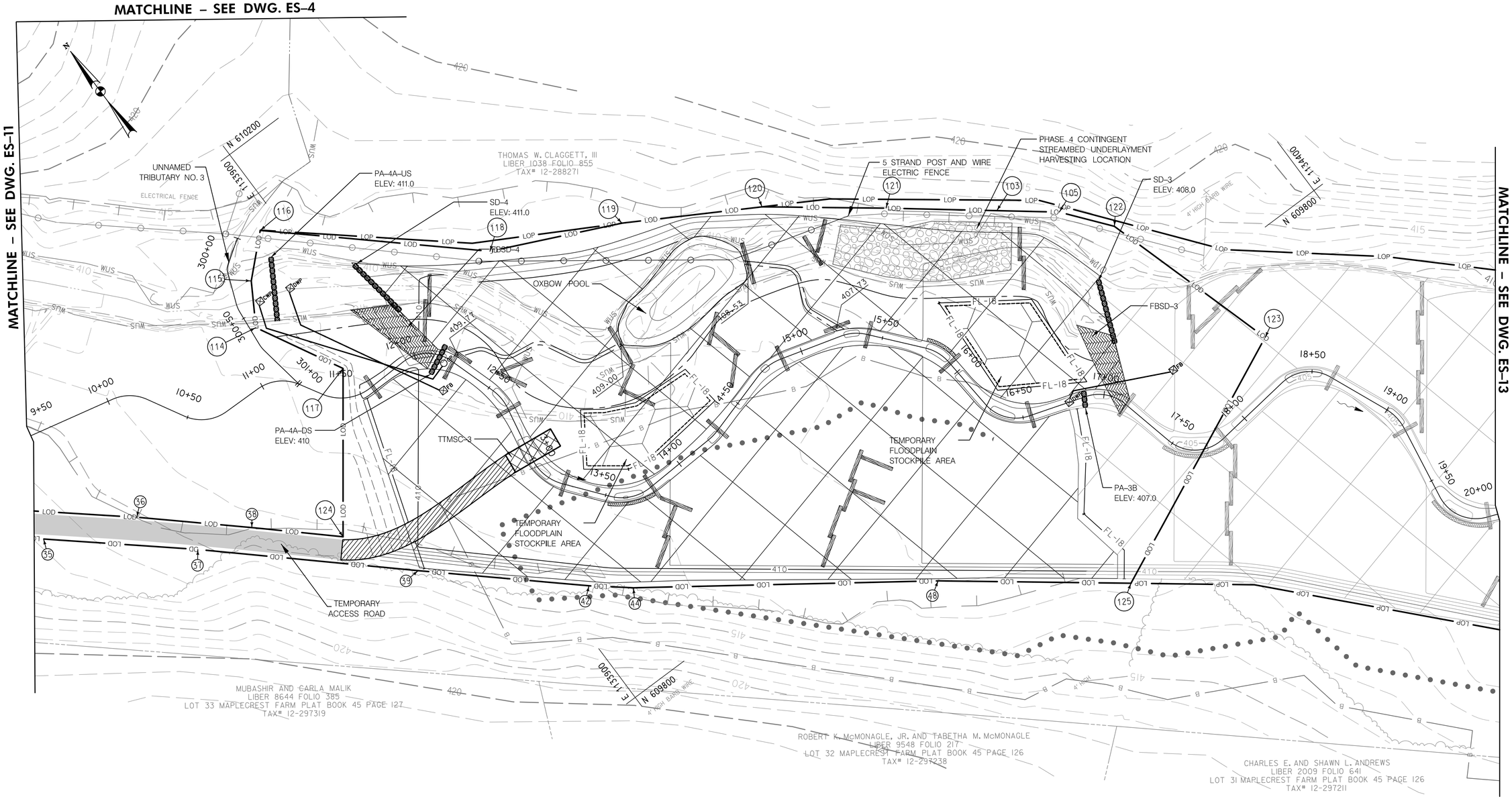
SCALE 1" = 30' ADVERTISED DATE JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY	MJD	COUNTY	FREDERICK COUNTY
DRAWN BY	MJD	LOGMILE	
CHECKED BY	ETK	HORIZONTAL SCALE	N/A
F.A.P. NO.	SEE TITLE SHEET	VERTICAL SCALE	N/A

DRAWING NO. ES-11 OF 20 SHEET NO. 33 OF 53

PLOTTED: Thursday, April 20, 2017 AT 03:42 PM
FILE: G:\Active\2014-16 BCS 2012-03D EPD Env Design-Permitting, EA-JMT\Task 17 Little Catoctin Creek\CAD\pES_P401_LittleCatoctin_CRII.dgn

BY: matthewd –



NOTE:
TEMPORARY PUMP–AROUND OF THE EXISTING CHANNEL MAY BE UTILIZED WHEN CONSTRUCTION DICTATES STREAMBED UNDERLAYMENT HARVESTING AT SPECIFIED LOCATIONS

18 INCH FILTER LOG			
FROM	TO	QTY (LF)	REMARKS
STA 11+63, 4.1' RT	STA 11+59, 80.7' RT	77	
STA 13+03, 11.5' LT	STA 13+07, 89.6' LT	17	
STA 13+33, 11.5' LT	STA 14+48, 37.0' LT	222	
STA 15+77, 27.8' LT	STA 16+92, 8.3' LT	229	

TYPE 'D' SOIL STABILIZATION MATTING
QTY
8,446 SY

HARDWOOD CONSTRUCTION MATS			
FROM	TO	QTY (SY)	REMARKS
STA 11+49, 89.6' RT	STA 12+97, 12.8' RT	147	

FABRIC BASED STREAM DIVERSION (FBSD)		
FROM	TO	REMARKS
STA 11+94, 37.1' LT	STA 12+12, 0.0'	FBSD-4

TEMPORARY TIMBER MAT STREAM CROSSING (TTMSC)		
TO	QTY (EA)	REMARKS
STA 12+95, 0.0'	1	TTMSC-3

30' 0 30' 60'
SCALE: 1" = 30'

DATUM: NAD 8391 Horizontal
NAVD 88 Vertical

COASTAL RESOURCES INC.

CROSS REFERENCE	
ITEM	SHEET NOs.
ABBREVIATIONS /GENERAL NOTES	2
STREAM RESTORATION PROFILES	4 – 8
KEY MAP	11
STREAM RESTORATION PLANS	12 – 15
STREAM RESTORATION DETAILS	16 – 18
ESC NOTES	19
ESC SEQUENCE OF CONSTRUCTION	20
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LANDSCAPING PLANS	45 – 47
LANDSCAPING DETAILS	48
STREAM RESTORATION CROSS SECTIONS	49 – 52
MOT PLANS	53

R /W PLAT NUMBER

REVISIONS

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

E&S CONTROL PLAN (PHASE 4)

SCALE 1" = 30' ADVERTISED DATE JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY MJD
DRAWN BY MJD
CHECKED BY ETK
F.A.P. NO. SEE TITLE SHEET

COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. ES-12 OF 20 SHEET NO. 34 OF 53

PLOTTED: Thursday, April 20, 2017 AT 03:42 PM
FILE: G:\Active\2014-16 BCS 2012-03D EPD Env Design-Permitting, EA-JMT\Task 17 Little Catoctin Creek\CAD\pES_P402_LittleCatoctin_CRI.dgn

BY: matthewd –

30' 0 30' 60'

SCALE: 1" = 30'

DATUM: NAD 83\91 Horizontal
NAVD 88 Vertical

NOTE:
NO PROPOSED WORK ON THIS SHEET
DURING PHASE 4 CONSTRUCTION

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

COASTAL RESOURCES INC.

CROSS REFERENCE		R / W PLAT NUMBER	REVISIONS

ITEM	SHEET NOs.
ABBREVIATIONS /GENERAL NOTES	2
STREAM RESTORATION PROFILES	4 – 8
KEY MAP	11
STREAM RESTORATION PLANS	12 – 15
STREAM RESTORATION DETAILS	16 – 18
ESC NOTES	19
ESC SEQUENCE OF CONSTRUCTION	20
LOD STAKEOUT	21 – 22
ESC DETAILS	43 – 44
LANDSCAPING PLANS	45 – 47
LANDSCAPING DETAILS	48
STREAM RESTORATION CROSS SECTIONS	49 – 52
MOT PLANS	53

E&S CONTROL PLAN (PHASE 4)

SCALE 1" = 30' ADVERTISED DATE JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY MJD
DRAWN BY MJD
CHECKED BY ETK
F.A.P. NO. SEE TITLE SHEET

COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

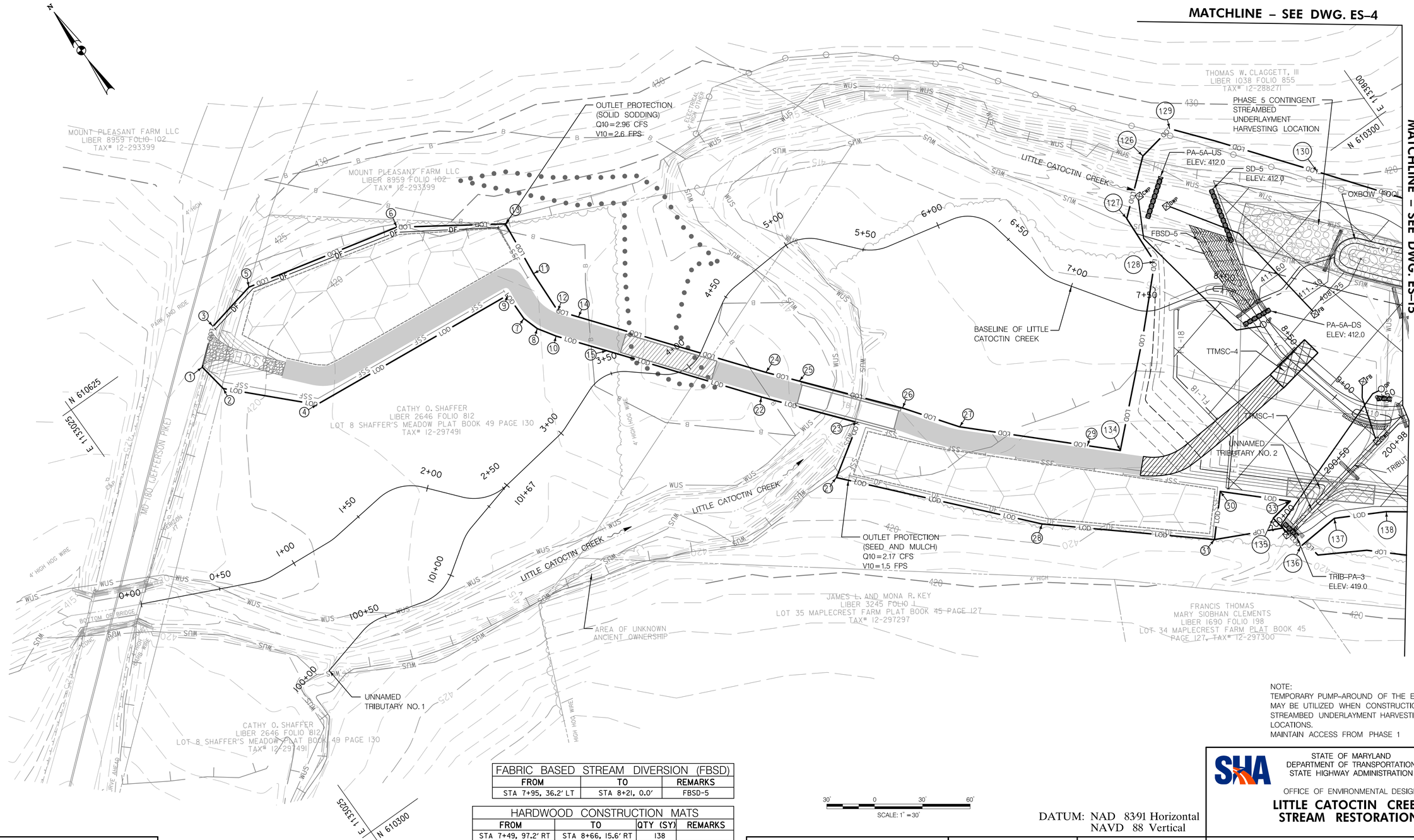
DRAWING NO. ES-13 OF 20 SHEET NO. 35 OF 53

PLOTTED: Thursday, April 20, 2017 AT 03:42 PM
FILE: G:\Active\2014-16 BCS 2012-033 EPD Env Design-Permitting, EA-JMT\Task 17 Little Catoctin Creek\CAD\pES_P403_LittleCatoctin_CRI.dgn

BY: matthewd –

MATCHLINE – SEE DWG. ES–4

MATCHLINE – SEE DWG. ES–15



NOTE:
TEMPORARY PUMP–AROUND OF THE EXISTING CHANNEL MAY BE UTILIZED WHEN CONSTRUCTION DICTATES STREAMBED UNDERLAYMENT HARVESTING AT SPECIFIED LOCATIONS.
MAINTAIN ACCESS FROM PHASE 1

PHASE 4 EXCAVATION	
CUT	FILL
5,705 CY	837 CY

TYPE 'D' SOIL STABILIZATION MATTING
QTY
2,265 SY

FABRIC BASED STREAM DIVERSION (FBSD)		
FROM	TO	REMARKS
STA 7+95, 36.2' LT	STA 8+21, 0.0'	FBSD-5

HARDWOOD CONSTRUCTION MATS			
FROM	TO	QTY (SY)	REMARKS
STA 7+49, 97.2' RT	STA 8+66, 15.6' RT	138	

18 INCH FILTER LOG					
FROM		TO		QTY (LF)	REMARKS
STA 7+69,	4.7' RT	STA 8+57,	58.3' RT	79	
STA 8+67,	59.5' RT	STA 8+86,	87.1' RT	34	

TEMPORARY TIMBER MAT STREAM CROSSING (TTMSC)		
LOCATION	QTY (EA)	REMARKS
8+67, 0.0'	1	TTMSC-4

30' 0 30' 60'
SCALE: 1" = 30'

DATUM: NAD 8391 Horizontal
NAVD 88 Vertical

CROSS REFERENCE	
ITEM	SHEET NOs.
ABBREVIATIONS /GENERAL NOTES	2
STREAM RESTORATION PROFILES	4 – 8
KEY MAP	11
STREAM RESTORATION PLANS	12 – 15
STREAM RESTORATION DETAILS	16 – 18
ESC NOTES	19
ESC SEQUENCE OF CONSTRUCTION	20
LOD STAKEOUT	21 – 22
ESC DETAILS	43 – 44
LANDSCAPING PLANS	45 – 47
LANDSCAPING DETAILS	48
STREAM RESTORATION CROSS SECTIONS	49 – 52
MOT PLANS	53

R / W PLAT NUMBER

REVISIONS

COASTAL RESOURCES INC.

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

E&S CONTROL PLAN (PHASE 5)

SCALE 1" = 30' ADVERTISED DATE JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY MJD
DRAWN BY MJD
CHECKED BY ETK
F.A.P. NO. SEE TITLE SHEET

COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. ES-14 OF 20
SHEET NO. 36 OF 53

PLOTTED: Thursday, April 20, 2017 AT 03:42 PM
FILE: G:\Active\2014-16 BCS 2012-030 EPD Env Design-Permitting, EA-JMT\Task 17 Little Catoctin Creek\CAD\pES_PS01_LittleCatoctin_CRI.dgn

BY: matthewd –

NOTE:
TEMPORARY PUMP–AROUND OF THE EXISTING CHANNEL MAY BE UTILIZED WHEN CONSTRUCTION DICTATES STREAMBED UNDERLAYMENT HARVESTING AT SPECIFIED LOCATIONS

30' 0 30' 60'
SCALE: 1" = 30'

DATUM: NAD 83\91 Horizontal
NAVD 88 Vertical

COASTAL RESOURCES INC.

TYPE 'D' SOIL STABILIZATION MATTING
QTY
3,706 SY

18 INCH FILTER LOG			
FROM	TO	QTY (LF)	REMARKS
STA 9+77, 30.6' LT	STA 11+03, 27.9' LT	281	

CROSS REFERENCE

ITEM	SHEET NOs.
ABBREVIATIONS /GENERAL NOTES	2
STREAM RESTORATION PROFILES	4 – 8
KEY MAP	11
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LANDSCAPING DETAILS	48
STREAM RESTORATION CROSS SECTIONS	49 – 52
MOT PLANS	53

R /W PLAT NUMBER

REVISIONS

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

E&S CONTROL PLAN (PHASE 5)

SCALE 1" = 30' ADVERTISED DATE JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY MJD
DRAWN BY MJD
CHECKED BY ETK
F.A.P. NO. SEE TITLE SHEET

COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. ES-15 OF 20
SHEET NO. 37 OF 53

PLOTTED: Thursday, April 20, 2017 AT 03:42 PM
FILE: G:\Active\2014-16 BCS 2012-033 EPD Env Design-Permitting, EA-JMT\Task 17 Little Catoctin Creek\CAD\pES_PS02_LittleCatoctin_CRI.dgn

BY: matthewd –

DATUM: NAD 83\91 Horizontal
NAVD 88 Vertical

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

COASTAL RESOURCES INC.

CROSS REFERENCE		R / W PLAT NUMBER	REVISIONS
ITEM	SHEET NOs.		
ABBREVIATIONS /GENERAL NOTES	2		
STREAM RESTORATION PROFILES	4 – 8		
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LANDSCAPING PLANS	45 – 47		
LANDSCAPING DETAILS	48		
STREAM RESTORATION CROSS SECTIONS	49 – 52		
MOT PLANS	53		

E&S CONTROL PLAN (PHASE 5)

SCALE 1" = 30' ADVERTISED DATE JUNE 2017 CONTRACT NO. FR5975182

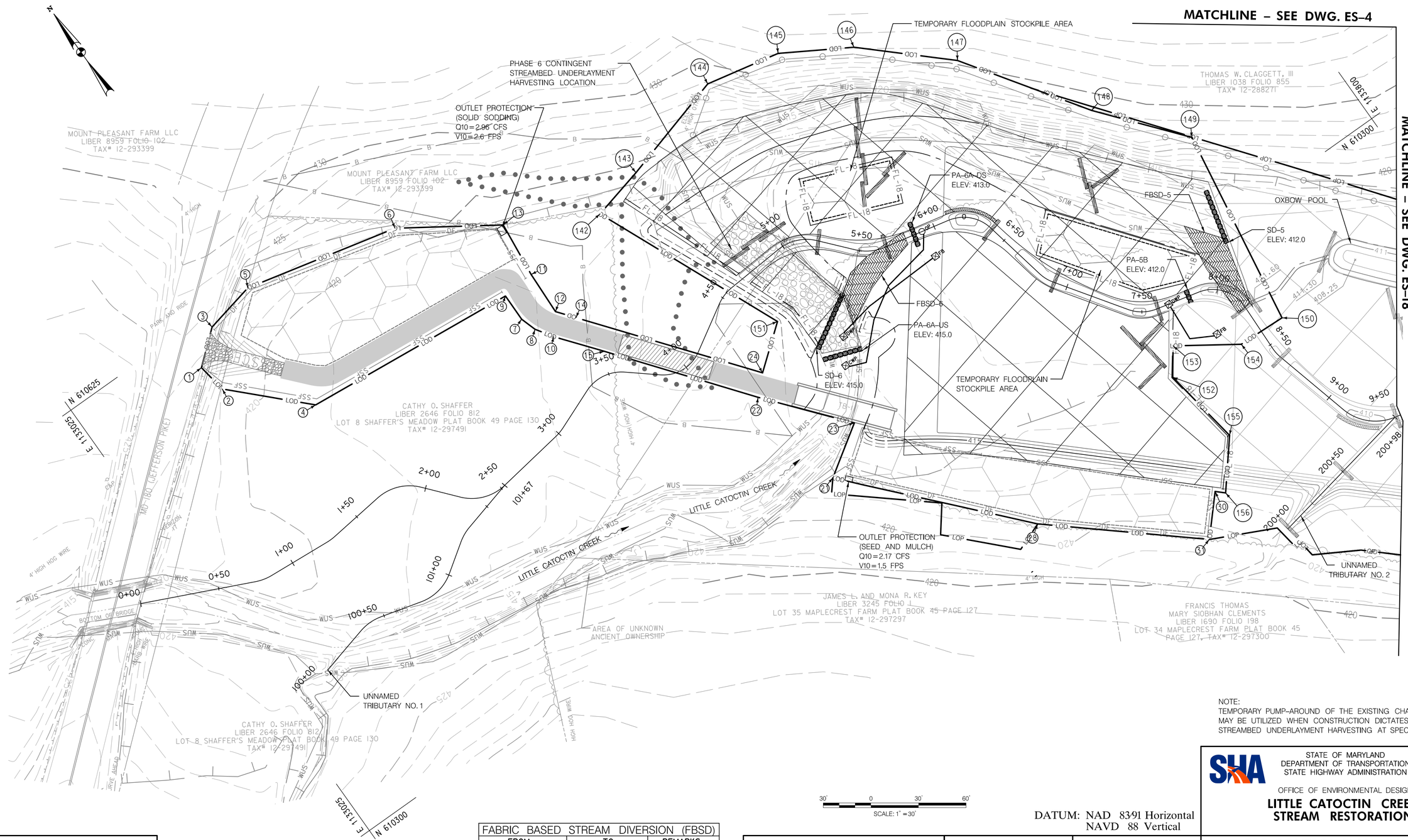
DESIGNED BY MJD
DRAWN BY MJD
CHECKED BY ETK
F.A.P. NO. SEE TITLE SHEET

COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. ES-16 OF 20 SHEET NO. 38 OF 53

PLOTTED: Thursday, April 20, 2017 AT 03:42 PM
FILE: G:\Active\2014-16 BCS 2012-030 EPD Env Design-Permitting, EA-JMT\Task 17 Little Catoctin Creek\CAD\pES_PS03_LittleCatoctin_CRI.dgn

BY: matthewd –



NOTE:
TEMPORARY PUMP–AROUND OF THE EXISTING CHANNEL MAY BE UTILIZED WHEN CONSTRUCTION DICTATES STREAMBED UNDERLAYMENT HARVESTING AT SPECIFIED LOCATIONS

30' 0 30' 60'
SCALE: 1" = 30'

DATUM: NAD 8391 Horizontal
NAVD 88 Vertical

PHASE 6 EXCAVATION	
CUT	FILL
3,953 CY	895 CY

TYPE 'D' SOIL STABILIZATION MATTING
QTY
5,526 SY

FABRIC BASED STREAM DIVERSION (FBSD)		
FROM	TO	REMARKS
STA 5+49, 37.8' RT	STA 5+80, 0.0'	FBSD-6

18 INCH FILTER LOG			
FROM	TO	QTY (LF)	REMARKS
STA 4+55, 87.1 LT	STA 4+67, 4.4 LT	86	
STA 4+71, 6.1 RT	STA 4+71, 5.1 LT	58	
STA 5+18, 8.9 LT	STA 5+93, 51.8 RT	180	
STA 6+71, 7.0 LT	STA 7+92, 23 RT	246	

CROSS REFERENCE	
ITEM	SHEET NOs.
ABBREVIATIONS /GENERAL NOTES	2
STREAM RESTORATION PROFILES	4 – 8
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LANDSCAPING DETAILS	48
STREAM RESTORATION CROSS SECTIONS	49 – 52
MOT PLANS	53

R / W PLAT NUMBER

REVISIONS

COASTAL RESOURCES INC.

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

E&S CONTROL PLAN (PHASE 6)

SCALE 1" = 30' ADVERTISED DATE JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY MJD
DRAWN BY MJD
CHECKED BY ETK
F.A.P. NO. SEE TITLE SHEET

COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. ES-17 OF 20 SHEET NO. 39 OF 53

PLOTTED: Thursday, April 20, 2017 AT 03:42 PM
FILE: G:\Active\2014-16 BCS 2012-03D EPD Env Design-Permitting, EA-JMT\Task 17 Little Catoctin Creek\CAD\pES_P601_LittleCatoctin_CRI.dgn

BY: matthewd –

MATCHLINE – SEE DWG. ES–4

MATCHLINE – SEE DWG. ES–17

MATCHLINE – SEE DWG. ES–19

30' 0 30' 60'

SCALE: 1" = 30'

DATUM: NAD 83\91 Horizontal
NAVD 88 Vertical

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

COASTAL RESOURCES INC.

CROSS REFERENCE		R / W PLAT NUMBER	REVISIONS
ITEM	SHEET NOs.		
ABBREVIATIONS /GENERAL NOTES	2		
STREAM RESTORATION PROFILES	4 – 8		
KEY MAP	11		
STREAM RESTORATION PLANS	12 – 15		
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ESC DETAILS	43 – 44		
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LANDSCAPING DETAILS	48		
STREAM RESTORATION CROSS SECTIONS	49 – 52		
MOT PLANS	53		

E&S CONTROL PLAN (PHASE 6)

SCALE 1" = 30' ADVERTISED DATE JUNE 2017 CONTRACT NO. FR5975182

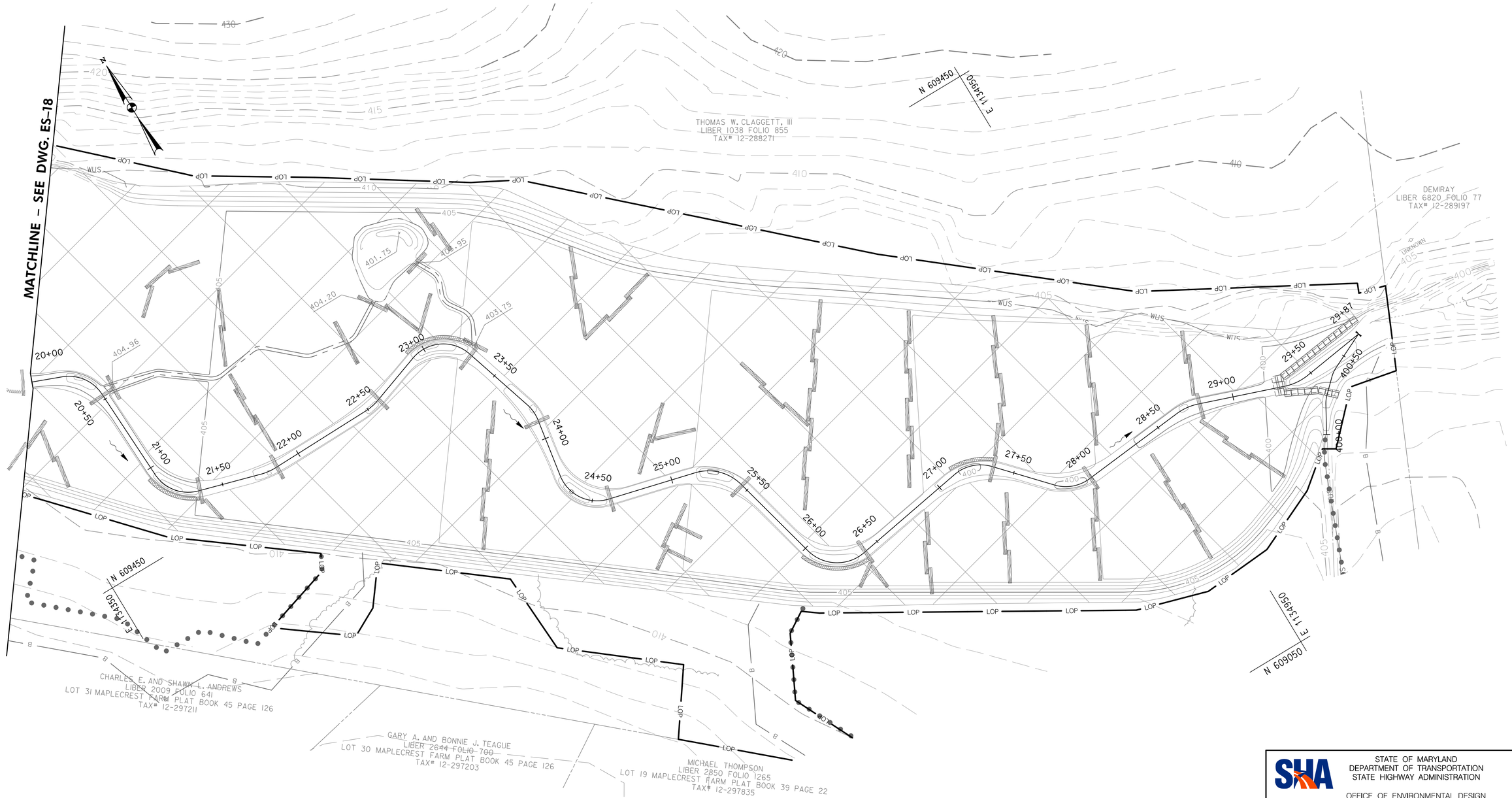
DESIGNED BY MJD
DRAWN BY MJD
CHECKED BY ETK
F.A.P. NO. SEE TITLE SHEET

COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. ES-18 OF 20 SHEET NO. 40 OF 53

PLOTTED: Thursday, April 20, 2017 AT 03:42 PM
FILE: G:\Active\2014-16 BCS 2012-033 EPD Env Design-Permitting, EA-JMT\Task 17 Little Catoctin Creek\CAD\pES_P602_LittleCatoctin_CRI.dgn

BY: matthewd –



30' 0 30' 60'

SCALE: 1" = 30'

DATUM: NAD 83\91 Horizontal
NAVD 88 Vertical

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

COASTAL RESOURCES INC.

CROSS REFERENCE		R / W PLAT NUMBER	REVISIONS
ITEM	SHEET NOs.		
ABBREVIATIONS /GENERAL NOTES	2		
STREAM RESTORATION PROFILES	4 – 8		
KEY MAP	11		
STREAM RESTORATION PLANS	12 – 15		
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ESC DETAILS	43 – 44		
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LANDSCAPING DETAILS	48		
STREAM RESTORATION CROSS SECTIONS	49 – 52		
MOT PLANS	53		

E&S CONTROL PLAN (PHASE 6)

SCALE 1" = 30' ADVERTISED DATE JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY MJD
DRAWN BY MJD
CHECKED BY ETK
F.A.P. NO. SEE TITLE SHEET

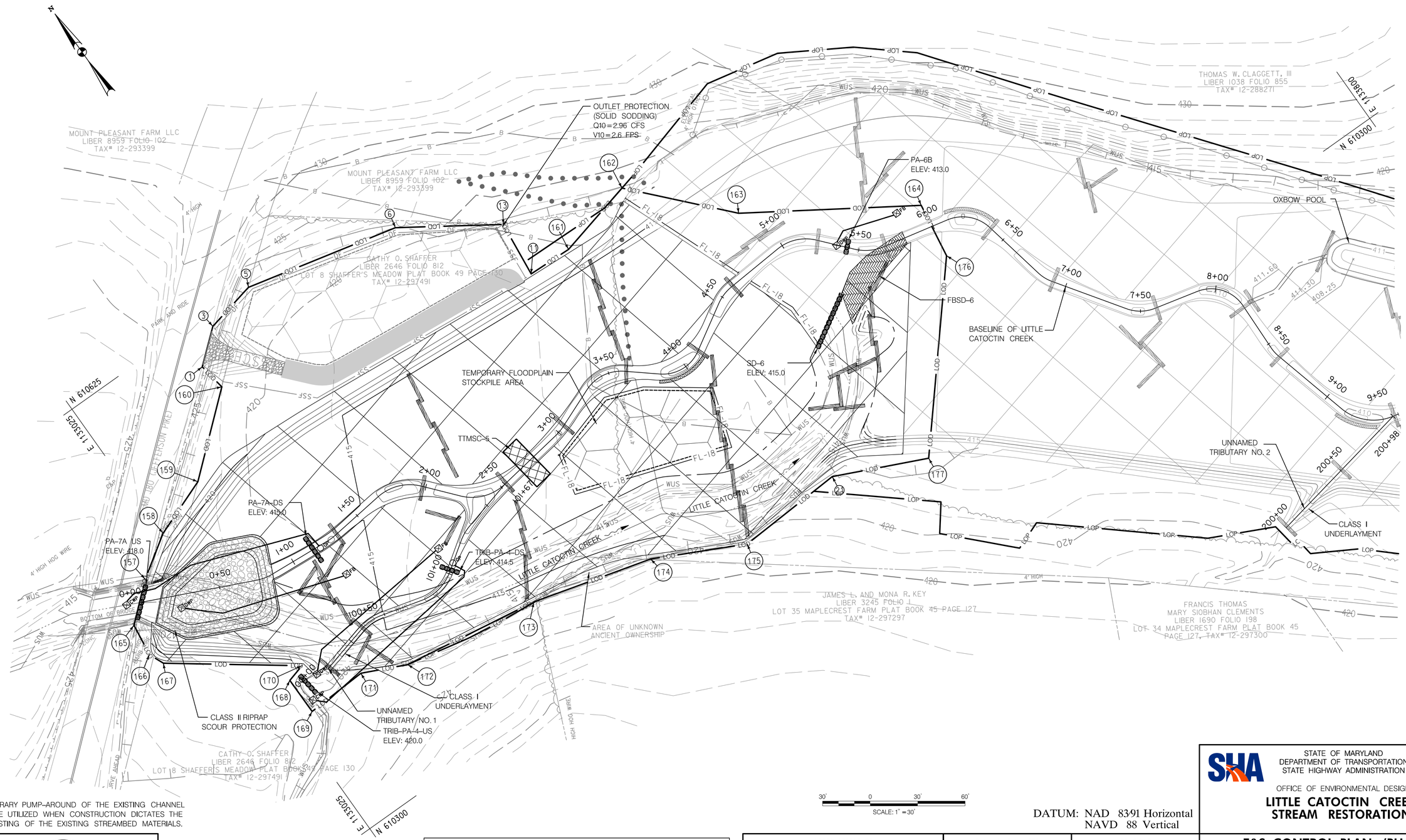
COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. ES-19 OF 20

SHEET NO. 41 OF 53

PLOTTED: Thursday, April 20, 2017 AT 03:42 PM
FILE: G:\Active\2014-16 BCS 2012-030 EPD Env Design-Permitting, EA-JMT\Task 17 Little Catoctin Creek\CAD\pES_P603_LittleCatoctin_CRI.dgn

BY: matthewd –



NOTE:
TEMPORARY PUMP-AROUND OF THE EXISTING CHANNEL MAY BE UTILIZED WHEN CONSTRUCTION DICTATES THE HARVESTING OF THE EXISTING STREAMBED MATERIALS.

DATUM: NAD 83\91 Horizontal
NAVD 88 Vertical

COASTAL RESOURCES INC.

PHASE 7 EXCAVATION	
CUT	FILL
7,741 CY	246 CY

TYPE 'D' SOIL STABILIZATION MATTING
QTY
7,820 SY

TEMPORARY TIMBER MAT STREAM CROSSING (TTMSC)		
LOCATION	QTY (EA)	REMARKS
STA 2+73, 0.00 RT	1	TTMSC-5

18 INCH FILTER LOG			
FROM	TO	QTY (LF)	REMARKS
STA 2+90 10.4 RT	STA 3+98 58.5 RT	286	

CROSS REFERENCE	
ITEM	SHEET NOs.
ABBREVIATIONS /GENERAL NOTES	2
STREAM RESTORATION PROFILES	4 – 8
KEY MAP	11
STREAM RESTORATION PLANS	12 – 15
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LANDSCAPING DETAILS	48
STREAM RESTORATION CROSS SECTIONS	49 – 52
MOT PLANS	53

R /W PLAT NUMBER

REVISIONS

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

E&S CONTROL PLAN (PHASE 7)

SCALE 1" = 30' ADVERTISED DATE JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY MJD
DRAWN BY MJD
CHECKED BY ETK
F.A.P. NO. SEE TITLE SHEET
COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. ES-20 OF 20
SHEET NO. 42 OF 53

PLOTTED: Thursday, April 20, 2017 AT 03:42 PM
FILE: G:\Active\2014-16 BCS 2012-030 EPD Env Design-Permitting, EA-JMT\Task 17 Little Catoctin Creek\CAD\pES_P701_LittleCatoctin_CRR.dgn

BY: matthewd –

PUMP–AROUND PRACTICE

DESCRIPTION THE WORK SHALL CONSIST OF INSTALLING A TEMPORARY PUMP AROUND AND SUPPORTING MEASURES TO DIVERT FLOW AROUND INSTREAM CONSTRUCTION SITES.

IMPLEMENTATION SEQUENCE SEDIMENT CONTROL MEASURES, PUMP–AROUND PRACTICES, AND ASSOCIATED CHANNEL AND BANK CONSTRUCTION SHALL BE COMPLETED IN THE FOLLOWING SEQUENCE (REFER TO DETAIL):

1. CONSTRUCTION ACTIVITIES INCLUDING THE INSTALLATION OF EROSION AND SEDIMENT CONTROL MEASURES SHALL NOT BEGIN UNTIL ALL NECESSARY EASEMENTS AND/OR RIGHT–OF–WAYS HAVE BEEN ACQUIRED. ALL EXISTING UTILITIES SHALL BE MARKED IN THE FIELD PRIOR TO CONSTRUCTION. THE CONTRACTOR IS RESPONSIBLE FOR ANY DAMAGE TO EXISTING UTILITIES THAT MAY RESULT FROM CONSTRUCTION AND SHALL REPAIR THE DAMAGE AT HIS/HER OWN EXPENSE TO THE COUNTY'S OR UTILITY COMPANY'S SATISFACTION.

2. THE CONTRACTOR SHALL NOTIFY THE REGIONAL ENVIRONMENTAL COORDINATOR AT (410) 365–0164 AT LEAST SEVEN (7) DAYS BEFORE COMMENCING ANY LAND DISTURBING ACTIVITY.

3. THE CONTRACTOR SHALL CONDUCT A PRE–CONSTRUCTION MEETING ON SITE WITH THE SEDIMENT CONTROL INSPECTOR AND THE ENGINEER TO REVIEW LIMITS OF DISTURBANCE, EROSION AND SEDIMENT CONTROL REQUIREMENTS, AND THE SEQUENCE OF CONSTRUCTION. THE CONTRACTOR SHALL STAKE OUT ALL LIMITS OF DISTURBANCE PRIOR TO THE PRE–CONSTRUCTION MEETING SO THEY MAY BE REVIEWED. THE PARTICIPANTS WILL ALSO DESIGNATE THE CONTRACTOR'S STAGING AREAS AND FLAG ALL TREES WITHIN THE LIMIT OF DISTURBANCE WHICH WILL BE REMOVED FOR CONSTRUCTION ACCESS. TREES SHALL NOT BE REMOVED WITHIN THE LIMIT OF DISTURBANCE WITHOUT APPROVAL FROM THE INSPECTOR.

4. CONSTRUCTION SHALL NOT BEGIN UNTIL ALL SEDIMENT AND EROSION CONTROL MEASURES HAVE BEEN INSTALLED AND APPROVED BY THE ENGINEER AND THE SEDIMENT CONTROL INSPECTOR. THE CONTRACTOR SHALL STAY WITHIN THE LIMITS OF THE DISTURBANCE AS SHOWN ON THE PLANS AND MINIMIZE DISTURBANCE WITHIN THE WORK AREA WHENEVER POSSIBLE.

5. UPON INSTALLATION OF ALL SEDIMENT CONTROL MEASURES AND APPROVAL BY THE SEDIMENT CONTROL INSPECTOR AND THE LOCAL ENVIRONMENTAL PROTECTION AND RESOURCE MANAGEMENT INSPECTION AND ENFORCEMENT DIVISION, THE CONTRACTOR SHALL BEGIN WORK AT THE UPSTREAM SECTION AND PROCEED DOWNSTREAM BEGINNING WITH THE ESTABLISHMENT OF STABILIZED CONSTRUCTION ENTRANCES. IN SOME CASES, WORK MAY BEGIN DOWNSTREAM IF APPROPRIATE. THE SEQUENCE OF CONSTRUCTION MUST BE FOLLOWED UNLESS THE CONTRACTOR GETS WRITTEN APPROVAL FOR DEVIATIONS FROM THE WMA. THE CONTRACTOR SHALL ONLY BEGIN WORK IN AN AREA WHICH CAN BE COMPLETED BY THE END OF THE DAY INCLUDING GRADING ADJACENT TO THE CHANNEL. AT THE END OF EACH WORK DAY, THE WORK AREA MUST BE STABILIZED AND THE PUMP AROUND REMOVED FROM THE CHANNEL. WORK SHALL NOT BE CONDUCTED IN THE CHANNEL DURING RAIN EVENTS.

6. SANDBAG DIKES SHALL BE SITUATED AT THE UPSTREAM AND DOWNSTREAM ENDS OF THE WORK AREA AS SHOWN ON THE PLANS, AND STREAM FLOW SHALL BE PUMPED AROUND THE WORK AREA. THE PUMP SHALL DISCHARGE ONTO A STABLE VELOCITY DISSIPATER MADE OF RIPRAP OR SANDBAGS AS A TEMPORARY MEASURE FOR DEWATERING IN CHANNEL CONSTRUCTION SITES.

7. WATER FROM THE WORK AREA SHALL BE PUMPED TO A SEDIMENT FILTERING MEASURE SUCH AS A DEWATERING BASIN, SEDIMENT BAG, OR OTHER APPROVED SOURCE. THE MEASURE SHALL BE LOCATED SUCH THAT THE WATER DRAINS BACK INTO THE CHANNEL BELOW THE DOWNSTREAM SANDBAG DIKE.

8. TRAVERSING A CHANNEL REACH WITH EQUIPMENT WITHIN THE WORK AREA WHERE NO WORK IS PROPOSED SHALL BE AVOIDED. IF EQUIPMENT HAS TO TRAVERSE SUCH A REACH FOR ACCESS TO ANOTHER AREA, THEN TIMBER MATS OR SIMILAR MEASURES SHALL BE USED TO MINIMIZE DISTURBANCE TO THE CHANNEL. TEMPORARY STREAM CROSSINGS SHALL BE USED ONLY WHEN NECESSARY AND SHALL BE USED ONLY WHERE NOTED ON THE PLANS OR SPECIFIED.

9. ALL STREAM RESTORATION MEASURES SHALL BE INSTALLED AS INDICATED BY THE PLANS AND ALL BANKS GRADED IN ACCORDANCE WITH THE GRADING PLANS AND TYPICAL CROSS–SECTIONS. ALL GRADING MUST BE STABILIZED AT THE END OF EACH DAY WITH SEED AND MULCH OR SEED AND MATTING AS SPECIFIED ON THE PLANS.

10. AFTER AN AREA IS COMPLETED AND STABILIZED, THE CLEAN WATER DIKE SHALL BE REMOVED. AFTER THE FIRST SEDIMENT FLUSH, A NEW CLEAN WATER DIKE SHALL BE ESTABLISHED UPSTREAM FROM THE OLD SEDIMENT DIKE. FINALLY, UPON ESTABLISHMENT OF A NEW SEDIMENT DIKE BELOW THE OLD ONE, THE OLD SEDIMENT DIKE SHALL BE REMOVED.

11. A PUMP AROUND MUST BE INSTALLED ON ANY TRIBUTARY OR STORM DRAIN OUTFALL WHICH CONTRIBUTES BASEFLOW TO THE WORK AREA. THIS SHALL BE ACCOMPLISHED BY LOCATING A SANDBAG DIKE AT THE DOWNSTREAM END OF THE TRIBUTARY OR STORM DRAIN OUTFALL AND PUMPING THE STREAM FLOW AROUND THE WORK AREA. THIS WATER SHALL DISCHARGE ONTO THE SAME VELOCITY DISSIPATER USED FOR THE MAIN STEM PUMP AROUND.

12. IF A TRIBUTARY IS TO BE RESTORED, CONSTRUCTION SHALL TAKE PLACE ON THE TRIBUTARY BEFORE WORK ON THE MAIN STEM REACHES THE TRIBUTARY CONFLUENCE. CONSTRUCTION IN THE TRIBUTARY, INCLUDING PUMP AROUND PRACTICES, SHALL FOLLOW THE SAME SEQUENCE AS FOR THE MAIN STEM OF THE RIVER OR STREAM. WHEN CONSTRUCTION ON THE TRIBUTARY IS COMPLETED, WORK ON THE MAIN STEM SHALL RESUME. WATER FROM THE TRIBUTARY SHALL CONTINUE TO BE PUMPED AROUND THE WORK AREA IN THE MAIN STEM.

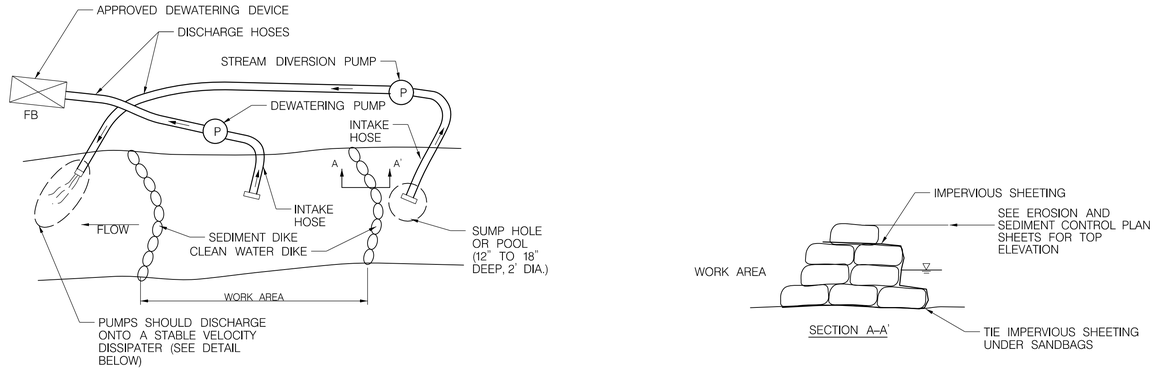
13. THE CONTRACTOR IS RESPONSIBLE FOR PROVIDING ACCESS TO AND MAINTAINING ALL EROSION AND SEDIMENT CONTROL DEVICES UNTIL THE SEDIMENT CONTROL INSPECTOR APPROVES THEIR REMOVAL.

14. AFTER CONSTRUCTION, ALL DISTURBED AREAS SHALL BE REGRADED AND REVEGETATED AS PER THE PLANTING PLAN.

15. IF, IN THE JUDGMENT OF THE ENGINEER, INADEQUATE ENERGY DISSIPATION OR CHANNEL BED EROSION IS OCCURRING, THE CONTRACTOR SHALL BE REQUIRED TO INCREASE THE MATERIAL OR PLACEMENT SIZE OF THE OUTFALL PROTECTION AT THE DIRECTION OF THE ENGINEER.

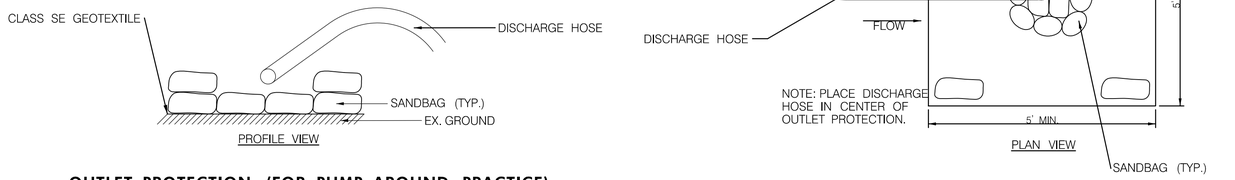
16. THE CONDITION OF THE OUTLET PROTECTION SANDBAGS IS TO BE CHECKED TWICE PER DAY (START OF WORK DAY AND MID–DAY) TO ENSURE THAT SAND IS NOT ESCAPING BAGS. DAMAGED OR LEAKING BAGS ARE TO BE REMOVED AND REPLACED.

17. OUTFALL PROTECTION MATERIALS AND GEOTEXTILE SHALL BE REMOVED FROM THE CHANNEL AT THE COMPLETION OF EACH CONSTRUCTION STAGE



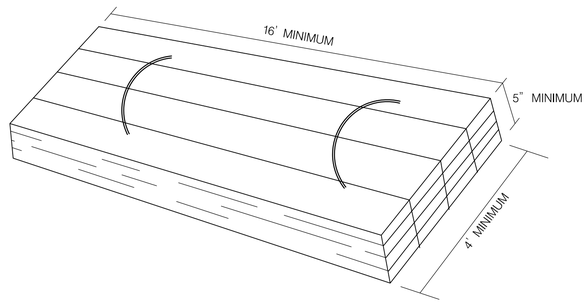
PUMP AROUND DETAIL

NOT TO SCALE



OUTLET PROTECTION (FOR PUMP AROUND PRACTICE)

NOT TO SCALE



TEMPORARY TIMBER MAT STREAM CROSSING DETAIL

NOT TO SCALE

NOTES:
1. TIMBER MATS SHALL BE USED TO TRAVERSE THE STREAM CHANNEL WHERE INDICATED ON THE PLANS AND IF THERE IS AN UTILITY LINE UNDERGROUND, TIMBER MATS CAN BE REUSED AS NECESSARY THROUGHOUT THE PROJECT
2. MATERIAL: DRAGLINE MATS OR SIMILAR TIMBER MATTING SHALL BE CONSTRUCTED FROM MIXED OAK AND HARDWOODS INCLUDING BEECH AND HICKORY.
3. THE CONTRACTOR IS RESPONSIBLE TO SELECT APPROPRIATE SIZE/STRENGTH OF TIMBER MATTING BASED ON EQUIPMENT TO BE USED.
4. TEMPORARY TIMBER MAT STREAM CROSSINGS SHOULD BE REMOVED AT THE END OF EACH WORKDAY AND REPLACED AT THE BEGINNING OF THE NEXT WORK DAY, UNLESS OTHERWISE SPECIFIED IN THE SEQUENCE OF CONSTRUCTION.

DATUM: NAD 83\91 Horizontal
NAVD 88 Vertical

COASTAL RESOURCES INC.

CROSS REFERENCE

ITEM	SHEET NOs.
ABBREVIATIONS /GENERAL NOTES	2
STREAM TYPICAL SECTIONS	3
STREAM RESTORATION PROFILES	4 – 8
KEY MAP	11
STREAM RESTORATION PLANS	12 – 15
STREAM RESTORATION DETAILS	16 – 17
ESC NOTES	18
ESC SEQUENCE OF CONSTRUCTION	19
ESC PLANS	20 – 23
LANDSCAPING PLANS	26 – 29
LANDSCAPING DETAILS	30
STREAM RESTOATION CROSS SECTIONS	31 – 34
MOT PLANS	35

R /W PLAT NUMBER

REVISIONS

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

EROSION & SEDIMENT CONTROL DETAIL

SCALE N.T.S. ADVERTISED DATE JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY MJD
DRAWN BY MJD
CHECKED BY ETK
F.A.P. NO. SEE TITLE SHEET

COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N./A
VERTICAL SCALE N./A

DRAWING NO. EN-5 OF 6

SHEET NO. 43 OF 53

PLOTTED: Thursday, April 20, 2017 AT 03:42 PM
FILE: G:\Active\2014-16 BCS 2012-03D EPD Env Design-Permitting, EA-JMT\Task 17 Little Catoctin Creek\CAD\pES-D001_LCC-CRI.dgn

BY: matthewd –

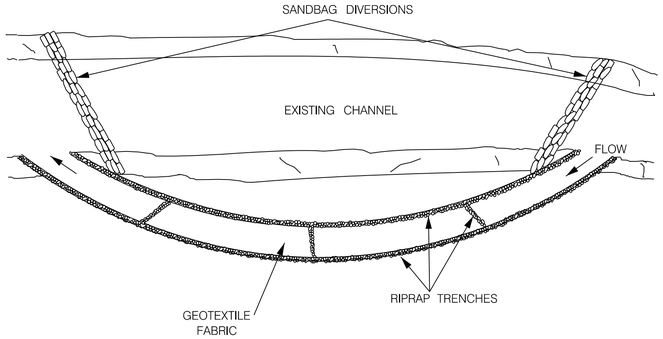
FABRIC– BASED STREAM DIVERSION

CHANNEL EXCAVATION
1. ALL DISTURBANCES RESULTING FROM CONSTRUCTION OF THE CHANNEL SHOULD BE CONTAINED BY APPROPRIATE SEDIMENT CONTROL MEASURES.
2. EXCAVATION OF THE CHANNEL SHOULD BEGIN AT THE DOWNSTREAM END AND PROCEED UPSTREAM. THE CHANNEL SHOULD HAVE A MINIMUM CAPACITY SUFFICIENT TO CONVEY THE STREAM'S BASE FLOW FOR PROJECTS WITH DURATION OF 2 WEEKS OR LESS. FOR PROJECTS OF LONGER DURATION, CHANNELS SHOULD HAVE A CAPACITY SUFFICIENT TO CONVEY BANKFULL FLOW. ALL EXCAVATED MATERIALS SHOULD BE STOCKPILED OUTSIDE OF THE 100 YEAR FLOOD PLAIN AND TEMPORARILY STABILIZED TO PREVENT RE–ENTRY INTO THE STREAM CHANNEL.
3. THE PROCESS OF EXCAVATION AND STABILIZATION WITH FABRIC SHOULD BE A CONTINUOUS AND UNINTERRUPTED OPERATION. ALL MATERIALS SHOULD BE ON–SITE PRIOR TO CHANNEL CONSTRUCTION.
4. THE DOWNSTREAM AND UPSTREAM CONNECTION TO THE NATURAL CHANNEL SHOULD BE CONSTRUCTED UNDER DRY CONDITIONS. THE STREAM SHOULD BE CONTAINED BY SANDBAGS ALONG THE OPPOSING BANK DURING THE PROCESS OF CUTTING THE DIVERSION CHANNEL INTO THE NATURAL STREAM CHANNEL. EXCAVATION AND STABILIZATION SHOULD BE A CONTINUOUS AND UNINTERRUPTED OPERATION.
5. ALL DEBRIS SUCH AS ROCKS, STICKS, ETC. SHOULD BE REMOVED AND THE CHANNEL SURFACES MADE SMOOTH SO THAT THE FABRIC WILL REST FLUSH WITH THE CHANNEL AT ALL SIDES AND BOTTOM.

STABILIZATION WITH GEOTEXTILE FABRIC
1. THE FABRIC SHOULD HAVE A MINIMUM WIDTH SUCH THAT IT IS KEYED IN AND ANCHORED AT THE TOP OF STREAM BANK.
2. FABRIC SHOULD BE PLACED SO THAT IT RESTS FLUSH WITH THE CHANNEL AT ALL POINTS OF CONTACT.
3. FABRIC SHOULD BE PLACED SUCH THAT ONE PIECE WILL LINE THE ENTIRE CHANNEL. IF THIS IS NOT POSSIBLE, FABRIC SHOULD BE PLACED SO THAT TRANSVERSE OVERLAPPING OCCURS IN ACCORDANCE WITH THE DETAIL. LONGITUDINAL OVERLAPS SHOULD NOT BE ALLOWED. UPSTREAM SECTIONS SHOULD OVERLAP DOWNSTREAM SECTIONS. OVERLAP WIDTH SHOULD EQUAL 2 FEET (0.6 METERS) MINIMUM.
4. THE FABRIC SHOULD BE KEYED INTO 2 BY 2–FOOT (0.6 BY 0.6–METER) TRENCHES LOCATED AT THE UPSTREAM EDGE AND AT 50–FOOT (15.25–METER) INTERVALS WITH THE OVERLAP PLACED NEAREST TO EACH 50 FEET INCREMENT. THE KEY–IN SHOULD BE FROM TOP OF CHANNEL TO TOP OF CHANNEL. CLASS I RIPRAP SHOULD BE CAREFULLY PLACED INTO THE TRENCH WITH ZERO DROP HEIGHT.
5. THE FABRIC SECTIONS SHOULD BE SECURED WITH HOLD DOWN PINS AND WASHERS. OVERLAPS SHOULD BE PINNED ALONG TRANSVERSE AND LONGITUDINAL AXES WITH SPACING EQUAL TO 3 FEET (0.9 METERS) MAXIMUM.
6. SEDIMENT FROM SURROUNDING AREAS OF DISTURBANCE SHOULD NOT BE ALLOWED TO ENTER THE DIVERSION CHANNEL.

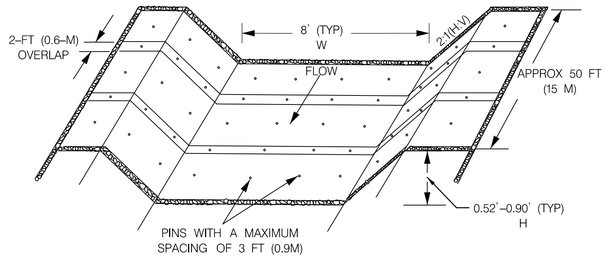
ALTERNATE METHODS OF PLACING THE FABRIC
1. THE ABOVE DESIGN MAY BE MODIFIED TO ALLOW SEWING OF THE GEOTEXTILE FABRIC. SEWING OF THE GEOTEXTILE FABRIC, RATHER THAN OVERLAPPING, SHOULD ELIMINATE THE REQUIREMENT FOR TRANSVERSE PLACEMENT OF THE FABRIC. EITHER TRANSVERSE OR LONGITUDINAL PLACEMENT SHOULD WORK EQUALLY WELL.
2. THE SPACING OF THE PINS COULD BE EITHER LARGER OR SMALLER DEPENDING ON THE ANTICIPATED VELOCITIES AND THICKNESS AND TYPE OF GEOTEXTILE FABRIC.
3. THE ENTIRE BOTTOM OF THE CHANNEL COULD BE RIPRAPPED IF HIGH VELOCITIES ARE ANTICIPATED. WHEN THE AREA IS RIPRAPPED, IT IS NOT REQUIRED THAT THE GEOTEXTILE FABRIC UNDERNEATH THE RIPRAP BE PINNED.

REMOVAL OF DIVERSION
1. WATER SHOULD NOT BE ALLOWED THROUGH THE NATURAL STREAM UNTIL ALL CONSTRUCTION IS COMPLETED.
2. AFTER REDIRECTING THE FLOW THROUGH THE NATURAL CHANNEL, ALL FABRIC SHOULD BE REMOVED FROM THE TEMPORARY DIVERSION. THE DIVERSION SHOULD THEN BE BACKFILLED AND STABILIZED. POINTS OF TIE–IN TO THE NATURAL CHANNEL SHOULD BE PROTECTED WITH RIPRAP ACCORDING TO THE RIPRAP GUIDELINES.



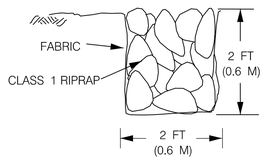
FABRIC BASED STREAM DIVERSION (FBSD)– PLAN VIEW

NOT TO SCALE



FBSD– SECTION VIEW

NOT TO SCALE



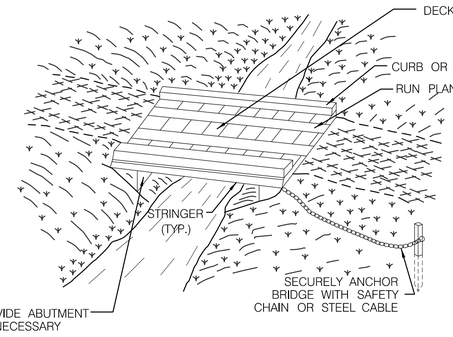
FBSD– TRENCHING DETAIL

NOT TO SCALE

NOTE:
ALL WORK AND MATERIALS REQUIRED FOR THE INSTALLATION OF THE FABRIC BASED STREAM DIVERSION IS CONSIDERED INCIDENTAL TO MAINTENANCE OF STREAM FLOW PAY ITEM

TEMPORARY ACCESS BRIDGE

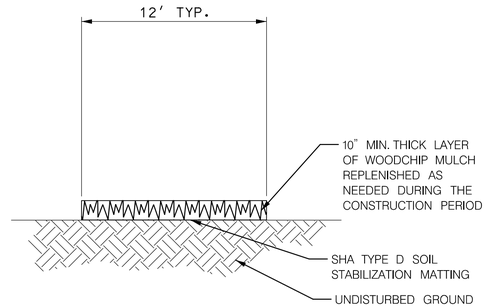
1. ABUTMENTS SHOULD BE PLACED PARALLEL TO, AND ON, STABLE BANKS SUCH THAT THE STRUCTURE IS AT OR ABOVE BANKFULL DEPTH TO PREVENT THE ENTRAPMENT OF FLOATING MATERIALS AND DEBRIS.
2. TEMPORARY ACCESS BRIDGES SHOULD BE CONSTRUCTED TO SPAN THE ENTIRE CHANNEL. IF THE BANKFULL CHANNEL WIDTH EXCEEDS 8 FEET (2.5 METERS), THEN A FOOTING, PIER, OR OTHER BRIDGE SUPPORT MAY BE CONSTRUCTED WITHIN THE WATERWAY. NO SUPPORT WILL BE PERMITTED WITHIN THE CHANNEL FOR WATERWAYS LESS THAN 8 FEET WIDE. ONE ADDITIONAL BRIDGE SUPPORT WILL BE PERMITTED FOR EACH ADDITIONAL 8–FOOT WIDTH OF THE CHANNEL.
3. ALL DECKING MEMBERS SHOULD BE PLACED PERPENDICULARLY TO THE STRINGERS, BUTTED TIGHTLY, AND SECURELY FASTENED TO THE STRINGERS. DECKING MATERIALS MUST BE BUTTED TIGHTLY TO PREVENT ANY SOIL MATERIAL TRACKED ONTO THE BRIDGE FROM FALLING INTO THE WATERWAY.
4. ALTHOUGH RUN PLANKS ARE OPTIONAL, THEY MAY BE NECESSARY TO PROPERLY DISTRIBUTE LOADS. ONE RUN PLANK SHOULD BE PROVIDED FOR EACH TRACK OF THE EQUIPMENT WHEELS AND SHOULD BE SECURELY FASTENED TO THE LENGTH OF THE SPAN.
5. CURBS OR FENDERS MAY BE INSTALLED ALONG THE OUTER SIDES OF THE DECK TO PROVIDE ADDITIONAL SAFETY.
6. BRIDGES SHOULD BE SECURELY ANCHORED AT ONE END USING STEEL CABLE OR CHAIN TO PREVENT THE BRIDGE FROM FLOATING DOWNSTREAM AND POSSIBLY CAUSING AN OBSTRUCTION TO THE FLOW. ANCHORING AT ONLY ONE END WILL PREVENT CHANNEL OBSTRUCTION IN THE EVENT THAT FLOOD WATERS FLOAT THE BRIDGE. ACCEPTABLE ANCHORS ARE LARGE TREES, BOULDERS, OR DRIVEN STEEL ANCHORS.
7. ALL AREAS DISTURBED DURING INSTALLATION SHOULD BE STABILIZED WITHIN 14 CALENDAR DAYS IN ACCORDANCE WITH A REVEGETATION PLAN APPROVED BY THE WMA.
8. PERIODIC INSPECTION SHOULD BE PERFORMED BY THE USER TO ENSURE THAT THE BRIDGE, STREAM BED, AND STREAM BANKS ARE MAINTAINED AND NOT DAMAGED.
9. MAINTENANCE SHOULD BE PERFORMED AS NEEDED TO ENSURE THAT THE STRUCTURE COMPLIES WITH ALL STANDARDS AND SPECIFICATIONS. THIS SHOULD INCLUDE THE REMOVAL OF TRAPPED SEDIMENT AND DEBRIS WHICH SHOULD THEN BE DISPOSED OF AND STABILIZED OUTSIDE THE FLOODPLAIN.
10. WHEN THE TEMPORARY BRIDGE IS NO LONGER NEEDED, ALL STRUCTURES INCLUDING ABUTMENTS AND OTHER BRIDGING MATERIALS SHOULD BE REMOVED WITHIN 14 CALENDAR DAYS. IN ALL CASES, THE BRIDGE MATERIALS SHOULD BE REMOVED WITHIN 1 YEAR OF INSTALLATION. REMOVAL OF THE BRIDGE AND CLEAN–UP OF THE AREA, INCLUDING PROTECTION AND STABILIZATION OF DISTURBED STREAM BANKS, SHOULD BE ACCOMPLISHED WITHOUT THE USE OF CONSTRUCTION EQUIPMENT IN THE WATERWAY.



TEMPORARY ACCESS BRIDGE

NOT TO SCALE

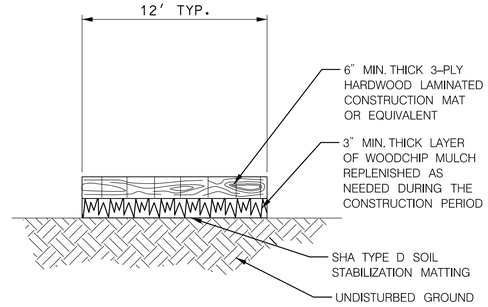
NOTE:
TIME OF YEAR RESTRICTIONS DO NOT APPLY TO THE CONSTRUCTION OR REMOVAL OF A TEMPORARY ACESS BRIDGE UNLESS THERE IS DISTURBANCE TO THE STREAM CHANNEL.



1. ACCESS ROUTES TO BE VERIFIED BY THE ENGINEER AT PRE–CONSTRUCTION MEETING. REVISIONS TO THE ALIGNMENT THAT MINIMIZE TREE DISTURBANCE ARE ENCOURAGED AND REQUIRE REVIEW AND APPROVAL BY THE ENGINEER.
2. SHA TYPE D SOIL STABILIZATION MATTING SHALL BE PLACED WITH SEAMS PARALLEL TO THE FLOW OF TRAFFIC. OVERLAP FABRIC BY 18" MIN. AT SEAMS.
3. CONTRACTOR SHALL MAINTAIN TEMPORARY ACCESS ROAD THROUGHOUT CONSTRUCTION PERIOD.

TEMPORARY MULCH ACCESS ROAD

NOT TO SCALE



1. HARDWOOD MATS TO BE INSTALLED AS INDICATED ON CONTRACT DOCUMENTS IN WETLANDS.
2. ACCESS ROUTES TO BE VERIFIED BY THE ENGINEER AT PRE–CONSTRUCTION MEETING. REVISIONS TO THE ALIGNMENT THAT MINIMIZE TREE DISTURBANCE ARE ENCOURAGED AND REQUIRE REVIEW AND APPROVAL BY THE ENGINEER.
3. SHA TYPE D SOIL STABILIZATION MATTING SHALL BE PLACED WITH SEAMS PARALLEL TO THE FLOW OF TRAFFIC. OVERLAP FABRIC BY 18" MIN. AT SEAMS.

HARDWOOD CONSTRUCTION MAT

NOT TO SCALE

COASTAL RESOURCES INC.

DATUM: NAD 8391 Horizontal
NAVD 88 Vertical

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

CROSS REFERENCE

ITEM	SHEET NOs.
ABBREVIATIONS /GENERAL NOTES	2
STREAM TYPICAL SECTIONS	3
STREAM RESTORATION PROFILES	4 – 8
KEY MAP	11
STREAM RESTORATION PLANS	12 – 15
STREAM RESTORATION DETAILS	16 – 17
ESC NOTES	18
ESC SEQUENCE OF CONSTRUCTION	19
ESC DETAILS	20 – 23
LANDSCAPING PLANS	26 – 29
LANDSCAPING DETAILS	30
STREAM RESTOATION CROSS SECTIONS	31 – 34
MOT PLANS	35

R / W PLAT NUMBER

REVISIONS

EROSION & SEDIMENT CONTROL DETAIL

SCALE N.T.S. ADVERTISED DATE JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY MJD
DRAWN BY MJD
CHECKED BY ETK
F.A.P. NO. SEE TITLE SHEET

COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. EN-6 OF 6

SHEET NO. 44 OF 53

PLOTTED: Thursday, April 20, 2017 AT 03:42 PM
FILE: G:\Active\2014-16 BCS 2012-03D EPD Env Design-Permitting, EA-JMT\Task 17 Little Catoctin Creek\CAD\pES-D002_LCC-CRI.dgn

BY: matthewd –

UPLAND TREE PLANT SCHEDULE (THIS SHEET)

QUANTITY	KEY	BOTANICAL NAME	COMMON NAME	HEIGHT	CONT. CLASS	SPACING/REMARKS
70	AR	Acer rubrum	Red Maple	5 ft.	#5	12' o.c.
40	CC	Cercis canadensis	Eastern Redbud	5 ft.	#5	12' o.c.
43	CF	Cornus florida	Flowering Dogwood	5 ft.	#5	12' o.c.
75	LT	Liriodendron tulipfera	Tulip Poplar	5 ft.	#5	12' o.c.
66	NS	Nyssa sylvatica	Black Gum	5 ft.	#5	12' o.c.
67	PO	Plantanus occidentalis	American Sycamore	5 ft.	#5	12' o.c.
71	QR	Quercus rubra	Northern Red Oak	5 ft.	#5	12' o.c.

SEED MIX SCHEDULE (THIS SHEET)

SEED MIX	SQUARE YARDS (SY)
FLOODPLAIN SEED MIX	12,238
UPLAND SEED MIX	8,321
TURFGRASS ESTABLISHMENT	50

NOTES:

1. SEE SHEET LD-4 FOR TOTAL PLANT AND SEED SCHEDULES.
2. SEE SHEET SD-1 FOR THE LIVE FASCINE DETAILS.
3. ALL OTHER DISTURBED AREAS WITHIN THE LIMITS OF DISTURBANCE, NOT IDENTIFIED ON THE LANDSCAPING PLANS SHALL BE PERMANENTLY STABILIZED WITH UPLAND SEED MIX.

MATCHLINE STA. 9+50 – SEE DWG. LP-2

MD 180 (JEFFERSON PIKE)

BASELINE OF LITTLE CATOCTIN CREEK

BANKFULL CHANNEL LIMITS

TURFGRASS ESTABLISHMENT & FURNISHED TOPSOIL 4" DEPTH (8' FROM EDGE OF ROAD)

TURFGRASS ESTABLISHMENT & FURNISHED TOPSOIL 4" DEPTH (8' FROM EDGE OF ROAD)

TURFGRASS ESTABLISHMENT & FURNISHED TOPSOIL 4" DEPTH (8' FROM EDGE OF ROAD)

TRIBUTARY 1

TRIBUTARY 2

OXBOW POOL

PARK AND RIDE

BOTTOM OF BRIDGE

N 610700 E 1133100

N 610300 E 1133150

LEGEND

- FLOODPLAIN SEED AND WETLAND SHRUB PLANTING AREA
- FLOODPLAIN SEED AREA
- UPLAND SEED/UPLAND TREE PLANTING AREA
- LIVE FASCINES
- LOG SILLS

SCALE: 1" = 30'

DATUM: NAD 8391 Horizontal
NAVD 88 Vertical

WETLAND SHRUB PLANT SCHEDULE (THIS SHEET)

QUANTITY	KEY	BOTANICAL NAME	COMMON NAME	HEIGHT	CONT. CLASS	SPACING/REMARKS
20	AS	Alnus serrulata	Smooth Alder	3 ft.	#3	10' o.c.
23	AA	Aronia arbutifolia	Red Chokeberry	3 ft.	#3	10' o.c.
22	CO	Cephalanthus occidentalis	Common Buttonbush	3 ft.	#3	10' o.c.
22	CA	Cornus amomum	Silky Dogwood	3 ft.	#3	10' o.c.
26	IV	Ilex verticillata	Common Winterberry	3 ft.	#3	10' o.c.
26	SC	Sambucus canadensis	American Black Elderberry	3 ft.	#3	10' o.c.
22	RP	Rosa palustris	Swamp Rose	3 ft.	#3	10' o.c.
29	SS	Salix serica	Silky Willow	3 ft.	#3	10' o.c.

JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future®

BY: barranger

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

CROSS REFERENCE

ITEM	SHEET NOs.
TITLE SHEET	1
ABBREVIATIONS /GENERAL NOTES	2
STREAM RESTORATION GEOMETRY	3–4
STREAM TYPICAL SECTIONS	5
STREAM RESTORATION PROFILES	6–10
KEY MAP	11
STREAM RESTORATION PLANS	12–15
STREAM RESTORATION DETAILS	16–18
ESC NOTES & SEQUENCE OF CONSTRUCTION	19–22
ESC PLANS	23–42
ESC DETAILS	43–44
LANDSCAPING PLANS	45–48
STREAM RESTORATION CROSS SECTIONS	49–52
MOT PLANS	53

R / W PLAT NUMBER

REVISIONS

LANDSCAPING PLANS

SCALE 1" = 30' ADVERTISED DATE: JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY FAB
DRAWN BY FAB/PVC
CHECKED BY MRG/FAB
F.A.P. NO. SEE TITLE SHEET

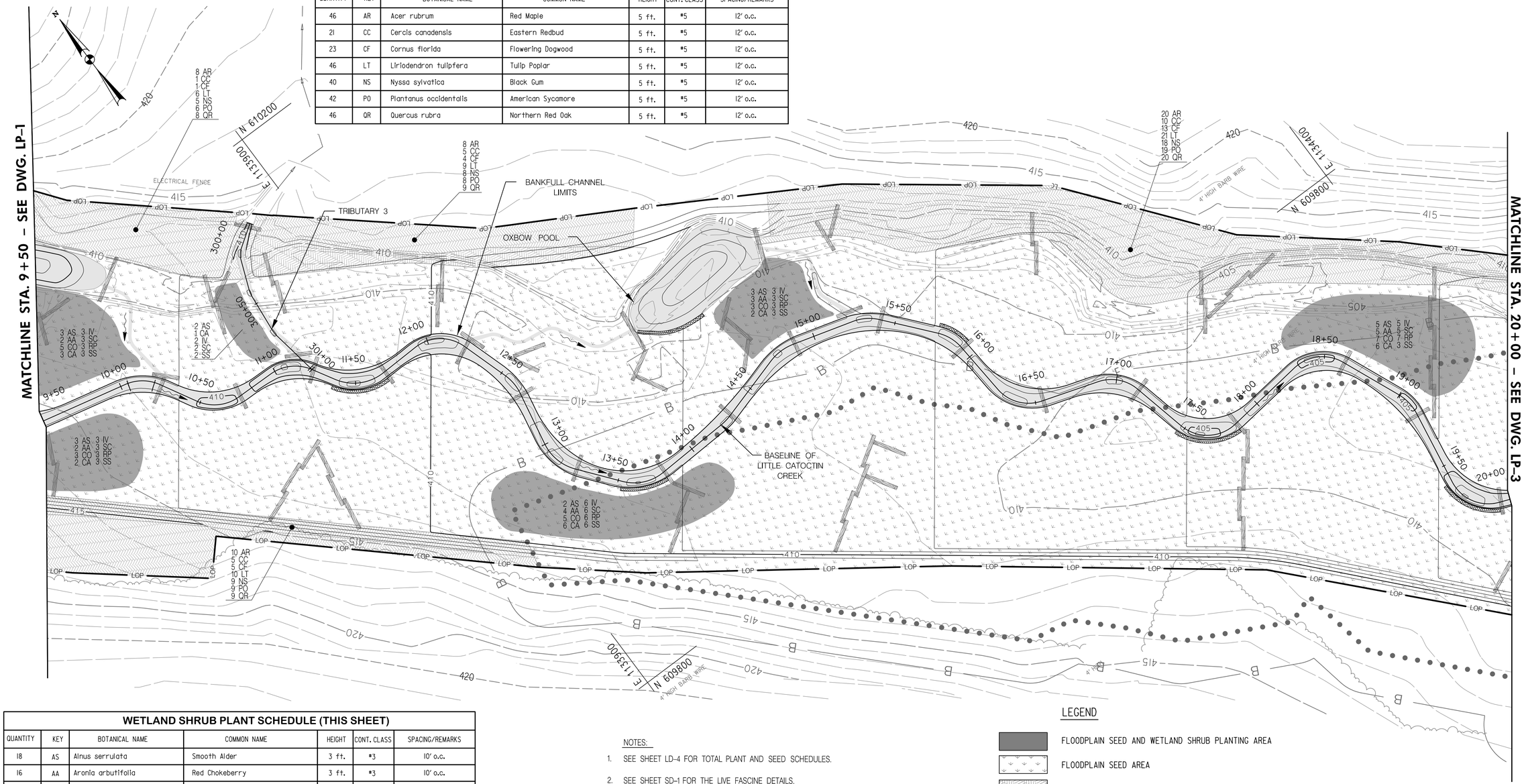
COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. LD– 1 OF 4 SHEET NO. 45 OF 53

PLOTTED: Tuesday, April 25, 2017 AT 08:26 AM
FILE: G:\SMD\120079_017_Little_Catoctin_Cree\CADD\pSLP_P001_LCC.dgn

UPLAND TREE PLANT SCHEDULE (THIS SHEET)

QUANTITY	KEY	BOTANICAL NAME	COMMON NAME	HEIGHT	CONT. CLASS	SPACING/REMARKS
46	AR	Acer rubrum	Red Maple	5 ft.	#5	12' o.c.
21	CC	Cercis canadensis	Eastern Redbud	5 ft.	#5	12' o.c.
23	CF	Cornus florida	Flowering Dogwood	5 ft.	#5	12' o.c.
46	LT	Liriodendron tulipfera	Tulip Poplar	5 ft.	#5	12' o.c.
40	NS	Nyssa sylvatica	Black Gum	5 ft.	#5	12' o.c.
42	PO	Plantanus occidentalis	American Sycamore	5 ft.	#5	12' o.c.
46	QR	Quercus rubra	Northern Red Oak	5 ft.	#5	12' o.c.



WETLAND SHRUB PLANT SCHEDULE (THIS SHEET)

QUANTITY	KEY	BOTANICAL NAME	COMMON NAME	HEIGHT	CONT. CLASS	SPACING/REMARKS
18	AS	Alnus serrulata	Smooth Alder	3 ft.	#3	10' o.c.
16	AA	Aronia arbutifolia	Red Chokeberry	3 ft.	#3	10' o.c.
23	CO	Cephalanthus occidentalis	Common Buttonbush	3 ft.	#3	10' o.c.
20	CA	Cornus amomum	Silky Dogwood	3 ft.	#3	10' o.c.
22	IV	Ilex verticillata	Common Winterberry	3 ft.	#3	10' o.c.
22	SC	Sambucus canadensis	American Black Elderberry	3 ft.	#3	10' o.c.
22	RP	Rosa palustris	Swamp Rose	3 ft.	#3	10' o.c.
20	SS	Salix serica	Silky Willow	3 ft.	#3	10' o.c.

NOTES:

1. SEE SHEET LD-4 FOR TOTAL PLANT AND SEED SCHEDULES.
2. SEE SHEET SD-1 FOR THE LIVE FASCINE DETAILS.
3. ALL OTHER DISTURBED AREAS WITHIN THE LIMITS OF DISTURBANCE, NOT IDENTIFIED ON THE LANDSCAPING PLANS SHALL BE PERMANENTLY STABILIZED WITH UPLAND SEED MIX.

LEGEND

- FLOODPLAIN SEED AND WETLAND SHRUB PLANTING AREA
- FLOODPLAIN SEED AREA
- UPLAND SEED/UPLAND TREE PLANTING AREA
- LIVE FASCINES
- LOGS SILLS

30' 0 30' 60'
SCALE: 1" = 30'

DATUM: NAD 83\91 Horizontal
NAVD 88 Vertical

JOHNSON, MIRMIRAN & THOMPSON
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SEED MIX SCHEDULE (THIS SHEET)

SEED MIX	SQUARE YARDS (SY)
FLOODPLAIN SEED MIX	14,748
UPLAND SEED MIX	3,641

CROSS REFERENCE

ITEM	SHEET NOs.
TITLE SHEET	1
ABBREVIATIONS /GENERAL NOTES	2
STREAM RESTORATION GEOMETRY	3–4
STREAM TYPICAL SECTIONS	5
STREAM RESTORATION PROFILES	6–10
KEY MAP	11
STREAM RESTORATION PLANS	12–15
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MOT PLANS	53

R /W PLAT NUMBER

REVISIONS

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

LANDSCAPING PLANS

SCALE 1" = 30' ADVERTISED DATE: JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY FAB COUNTY FREDERICK COUNTY
DRAWN BY FAB/PVC LOGMILE
CHECKED BY MRG/FAB HORIZONTAL SCALE N/A
F.A.P. NO. SEE TITLE SHEET VERTICAL SCALE N/A

DRAWING NO. LD- 2 OF 4 SHEET NO. 46 OF 53

PLOTTED: Tuesday, April 25, 2017 AT 08:27 AM
FILE: Q:\SMD\150079_017_Little_Catoctin_Creek\CADD\pSLP_P002_LCC.dgn

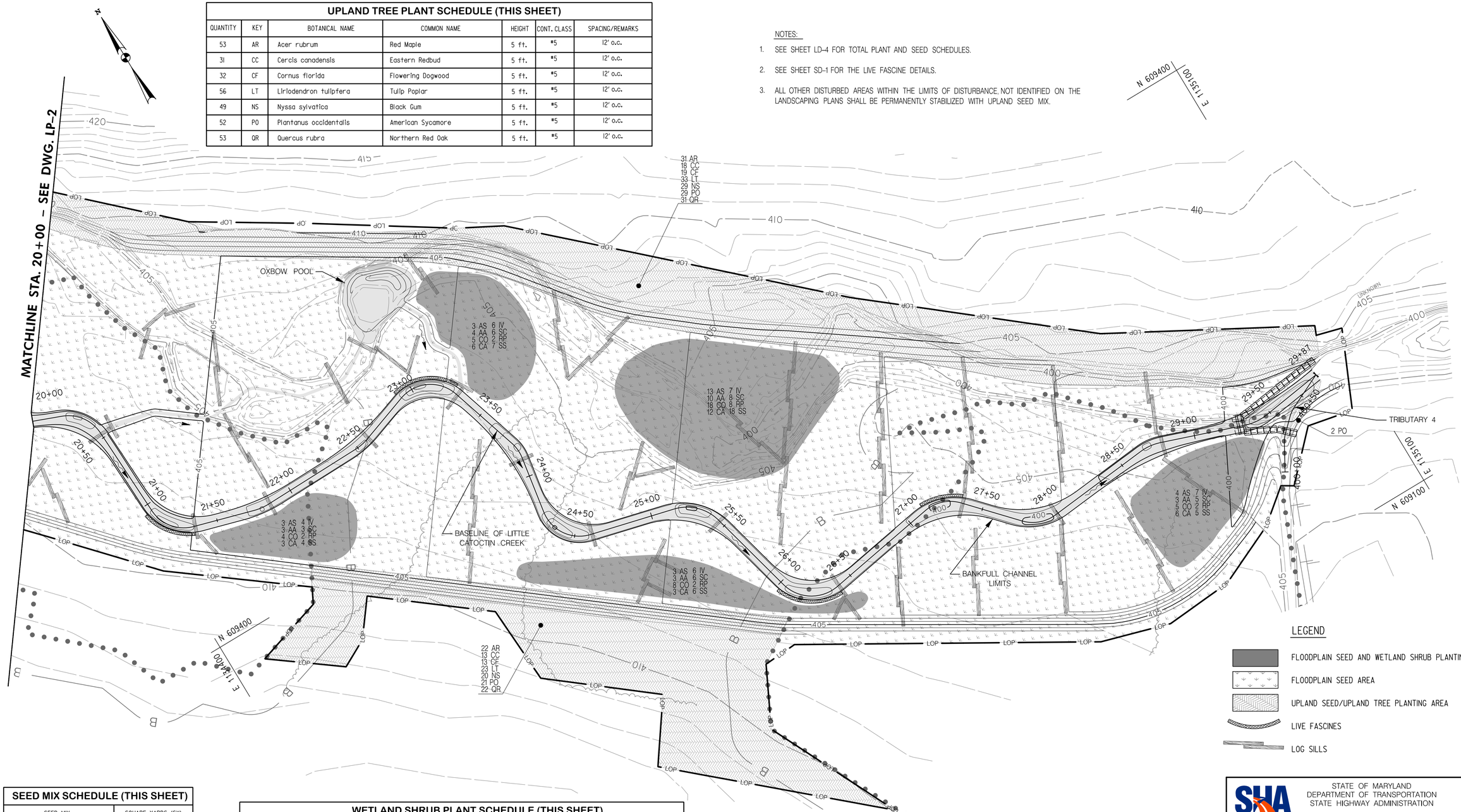
BY: barranger

UPLAND TREE PLANT SCHEDULE (THIS SHEET)

QUANTITY	KEY	BOTANICAL NAME	COMMON NAME	HEIGHT	CONT. CLASS	SPACING/REMARKS
53	AR	Acer rubrum	Red Maple	5 ft.	#5	12' o.c.
31	CC	Cercis canadensis	Eastern Redbud	5 ft.	#5	12' o.c.
32	CF	Cornus florida	Flowering Dogwood	5 ft.	#5	12' o.c.
56	LT	Liriodendron tulipfera	Tulip Poplar	5 ft.	#5	12' o.c.
49	NS	Nyssa sylvatica	Black Gum	5 ft.	#5	12' o.c.
52	PO	Plantanus occidentalis	American Sycamore	5 ft.	#5	12' o.c.
53	QR	Quercus rubra	Northern Red Oak	5 ft.	#5	12' o.c.

NOTES:

1. SEE SHEET LD-4 FOR TOTAL PLANT AND SEED SCHEDULES.
2. SEE SHEET SD-1 FOR THE LIVE FASCINE DETAILS.
3. ALL OTHER DISTURBED AREAS WITHIN THE LIMITS OF DISTURBANCE, NOT IDENTIFIED ON THE LANDSCAPING PLANS SHALL BE PERMANENTLY STABILIZED WITH UPLAND SEED MIX.



LEGEND

- FLOODPLAIN SEED AND WETLAND SHRUB PLANTING AREA
- FLOODPLAIN SEED AREA
- UPLAND SEED/UPLAND TREE PLANTING AREA
- LIVE FASCINES
- LOG SILLS

SEED MIX SCHEDULE (THIS SHEET)

SEED MIX	SQUARE YARDS (SY)
FLOODPLAIN SEED MIX	13,851
UPLAND SEED MIX	4,881

WETLAND SHRUB PLANT SCHEDULE (THIS SHEET)

QUANTITY	KEY	BOTANICAL NAME	COMMON NAME	HEIGHT	CONT. CLASS	SPACING/REMARKS
26	AS	Alnus serrulata	Smooth Alder	3 ft.	#3	10' o.c.
23	AA	Aronia arbutifolia	Red Chokeberry	3 ft.	#3	10' o.c.
40	CO	Cephalanthus occidentalis	Common Buttonbush	3 ft.	#3	10' o.c.
30	CA	Cornus amomum	Silky Dogwood	3 ft.	#3	10' o.c.
30	IV	Ilex verticillata	Common Winterberry	3 ft.	#3	10' o.c.
28	SC	Sambucus canadensis	American Black Elderberry	3 ft.	#3	10' o.c.
16	RP	Rosa palustris	Swamp Rose	3 ft.	#3	10' o.c.
40	SS	Salix serica	Silky Willow	3 ft.	#3	10' o.c.

30' 0 30' 60'
SCALE: 1" = 30'

DATUM: NAD 83\91 Horizontal
NAVD 88 Vertical

JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future®

BY: barranger

CROSS REFERENCE

ITEM	SHEET NOs.
TITLE SHEET	1
ABBREVIATIONS /GENERAL NOTES	2
STREAM RESTORATION GEOMETRY	3–4
STREAM TYPICAL SECTIONS	5
STREAM RESTORATION PROFILES	6–10
KEY MAP	11
STREAM RESTORATION PLANS	12–15
STREAM RESTORATION DETAILS	16–18
ESC NOTES & SEQUENCE OF CONSTRUCTION	19–22
ESC PLANS	23–42
ESC DETAILS	43–44
LANDSCAPING PLANS	45–48
STREAM RESTORATION CROSS SECTIONS	49–52
MOT PLANS	53

R /W PLAT NUMBER

REVISIONS

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

LANDSCAPING PLANS

SCALE 1" = 30' ADVERTISED DATE: JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY FAB COUNTY FREDERICK COUNTY
DRAWN BY FAB/PVC LOGMILE
CHECKED BY MRG/FAB HORIZONTAL SCALE N/A
F.A.P. NO. SEE TITLE SHEET VERTICAL SCALE N/A

DRAWING NO. LD– 3 OF 4 SHEET NO. 47 OF 53

PLOTTED: Tuesday, April 25, 2017 AT 09:29 AM
FILE: G:\SMD\120079_017_Little_Catoctin_Cree\CADD\pSLP_P003_LCC.dgn

UPLAND TREE PLANT SCHEDULE (TOTAL)

QUANTITY	KEY	BOTANICAL NAME	COMMON NAME	HEIGHT	CONT. CLASS	SPACING/REMARKS
169	AR	Acer rubrum	Red Maple	5 ft.	#5	12' o.c.
92	CC	Cercis canadensis	Eastern Redbud	5 ft.	#5	12' o.c.
98	CF	Cornus florida	Flowering Dogwood	5 ft.	#5	12' o.c.
177	LT	Liriodendron tulipfera	Tulip Poplar	5 ft.	#5	12' o.c.
155	NS	Nyssa sylvatica	Black Gum	5 ft.	#5	12' o.c.
161	PO	Plantanus occidentalis	American Sycamore	5 ft.	#5	12' o.c.
170	QR	Quercus rubra	Northern Red Oak	5 ft.	#5	12' o.c.

WETLAND SHRUB PLANT SCHEDULE (TOTAL)

QUANTITY	KEY	BOTANICAL NAME	COMMON NAME	HEIGHT	CONT. CLASS	SPACING/REMARKS
64	AS	Alnus serrulata	Smooth Alder	3 ft.	#3	10' o.c.
62	AA	Aronia arbutifolia	Red Chokeberry	3 ft.	#3	10' o.c.
85	CO	Cephalanthus occidentalis	Common Buttonbush	3 ft.	#3	10' o.c.
72	CA	Cornus amomum	Silky Dogwood	3 ft.	#3	10' o.c.
78	IV	Ilex verticillata	Common Winterberry	3 ft.	#3	10' o.c.
76	SC	Sambucus canadensis	American Black Elderberry	3 ft.	#3	10' o.c.
60	RP	Rosa palustris	Swamp Rose	3 ft.	#3	10' o.c.
89	SS	Salix serica	Silky Willow	3 ft.	#3	10' o.c.

LIVE FASCINE PLANT SCHEDULE (TOTAL)

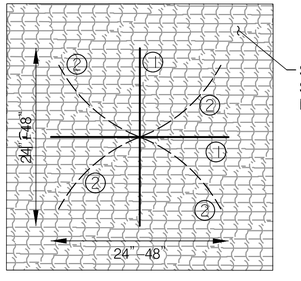
BOTANICAL NAME	COMMON NAME	LENGTH OF WHIP	DIAMETER OF FASCINE	LENGTH (FT)
Cornus amomum	Silky Dogwood	6' to 8'	8"	453.0'
Cornus sericea	Red-Osier Dogwood	6' to 8'	8"	453.0'
Salix exigua ssp. interior	Sandbar Willow	6' to 8'	8"	453.0'
Salix sericea	Silky Willow	6' to 8'	8"	453.0'

NOTE: EQUAL QUANTITIES OF ALL 4 SPECIES SHALL BE COMBINED TO FORM EACH FASCINE BUNDLE.

SEED MIX SCHEDULE (TOTAL)

SEED MIX	SQUARE YARDS (SY)
FLOODPLAIN SEED MIX	40,837.0
UPLAND SEED MIX	17,431.0
TURFGRASS ESTABLISHMENT	50.0

TREE & SHRUB INSTALLATION THROUGH SOIL STABILIZATION MATTING



1. MAKE CUT WITH SHARP KNIFE THROUGH SOIL STABILIZATION MATTING – SEE SOLID LINE IN DIAGRAM ABOVE. NOTE THAT ALL CUTS IN THE MATTING SHALL BE A MINIMUM OF 2 FEET CLEAR OF ALL MATTING SEAMS, OVERLAPS AND EDGES.
2. TEMPORARILY PIN BACK MATTING WITH 4 STAPLES TO INSTALL TREE OR SHRUB – SEE DASHED LINE IN DIAGRAM ABOVE.
3. INSTALL PLANT THROUGH PINNED BACK MATTING. INSTALL PLANT AT PROPER GRADE TO GROUND PLANE.
4. REMOVE 4 STAPLES PLACED IN STEP 2 ABOVE THAT WERE USED TO TEMPORARILY PIN BACK THE MATTING DURING ROOT BALL INSTALLATION.
5. PLACE 4 STAPLES IN EACH OF FOUR CUT SECTIONS TO WELL ANCHOR SOIL STABILIZATION MATTING BACK OVER TOP OF THE ROOT BALL.
6. FOR TREE INSTALLATIONS, INSTALL TREE STAKES THROUGH MATTING, ONCE RE-ANCHORED OVER ROOT BALL.

DATUM: NAD 8391 Horizontal
NAVD 88 Vertical

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

LANDSCAPING PLANS

CROSS REFERENCE

ITEM	SHEET NOs.
TITLE SHEET	1
ABBREVIATIONS /GENERAL NOTES	2
STREAM RESTORATION GEOMETRY	3-4
STREAM TYPICAL SECTIONS	5
STREAM RESTORATION PROFILES	6-10
KEY MAP	11
STREAM RESTORATION PLANS	12-15
STREAM RESTORATION DETAILS	16-18
ESC NOTES & SEQUENCE OF CONSTRUCTION	19-22
ESC PLANS	23-42
ESC DETAILS	43-44
LANDSCAPING PLANS	45-48
STREAM RESTORATION CROSS SECTIONS	49-52
MOT PLANS	53

R / W PLAT NUMBER

REVISIONS

SCALE 1"=30" ADVERTISED DATE: JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY FAB
DRAWN BY FAB/PVC
CHECKED BY MRG/FAB
F.A.P. NO. SEE TITLE SHEET

COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. LD- 4 OF 4

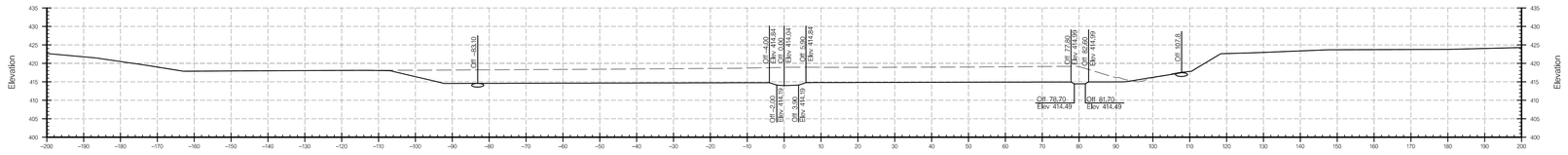
SHEET NO. 48 OF 53

JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future®

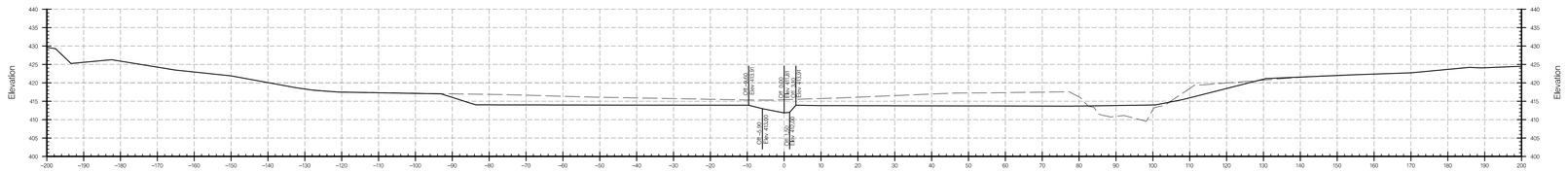
BY: barranger

PLOTTED: Tuesday, April 25, 2017 AT 08:30 AM
FILE: G:\SMD\120079_017_Little_Catoctin_Cree\CADD\pSLP_P004_LCC.dgn

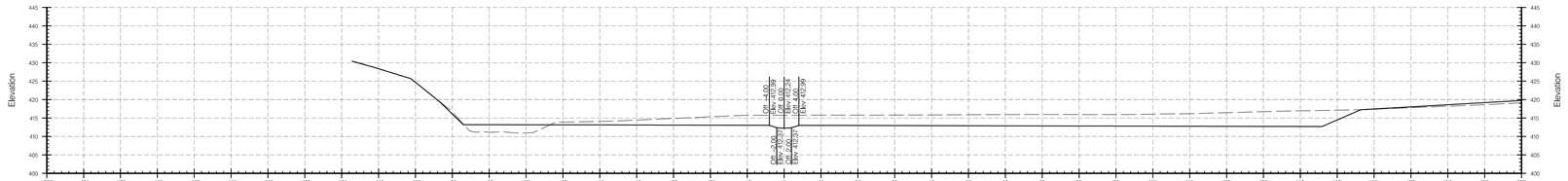
LITTLE CATOCTIN CREEK – STA. 2+00.00



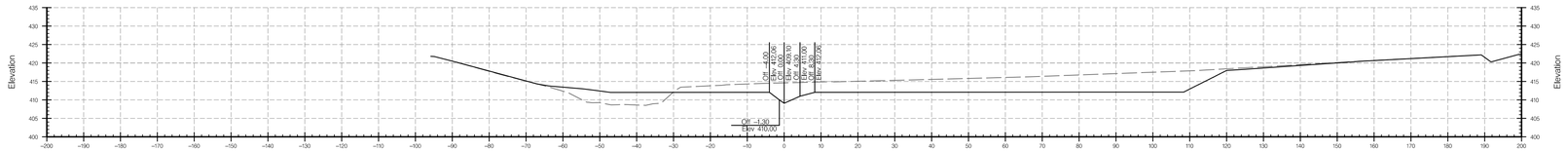
LITTLE CATOCTIN CREEK – STA. 4+00.00



LITTLE CATOCTIN CREEK – STA. 6+00.00



LITTLE CATOCTIN CREEK – STA. 8+00.00



LEGEND

EX. GROUND	
PROPOSED GROUND	
BURIED LOG SILL	
OFFSET /ELEVATION LABELS	Off 5.90 / Elev 414.84

DATUM: NAD 83\91 Horizontal
NAVD 88 Vertical

JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future®

BY: barranger

CROSS REFERENCE		R /W PLAT NUMBER	REVISIONS
ITEM	SHEET NOs.		
TITLE SHEET	1		
ABBREVIATIONS /GENERAL NOTES	2		
STREAM RESTORATION GEOMETRY	3–4		
STREAM TYPICAL SECTIONS	5		
STREAM RESTORATION PROFILES	6–10		
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STREAM RESTORATION CROSS SECTIONS	49–52		
MOT PLANS	53		

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK
STREAM RESTORATION

STREAM RESTORATION CROSS SECTIONS

SCALE 1" = 20' ADVERTISED DATE: JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY FAB COUNTY FREDERICK COUNTY
DRAWN BY FAB/PVC LOGMILE
CHECKED BY MRG/FAB HORIZONTAL SCALE N/A
F.A.P. NO. SEE TITLE SHEET VERTICAL SCALE N/A

DRAWING NO. **CS – 1** OF **4** SHEET NO. 49 OF 53

PLOTTED: Tuesday, April 25, 2017 AT 08:34 AM
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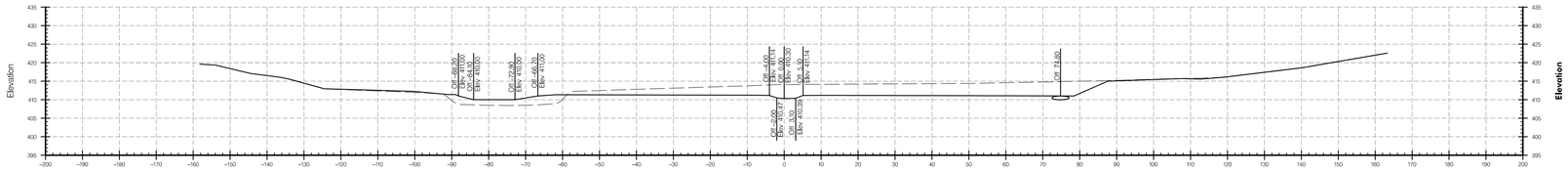
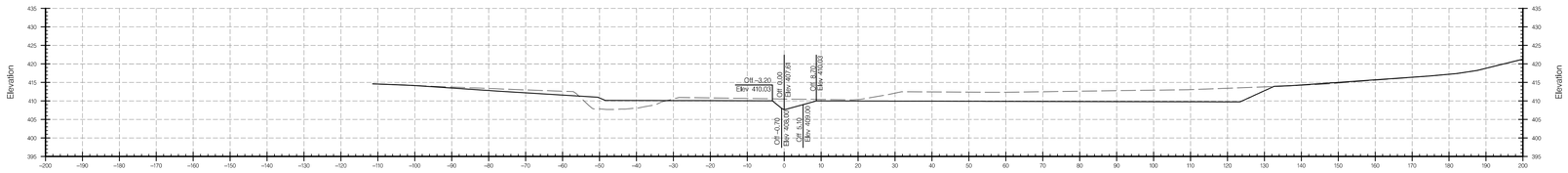
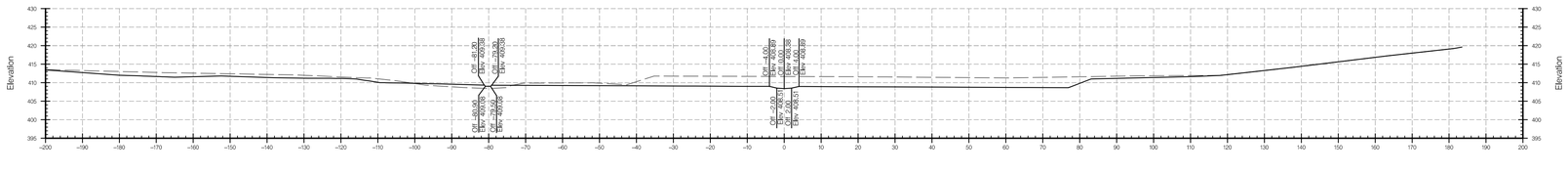
LITTLE CATOCTIN CREEK – STA. 10+00.00



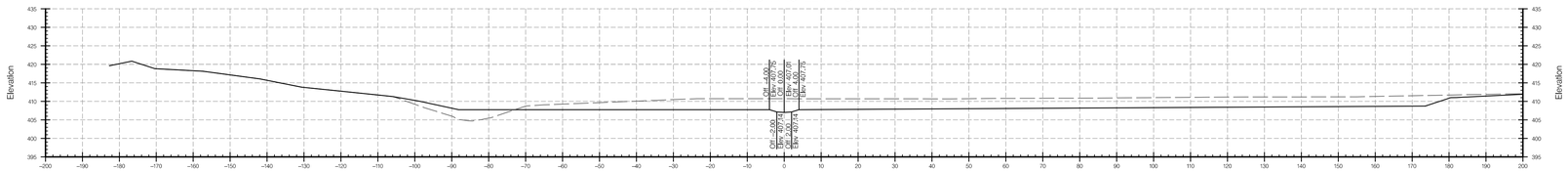
LITTLE CATOCTIN CREEK – STA. 12+00.00



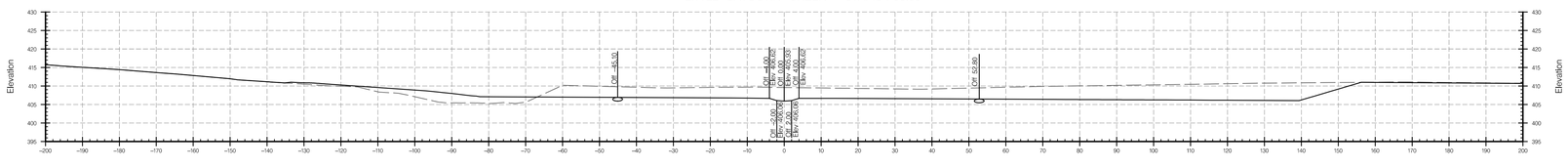
LITTLE CATOCTIN CREEK – STA. 14+00.00



LITTLE CATOCTIN CREEK – STA. 16+00.00



LITTLE CATOCTIN CREEK – STA. 18+00.00



LEGEND

EX. GROUND

PROPOSED GROUND

BURIED LOG SILL

OFFSET /ELEVATION LABELS — Off 5.90 / Elev 414.84

DATUM: NAD 83\91 Horizontal
NAVD 88 Vertical

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK
STREAM RESTORATION

JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future®

BY: barranger

CROSS REFERENCE

ITEM	SHEET NOs.
TITLE SHEET	1
ABBREVIATIONS /GENERAL NOTES	2
STREAM RESTORATION GEOMETRY	3–4
STREAM TYPICAL SECTIONS	5
STREAM RESTORATION PROFILES	6–10
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STREAM RESTORATION PLANS	12–15
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ESC PLANS	23–42
ESC DETAILS	43–44
LANDSCAPING PLANS	45–48
STREAM RESTORATION CROSS SECTIONS	49–52
MOT PLANS	53

R /W PLAT NUMBER

REVISIONS

STREAM RESTORATION CROSS SECTIONS

SCALE 1"=20' ADVERTISED DATE: JUNE 2017 CONTRACT NO. FR5975182

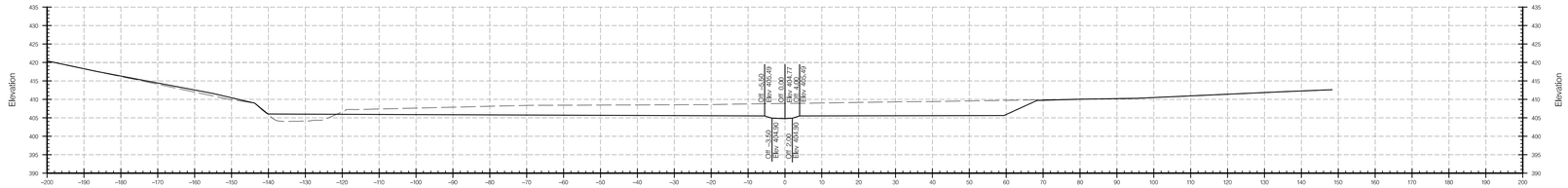
DESIGNED BY FAB
DRAWN BY FAB/PVC
CHECKED BY MRG/FAB
F.A.P. NO. SEE TITLE SHEET

COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

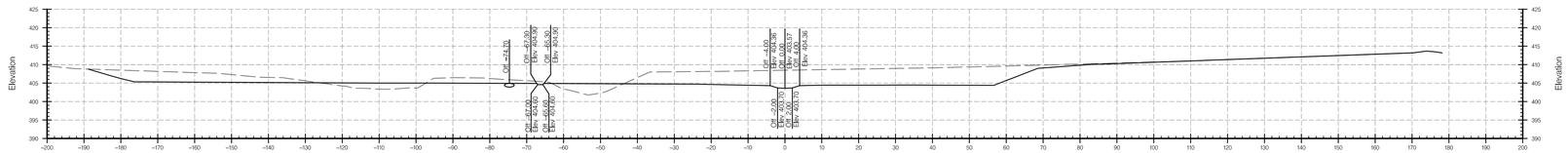
DRAWING NO. CS – 2 OF 4 SHEET NO. 50 OF 53

PLOTTED: Tuesday, April 25, 2017 AT 08:37 AM
FILE: G:\SMD\120079_017_Little_Catoctin_Cree\CADD\pHC_P002_LCC90.dgn

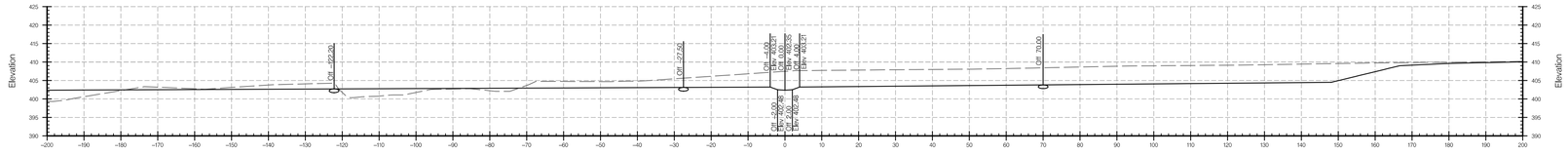
LITTLE CATOCTIN CREEK – STA. 20+00.00



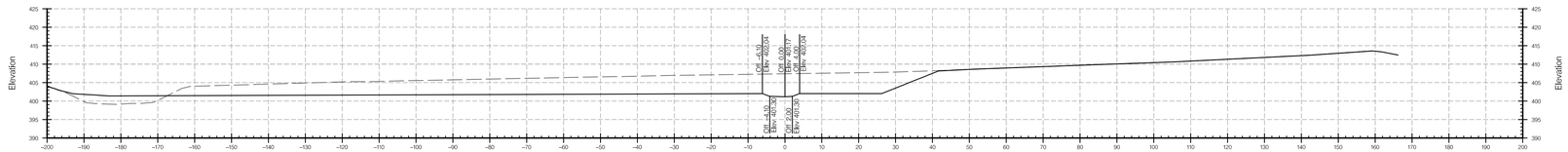
LITTLE CATOCTIN CREEK – STA. 22+00.00



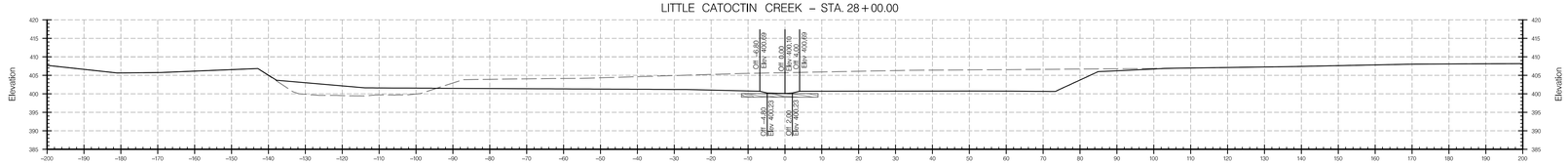
LITTLE CATOCTIN CREEK – STA. 24+00.00



LITTLE CATOCTIN CREEK – STA. 26+00.00



LITTLE CATOCTIN CREEK – STA. 28+00.00



LEGEND

EX. GROUND	— — — — —
PROPOSED GROUND	———
BURIED LOG SILL	⬭
OFFSET /ELEVATION LABELS	Off 5.90 / Elev 414.84

DATUM: NAD 83⁄91 Horizontal
NAVD 88 Vertical

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK
STREAM RESTORATION

JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future®

BY: barranger

CROSS REFERENCE

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ESC DETAILS	43–44
LANDSCAPING PLANS	45–48
STREAM RESTORATION CROSS SECTIONS	49–52
MOT PLANS	53

R /W PLAT NUMBER

REVISIONS

STREAM RESTORATION CROSS SECTIONS

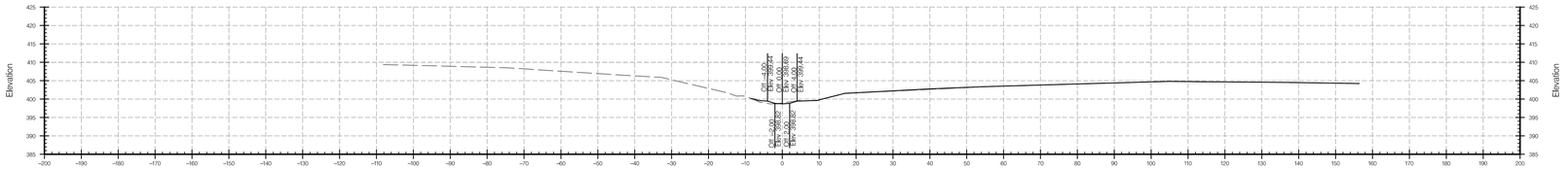
SCALE 1" = 20' ADVERTISED DATE: JUNE 2017 CONTRACT NO. FR5975182

DESIGNED BY FAB COUNTY FREDERICK COUNTY
DRAWN BY FAB⁄PVC LOGMILE
CHECKED BY MRG⁄FAB HORIZONTAL SCALE N /A
F.A.P. NO. SEE TITLE SHEET VERTICAL SCALE N /A

DRAWING NO. CS – 3 OF 4 SHEET NO. 51 OF 53

PLOTTED: Tuesday, April 25, 2017 AT 08:38 AM
FILE: G:\SMD\120079_017_Little_Catoctin_Cree\CADD\pHC_P003_LCC90.dgn

LITTLE CATOCTIN CREEK – STA. 29+87.32



LEGEND

EX. GROUND	
PROPOSED GROUND	
BURIED LOG SILL	
OFFSET /ELEVATION LABELS	Off 5.90 / Elev 414.84

DATUM: NAD 83\91 Horizontal
NAVD 88 Vertical

CROSS REFERENCE

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R /W PLAT NUMBER

REVISIONS

JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future®

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK
STREAM RESTORATION

STREAM RESTORATION CROSS SECTIONS

SCALE 1"=20' ADVERTISED DATE: JUNE 2017 CONTRACT NO. FR5975182

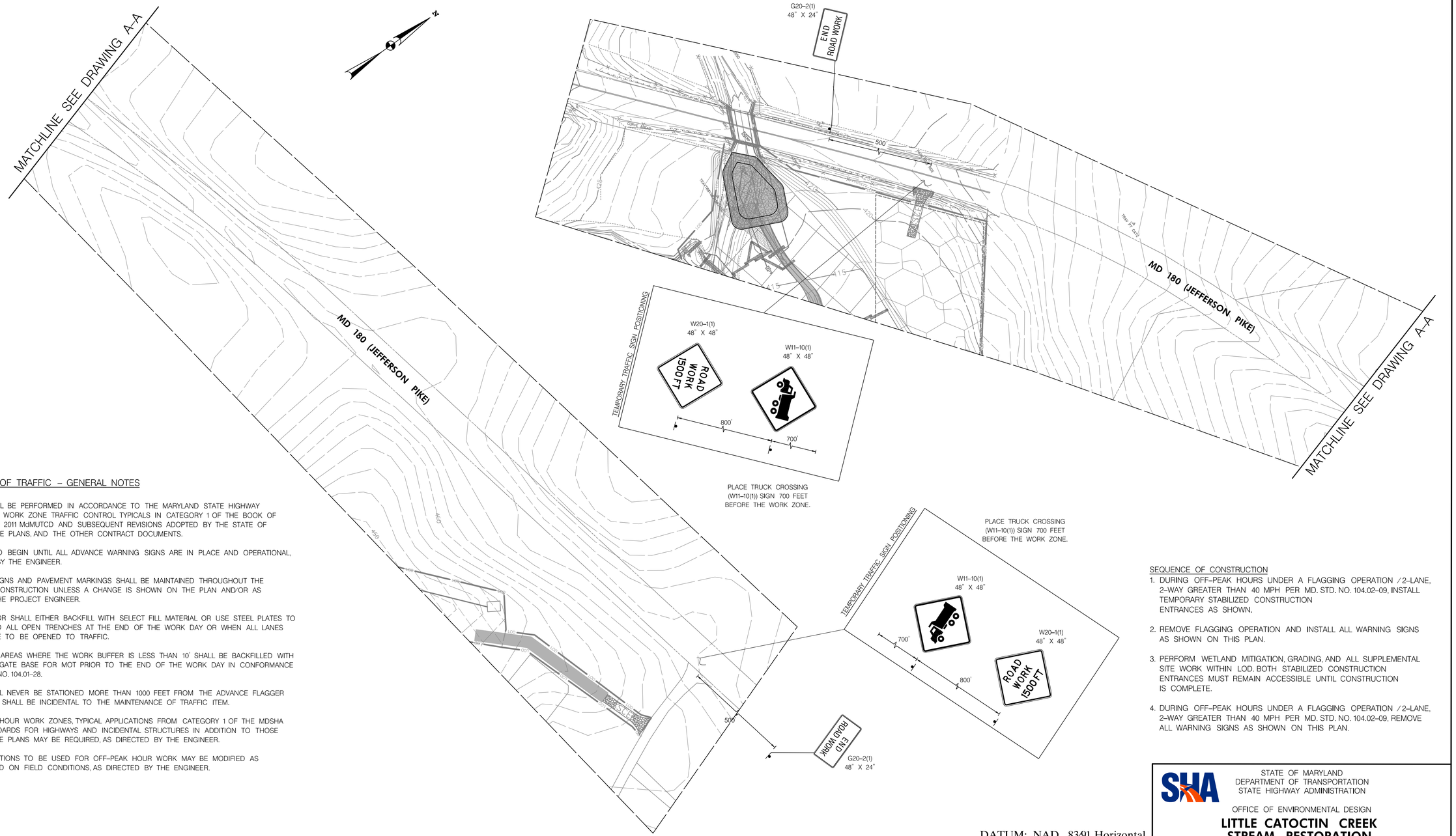
DESIGNED BY FAB
DRAWN BY FAB/PVC
CHECKED BY MRG/FAB
F.A.P. NO. SEE TITLE SHEET

COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. **CS – 4** OF **4** SHEET NO. 52 OF 53

PLOTTED: Tuesday, April 25, 2017 AT 08:45 AM
FILE: G:\SMD\120079_017_Little_Catoctin_Cree\CADD\pHC_P004_LCC90.dgn

BY: barranger



MAINTENANCE OF TRAFFIC – GENERAL NOTES

1. ALL WORK SHALL BE PERFORMED IN ACCORDANCE TO THE MARYLAND STATE HIGHWAY ADMINISTRATION WORK ZONE TRAFFIC CONTROL TYPICALS IN CATEGORY 1 OF THE BOOK OF STANDARDS, THE 2011 MdMUTCD AND SUBSEQUENT REVISIONS ADOPTED BY THE STATE OF MARYLAND, THESE PLANS, AND THE OTHER CONTRACT DOCUMENTS.
2. NO WORK IS TO BEGIN UNTIL ALL ADVANCE WARNING SIGNS ARE IN PLACE AND OPERATIONAL, AS APPROVED BY THE ENGINEER.
3. ALL EXISTING SIGNS AND PAVEMENT MARKINGS SHALL BE MAINTAINED THROUGHOUT THE DURATION OF CONSTRUCTION UNLESS A CHANGE IS SHOWN ON THE PLAN AND/OR AS DIRECTED BY THE PROJECT ENGINEER.
4. THE CONTRACTOR SHALL EITHER BACKFILL WITH SELECT FILL MATERIAL OR USE STEEL PLATES TO COVER ANY AND ALL OPEN TRENCHES AT THE END OF THE WORK DAY OR WHEN ALL LANES OF TRAFFIC ARE TO BE OPENED TO TRAFFIC.
5. EXCAVATION IN AREAS WHERE THE WORK BUFFER IS LESS THAN 10' SHALL BE BACKFILLED WITH GRADED AGGREGATE BASE FOR MOT PRIOR TO THE END OF THE WORK DAY IN CONFORMANCE WITH MD STD NO. 104.01-28.
6. FLAGGERS SHALL NEVER BE STATIONED MORE THAN 1000 FEET FROM THE ADVANCE FLAGGER SIGN. FLAGGERS SHALL BE INCIDENTAL TO THE MAINTENANCE OF TRAFFIC ITEM.
7. FOR OFF-PEAK HOUR WORK ZONES, TYPICAL APPLICATIONS FROM CATEGORY 1 OF THE MDSHA BOOK OF STANDARDS FOR HIGHWAYS AND INCIDENTAL STRUCTURES IN ADDITION TO THOSE CITED ON THESE PLANS MAY BE REQUIRED, AS DIRECTED BY THE ENGINEER.
8. TYPICAL APPLICATIONS TO BE USED FOR OFF-PEAK HOUR WORK MAY BE MODIFIED AS REQUIRED BASED ON FIELD CONDITIONS, AS DIRECTED BY THE ENGINEER.

SEQUENCE OF CONSTRUCTION

1. DURING OFF-PEAK HOURS UNDER A FLAGGING OPERATION / 2-LANE, 2-WAY GREATER THAN 40 MPH PER MD. STD. NO. 104.02-09, INSTALL TEMPORARY STABILIZED CONSTRUCTION ENTRANCES AS SHOWN.
2. REMOVE FLAGGING OPERATION AND INSTALL ALL WARNING SIGNS AS SHOWN ON THIS PLAN.
3. PERFORM WETLAND MITIGATION, GRADING, AND ALL SUPPLEMENTAL SITE WORK WITHIN LOD. BOTH STABILIZED CONSTRUCTION ENTRANCES MUST REMAIN ACCESSIBLE UNTIL CONSTRUCTION IS COMPLETE.
4. DURING OFF-PEAK HOURS UNDER A FLAGGING OPERATION / 2-LANE, 2-WAY GREATER THAN 40 MPH PER MD. STD. NO. 104.02-09, REMOVE ALL WARNING SIGNS AS SHOWN ON THIS PLAN.

DATUM: NAD 83\91 Horizontal
NAVD 88 Vertical

JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future®

BY: barranger

MAINTENANCE OF TRAFFIC LEGEND

SIGN

STABILIZED CONSTRUCTION ENTRANCE (SCE)

CROSS REFERENCE

ITEM	SHEET NOs.
TITLE SHEET	1
ABBREVIATIONS /GENERAL NOTES	2
STREAM RESTORATION GEOMETRY	3-4
STREAM TYPICAL SECTIONS	5
STREAM RESTORATION PROFILES	6-10
KEY MAP	11
STREAM RESTORATION PLANS	12-15
STREAM RESTORATION DETAILS	16-18
ESC NOTES & SEQUENCE OF CONSTRUCTION	19-22
ESC PLANS	23-42
ESC DETAILS	43-44
LANDSCAPING PLANS	45-48
STREAM RESTORATION CROSS SECTIONS	49-52
MOT PLANS	53

R / W PLAT NUMBER

REVISIONS

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN

LITTLE CATOCTIN CREEK STREAM RESTORATION

MAINTENANCE OF TRAFFIC PLANS

SCALE 1" = 50' ADVERTISED DATE: JUNE 2017 CONTRACT NO. FR5975182

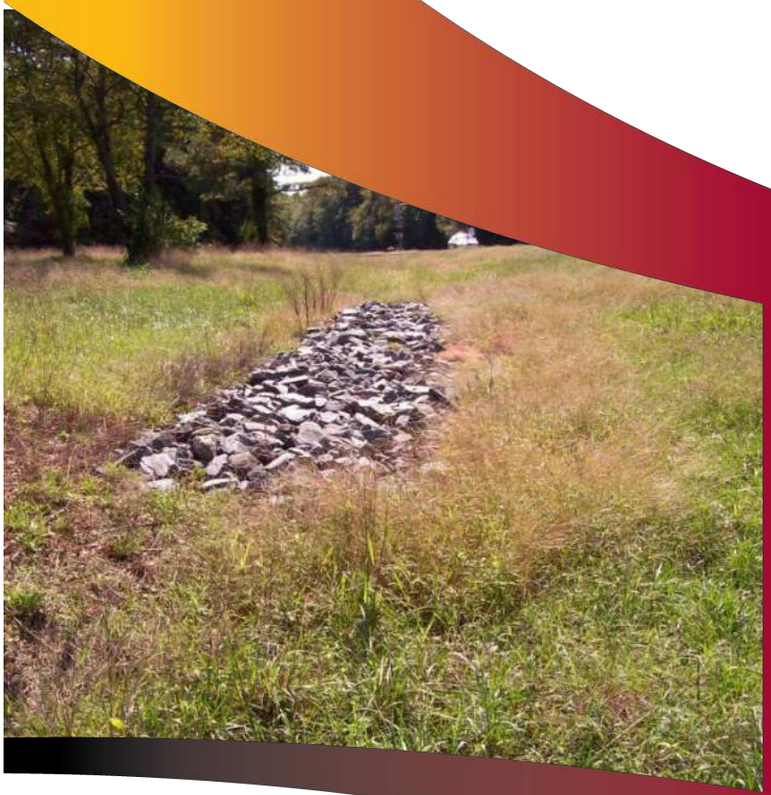
DESIGNED BY FAB
DRAWN BY FAB/PVC
CHECKED BY MRG/FAB
F.A.P. NO. SEE TITLE SHEET

COUNTY FREDERICK COUNTY
LOGMILE
HORIZONTAL SCALE N/A
VERTICAL SCALE N/A

DRAWING NO. **MOT -1** OF **1** SHEET NO. 53 OF 53

PLOTTED: Tuesday, April 25, 2017 AT 08:46 AM
FILE: Q:\SMD\120079_017_Little_Catoctin_Cree\CADD\pMT_P001_LCC.dgn

Appendix K



Stormwater Management Assessment Monitoring Plan for Environmental Site Design (ESD) at Interstate 70

Appendix K

Stormwater Management Assessment Monitoring Plan for Environmental Site Design (ESD) at Interstate I-70

Note:

The physical copy of the MDOT SHA 2017 MS4 Annual Report includes the front-end of this monitoring plan only. The complete monitoring plan, together with all appendices, is included in the digital copy of the annual report, submitted to MDE via compact disc.

MARYLAND DEPARTMENT OF TRANSPORTATION

STATE HIGHWAY ADMINISTRATION

MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

Larry Hogan
Governor
Boyd K. Rutherford
Lt. Governor
Pete K. Rahn
Secretary
Gregory Slater
Administrator

October 9, 2017

Mr. Raymond Bahr
Sediment, Stormwater and Dam Safety Program
Water and Science Administration
Maryland Department of the Environment
1800 Washington Boulevard, Suite 440
Baltimore MD 21230

Dear Mr. Bahr:

The Maryland Department of Transportation State Highway Administration (MDOT SHA) Office of Environmental Design (OED) has received your comment letter dated August 30, 2017 regarding OED submittal of the *Assessment of Controls ESD for I-70 Howard County, Maryland* monitoring plan. In that letter, MDE granted OED formal approval to conduct monitoring, contingent upon OED addressing three requested items. In accordance with the comments, an updated monitoring plan is appended to the MDOT SHA 2017 MS4 Report as Appendix K and OED responses to the three contingencies are listed below:

1. MDE Comment: *While MDOT SHA's proposal focuses primarily on its restoration activities, MDE requests that an updated assessment of controls monitoring plan be submitted, including revised tables, treatment amounts, maps, etc., that reflect the addition of the proposed Howard County BMP's.*

    - OED Response: An updated assessment of controls monitoring plan is appended to the MDOT SHA 2017 MS4 Report as Appendix K. All Howard County Data was added to the mapping tables and text of the report. The report includes planning level data and 60% design as part of the Marriottsville Road widening. Sections 2.3.2 and 2.3.3 of the report include a detailed summary of the Howard County facility data.

2. MDE Comment: *Furthermore, the updated plan should also include TR-20 results for the existing and proposed conditions with and without proposed BMP's as well as with and without all BMP in the watershed.*

    - OED Response: The BMP data throughout the watershed in Howard County is largely assumed and is based on aerial imagery, observed features, shapefiles, etc. The actual credit treated, drainage areas and other design data are mostly unknown. Therefore, a TR-20 model showing BMPs in the watershed could not be accomplished due to insufficient design evaluation.

The BMPs planned by Howard County for the Marriottsville Road widening project, do have preliminary investigation (PI) results that could be input into TR-20. For this reason, these facilities were combined into a single conglomerate watershed with a RCN and hypothetical routing for proposed conditions based on the PI results. A more detailed explanation is found in Section 2.3.3 of the report.

Three additional TR-20 models are included in the analysis:

a. Existing Conditions (no facilities)
b. Proposed Conditions (updated RCN, no routing)
c. Proposed Conditions (with routing)

3. MDE Comment: *MDE encourages MDOT SHA to include SHA's Outfall Stabilization protocol.*

- OED Response: The outfall stabilization protocol was initially planned along the LPR at the outfall of the SHA Bioretention facility on the downstream side of I-70. However, due to the proximity of the outfall to the streambed, the outfall stabilization protocol is not applicable considering that there is no horizontal or vertical difference between the outfall and receiving stream channel. However, MDOT SHA will investigate adding this outfall to an upcoming project to stabilize it.

Thank you again for your review, comment, and continued support of the MDOT SHA OED MS4 program. If you have additional questions or need additional information about this matter, please don't hesitate to contact me at (410) 545-8407 or KCoffman@sha.state.md.us .

Sincerely,

Karen Coffman, Chief
OED Water Programs Division

CC: Mr. Brian Cooper, MDE WSA SSDSP
Mr. Robert Shreeve, Deputy Director, MDOT SHA OED

MARYLAND DEPARTMENT OF TRANSPORTATION

STATE HIGHWAY ADMINISTRATION

STATE HIGHWAY ADMINISTRATION

NPDES/MS4 ASSESSMENT OF CONTROLS

for

Environmental Site Design (ESD) for

Interstate 70

Howard County, Maryland

October 2017

Table of Contents

1 INTRODUCTION 3
1.1 Monitoring Plan Goals 3
1.2 Stormwater Project Description 3
1.2.1 Stream Classification 4
1.3 LPR Watershed Description 5
1.4 Geomorphologic Assessment 6
1.5 Stormwater Control Catchment Description 6
1.6 Howard County Watershed Stormwater Control 7
1.7 Physiographic Province and Region for the LPR Watershed 7
1.8 Local TMDLs 7
1.9 Additional Watershed Initiatives 7
2 PRELIMINARY INVESTIGATIONS 8
2.1 Preliminary Hydrology 8
2.2 Channel Stability 8
2.2.1 Stable Channel Discharge 9
2.3 Howard County 10
2.3.1 Watershed Sensitivity 10
2.3.2 Planning Level Data 11
2.3.3 Marriottsville Road Improvement Impacts 12
2.4 Drainage Area Ratio 14
3 MONITORING 15
3.1 Assessment Reach 15
3.2 Physical Monitoring 15
3.2.1 Sediment Mobility Assessment 16

3.3 Continuous Flow Measurements 17
3.4 Monitoring Locations 18
4 HYDROLOGIC AND HYDRAULIC MODELING 19
5 FIELD DOCUMENTATION 20
5.1 Field Data Collection Forms 20
5.2 Documentation 20
6 DATA QUALITY OBJECTIVES AND REQUIREMENTS 21
6.1 Field Procedures and Quality Control 21
6.1.1 Cross-sections 22
6.1.1 Longitudinal Profile 22
6.1.2 Wolman Pebble Count 23
7 SCHEDULE FOR MONITORING PROGRAM IMPLEMENTATION 23
8 DATA ANALYSIS 23
9 BIBLIOGRAPHY 25

Appendix List

(Included with Digital Submission Only)

APPENDIX A ..... MONITORING PLAN AND SCHEDULE
APPENDIX B ..... LITTLE PATUXENT RIVER WATERSHED MAPPING
APPENDIX C ..... PRELIMINARY ESD DESIGN REPORTS
APPENDIX D ..... HYDROLOGY COMPUTATIONS
APPENDIX E ..... FIELD FORMS
APPENDIX F ..... HOWARD COUNTY DATA AND PLANNING
- APPENDIX F.1 ..... TR-20 ANALYSIS AND SUPPORTING DOCUMENTATION
- APPENDIX F.2 ..... MARRIOTTSVILLE ROAD IMPROVEMENT PLANS
- APPENDIX F.3 ..... LITTLE PATUXENT WATERSHED PLAN

1 INTRODUCTION

1.1 Monitoring Plan Goals

The Maryland Department of Transportation State Highway Administration (SHA) is currently planning, designing, and constructing practices with the intent to improve stormwater quality. The efforts are towards implementing the Chesapeake Bay Total Maximum Daily Load (Bay TMDL) and MS4 impervious restoration requirements.

In compliance with the SHA MS4 Phase I Permit Part IV.F, Assessment of Controls, Section 2, Stormwater Management Assessment, SHA is required to determine the effectiveness of stormwater management practices for stream channel protection as implemented under the latest stormwater regulations. SHA is proposing this monitoring plan for several bioswales, grass swales, and a bioretention facility along Interstate 70 (I-70) at the intersection with Marriottsville Road in Howard County, Maryland. This site is within the Little Patuxent River (LPR) watershed (02131105) and the stream channel to be assessed is the Little Patuxent River main stem.

It should be noted the Environmental Site Design (ESD) practices, as outlined in this monitoring plan and intended as part of SHA's Chesapeake Bay TMDL efforts, are currently not designed for PE's above 1 inch. It is the intention of the designer that level of treatment is the maximum extent practicable. Therefore, the ESD practices, as ultimately designed, may not be reducing peak discharges for storms greater than one inch. The purpose and need for these facilities at the chosen site is primarily water quality, not necessarily water quantity, and may have limited influence on changes in channel stability.

Because the size of the watershed draining to LPR downstream of this site is sizeable (1,249 Acres) compared to the areas treated by the proposed BMPs, SHA does not anticipate significant impacts to the channel itself through implementation of these ESD practices.

The primary goal of this plan is to answer several questions pertaining to ESD controls and stream channel response:

- Will the peak discharge coming from controlled catchments be reduced once controls have been implemented?
- Will there be geomorphological response to the Little Patuxent River once controls are in place?
- What are the thresholds for stream stability and do the catchment controls improve stream stability through peak discharge attenuation?
- Can a partnership with Howard County on a larger watershed monitoring plan increase the opportunity to observe a difference in discharge and channel stability?

1.2 Stormwater Project Description

The Water Programs Division (WPD) in the Office of Environmental Design (OED) is currently planning, designing and implementing controls for the Bay TMDL and MS4 efforts. SHA WPD is planning several facilities within existing SHA right-of-way (ROW) at I-70. One bioretention is planned for the interior of a ramp, 3 bioswales and 2 grass swales are planned for the median of I-70 near the Marriottsville Interchange.

Please refer to the appendices for calculations developed in the planning phase of design. Currently, the bioretention calculations are included in the appendices. Further design is needed for the grass swales and bioswales.

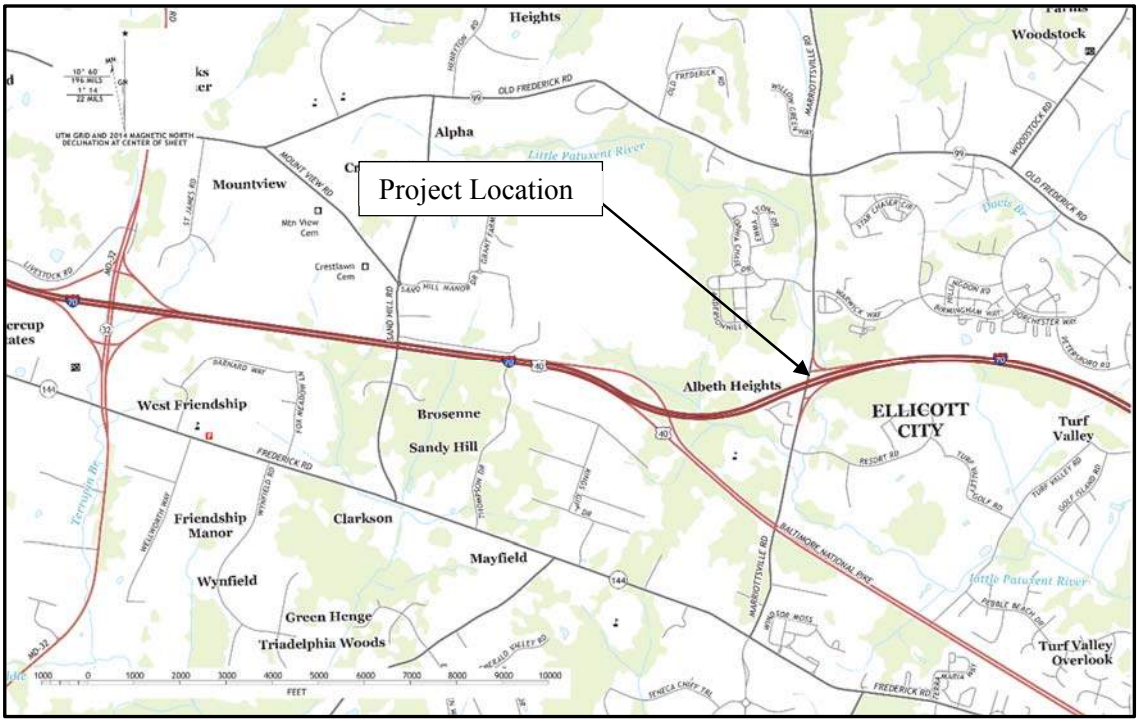


Figure 1: Proximity Map

Table 1: General Coordinates for the Project Location

	Northing/Latitude	*Easting/Longitude*
State Plane NAD 83 (Meters)	181,678.47	408,756.01
GCS North America 1983	39° 18’ 11.78” N	76° 53’ 54.55” W

1.2.1 Stream Classification

The LPR is classified as surface water use designation IV-P, *Recreational Trout Waters and Public Water Supply.* Use IV-P waters allow any reasonable and lawful use if surface water quality is not adversely affected. Legal use may include water contact sports, leisure time activities, fishing, propagation of fish (other than trout), agricultural water supply, industrial water supply, and public water supply.

Use IV-P waters by the Code of Maryland Regulations §26.08.02 (COMAR, Reference 4) have in-stream construction restrictions from March 1 through May 31, inclusive.

1.3 LPR Watershed Description

Table 2 provides a summary of existing conditions for the LPR upstream watershed. Appendix B includes LPR Watershed mapping, which provides visual verification of summary data provided here. Appendix B includes the following maps:

1. Vicinity Map
2. Watershed Map
3. Land Use Map
4. Zoning Map
5. Soils Map
6. SHA TMDL Map
7. Watershed Approach – Classification Map
8. SHA Proposed ESD Facilities

Table 2: LPR Watershed Parameters

	To I-70
Total DA	1,248.90 Acres
	1.95 Mi²
SHA Impervious Area	20.49 Acres
	1.64 %
Total Impervious Area	110.21 Acres
	8.82 %
2010 MDP RCN	74
Zoning RCN	77
Forest Cover	325.96 Acres
	26.10 %

Land use data was obtained from the 2010 Maryland Department of Planning (MDP) and visually verified in comparison to recent aerial imagery. In conjunction with SSURGO hydrologic soil group (HSG) classifications, the MDP land use categories were related to similar land use descriptions from NRCS Technical Release 55 (TR55) to develop Runoff Curve Number (RCN) values. Soils data for the HSG were obtained from NRCS' Web Soil Survey, known as the SSURGO soils database.

Zoning spatial data was obtained from Howard County's Office of Planning and Zoning GIS data (2013). Just as with the 2010 MDP data, TR55 descriptions were paired with zoning descriptions when developing the RCN values. The zoning RCN proved higher than the 2010 MDP-derived RCN.

Area summaries for both the 2010 MDP and Howard County Zoning data can be found in Table 3 (following page).

Table 3: LPR Watershed Land Use & Zoning

	Category	Area Sum	Percent
2010 MDP Land Use Data	Cropland	283.6 Acres	22.7%
	Bare ground	233.1 Acres	18.7%
	Brush	170.2 Acres	13.6%
	Low-density residential	154.7 Acres	12.4%
	Deciduous forest	132.4 Acres	10.6%
	Large lot subdivision	95.3 Acres	7.6%
	Open urban land	71.2 Acres	5.7%
	Institutional	42.4 Acres	3.4%
	Commercial	34.7 Acres	2.8%
	Transportation	24.7 Acres	2.0%
	Extractive	5.0 Acres	0.4%
	High-density residential	1.4 Acres	0.1%
	Medium-density residential	0.1 Acres	0.0%
	Total	**1,248.9**	**100%**
2013 Howard County Zoning Data	Rural Residential	904.0 Acres	72.4%
	High Density Residential	149.4 Acres	12.0%
	Office/Commercial	141.9 Acres	11.4%
	Low Density Residential	51.3 Acres	4.1%
	Planned Golf Course Community	2.4 Acres	0.2%
	Total	**1,248.9**	**100%**

1.4 Geomorphologic Assessment

Per USFWS regional equations, the 'bankfull' discharge in the Piedmont Region for the 1,249-acre drainage area is 140.5 cubic feet per second (CFS). The slightly entrenched and moderately sinuous channel has been identified as an E5 Rosgen channel type. The bed material is composed primarily of a sandy gravel material.

1.5 Stormwater Control Catchment Description

Stormwater controls are proposed for three areas within the I-70/Marriottsville Road interchange; 3 bioswales and 2 grass swales in the median and one bioretention facility (HOGr1-JMT-040) on the south side of I-70 adjacent to NB Marriottsville Rd. The bioswales and grass swales will capture runoff from a portion of the I-70 east and west bound lanes while the bioretention facility will capture runoff from Marriottsville Road and the east bound ramp to I-70. A map showing the drainage areas and BMP footprints is included in Appendix B.

A summary of anticipated treatment for these facilities is included in Section 2.3.3 of this report. Refer to Table 9 for a summary of the facilities and associated treatment. The design of these facilities is on-going and will be modified as the design is finalized.

1.6 Howard County Watershed Stormwater Control

Per the Howard County NPDES GIS data, the county currently owns and operates four stormwater controls within the drainage area boundary. The combined drainage area for these controls is 131 acres and treats the landfill, school, a portion of the Golf Course and facilities, and a portion of a residential subdivision located near the landfill site. The treatment value of these facilities is unknown. Drainage areas and footprints for the Howard County Stormwater Controls are shown on a map in Appendix B.

Additional stormwater controls can also be seen from aerial imagery of the watershed. The GIS NPDES Howard County layer contains footprints and a single drainage area for 3 ponds in series within Alpha Ridge Landfill while the aerial imagery shows 7 wet and dry ponds in the same area. Four more ponds can also be seen in the residential development immediately east of the landfill and west of Marriottsville Road.

SHA contacted Howard County to determine watershed plans for LPR upstream of the monitoring site proposed here. The data provided is included in section 2.3 below with descriptions and expected contributions from County planned efforts.

1.7 Physiographic Province and Region for the LPR Watershed

The LPR watershed is entirely within the Piedmont Plateau Province and the Harford Plateaus and Gorges Region. The upstream LPR watershed is entirely within the Hampstead Upland District. This district is characterized as Coarse-grained quartz schists (Loch Raven Schist) and fine- to medium-grained mafic schists (Piney Run, Pleasant Grove, and Prettyboy Formations). Lesser amounts of metagraywacke, boulder gneiss, metaconglomerate and isolated ultramafic bodies. The Middletown Valley is comprised of quartzite, sandstone, siltstone, graywacke, phyllite, and shale. The Hampstead Upland District is comprised of rolling to hilly uplands interrupted by steep-walled gorges. Differential weathering of adjacent, contrasting lithologies produces distinctive ridges, hills, barrens, and valleys. Streams may have short segments of narrow, steep-sided valleys.

1.8 Local TMDLs

A review of local TMDLs within watershed 02131105 (LPR) was performed. Three local TMDLs were located for the LPR watershed. Two are for Centennial Lake approximately 5 miles south/downstream of the project site. One is specifically for LPR identifying sediment as the impairment.

Table 4 outlines all local TMDLs identified for LPR.

Table 4: Local LPR TMDLs

Location	Substance	Waterbody Type	Report Name	GIS ID	Approval
8 Digit WS 02131105 / LPR	Sediment	Non-Tidal Rivers	LPR Sediment	G1118	9/30/2011
Centennial Lake	Phosphorus	Impoundments	Centennial Lk Phos. &	G2524	4/24/02
Centennial Lake	Sediment	Impoundments	Centennial Lk Phos. &	G2524	4/24/02

1.9 Additional Watershed Initiatives

SHA has ongoing stormwater investigations for watershed improvements and tree planting efforts throughout their permit area. For the LPR watershed a small active tree maintenance area currently exists.

Minimal SHA infrastructure, drainage or otherwise, exists in the watershed. MD 99 (Old Frederick Road) is the only route in the LPR watershed upstream from the monitoring site. Although investigations are continuing, no additional restoration projects are currently planned for this watershed.

2 PRELIMINARY INVESTIGATIONS

2.1 Preliminary Hydrology

A preliminary hydrologic model was developed using TR-20 for existing and proposed conditions within the catchment. Existing conditions are described in Section 1.3, while proposed conditions, including SHA implementation of ESD facilities along I-70, are described in Section 1.5. For the SHA ESD facilities, it is assumed that the facilities will restore each respective drainage area to "woods in good condition" and the RCN value was modified appropriately. As stated above, the designer will maximize treatment areas as the design advances. For this analysis, RCN adjustments are assumed to represent an ultimate treatment scenario.

Results from the TR-20 model are shown in Table 5 along with the existing and proposed RCN values. The largest change in discharge occurred during the 2-year event which decreased by 0.94%. The 100-yr discharge decreased by 0.25%.

Table 5: WinTR-20 Results

Recurrence	Existing	Proposed	Difference
RCN	*75.78*	*75.66*	*-0.16%*
1-year	132 ft³/s	131 ft³/s	0.75%
2-year	211 ft³/s	209 ft³/s	0.94%
5-year	348 ft³/s	346 ft³/s	0.57%
10-year	553 ft³/s	550 ft³/s	0.54%
25-year	772 ft³/s	769 ft³/s	0.38%
50-year	961 ft³/s	958 ft³/s	0.31%
100-year	1,166 ft³/s	1,163 ft³/s	0.25%
200-year	1,392 ft³/s	1,388 ft³/s	0.28%
500-year	1,719 ft³/s	1,716 ft³/s	0.17%
Average			**0.47%**
Median			**0.38%**

2.2 Channel Stability

The channel stability will be defined when boundary shear stress is 20% higher than the critical shear stress determined from the project site's channel bed material. In short, a ratio of 1.2 of boundary shear stress to

critical shear stress will achieve channel stability for the 'bankfull' or effective discharge. Until this plan is implemented and the 'bankfull' or effective discharge is determined, this plan is assuming the 2-year return interval discharge is the 'bankfull' discharge.

2.2.1 Stable Channel Discharge

A stable channel is typically defined as one that neither aggrades nor degrades over time; the channel should maintain a balance between erosion and deposition. A channel with a steep slope has more energy to carry large sediment. Structures, geology and stream features influence the slope of a channel and effectively the stability of a channel. A head cut can propagate upstream until it reaches bedrock or a culvert. River controls often have more influence on stream stability than discharge because of their ability to change or maintain a channel slope. Changes in discharge due to land use, such as deforestation, result in increased peak discharges that adversely affect channel stability.

Channel stability can also be defined in terms of shear stress. The channel becomes unstable when the channel shear stress exceeds 20% of the critical shear stress required to move the median sized grain in the center of the channel (Cappuccitti, 2000). A curve was developed for the project reach using cross section data and median grain size of the channel bed to find the stable channel discharge. Stage is plotted on the x-axis and the ratio of channel shear to critical shear was plotted on the y-axis. By finding the stage at a shear ratio of 1.2 we can estimate the stable channel discharge. By plotting shear stress ratio in Figure 2 and using Table 6 to look up discharges, the stable channel discharge for LPR is 25 CFS.

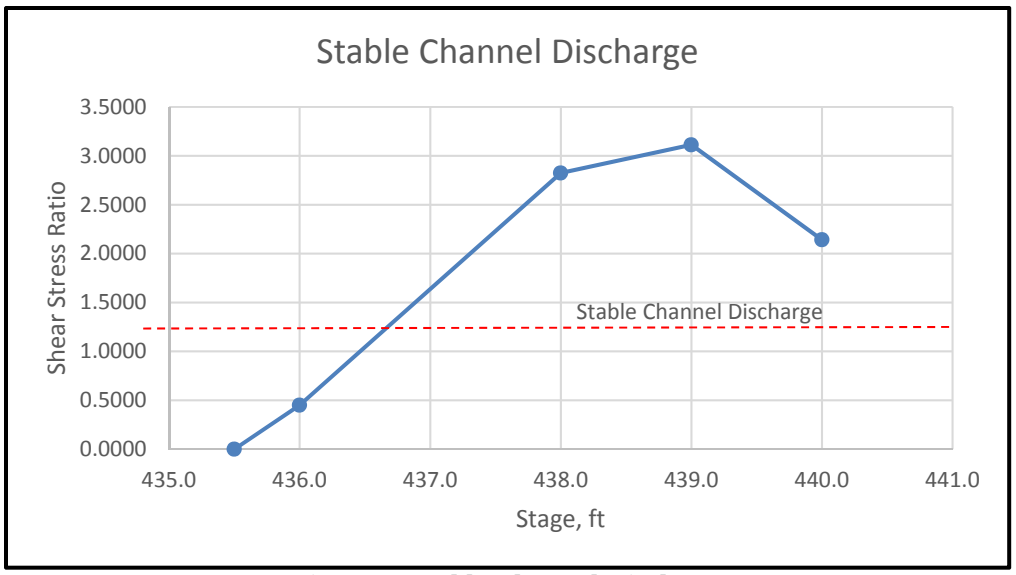


Figure 2: Stable Channel Discharge

Table 6: Stable Channel Discharge

Stage (ft)	R (ft)	Q (cfs)	Shear (psf)	SS Ratio
435.5	0.00	0.00	0.0000	0.0000
436.0	0.25	1.84	0.0468	0.4498
438.0	1.57	75.43	0.2940	2.8249
439.0	1.73	142.61	0.3239	3.1127
440.0	1.19	1385.79	0.2228	2.1411

2.3 Howard County

A comprehensive collection of data was gathered from Howard County to quantify potential and planned impacts within the watershed. A sensitivity analysis was also prepared to demonstrate the amount of runoff reduction potential using a holistic approach within the watershed. In reaching out to Howard County, planning level data was obtained as well as PI level plans near the Marriottsville Road and I-70 interchange. Howard County has plans moving forward on a road widening project on Marriottsville Road crossing over I-70 that are in the Preliminary Investigation phase. New impervious area created by the project will be treated using various ESD facilities. A hydrologic study was performed to investigate the impacts of these facilities on the LPR study point.

2.3.1 Watershed Sensitivity

To test the sensitivity of a holistic approach, land uses were categorized within the watershed to determine the potential for treatment. For example, it was assumed that all post-2011 developments meet current Maryland Stormwater regulations. The other areas were grouped together to represent phases of ESD implementation across the watershed. Pre-2011 HOA subdivisions, commercial developments, and private individual residents were grouped into separate phases depending on the difficulty of implementing ESD facilities in that area. Table 7 includes descriptions of the phases and the resulting RCN necessary to achieve the "woods in good condition" parameter. The resulting RCN is the cumulative result of the described phase and all other prior phases.

Using the USFWS bankfull discharge, a return interval and corresponding rainfall depth was determined for the TR-20 model of the watershed. It was determined that the bankfull return interval was 1.12 years and the equivalent rainfall depth was 2.35 inches. The TR-20 model was then run for each new curve number to determine the new discharge at the same recurrence interval.

Table 7: Watershed Approach

Bankfull Q - 1.12-yr	RCN	Description of Watershed Focus
140.5 ft³/s	75.78	Existing Conditions
138.8 ft³/s	75.66	Proposed Conditions – SHA ESD Facilities
113.4 ft³/s	73.28	Assumed Treatment from post 2011 Developments
89.8 ft³/s	70.74	Howard County Participation (Gov. Buildings)
86.5 ft³/s	70.34	Subdivision Participation (with HOA)
77.3 ft³/s	69.19	Business Participation

Bankfull Q - 1.12-yr	RCN	Description of Watershed Focus
53.0 ft³/s	65.68	All Resident Participation
52.4 ft³/s	65.58	Conversion of all Open Space
38.3 ft³/s	63.04	All Roadways and Associated Easements
37.1 ft³/s	62.81	Golf Course
34.7 ft³/s	62.30	Landfill (All Woods in good Condition)

If the entire watershed is treated and converted into the "woods in good condition" cover type, the channel discharge may be reduced from 140.5 ft³/s to 34.7 ft³/s. Realistically, a partnership with the county would not result in the entire watershed converting back to woods in good condition in a short timeframe. One small area change in a large watershed may not have noticeable effects. However, small incremental changes over the entire watershed may have a greater influence on the total observed channel discharge.

2.3.2 Planning Level Data

In contacting Howard County watershed managers, the plan for the LPR was requested. The *'Little Patuxent River Watershed Assessment'* (November 2015) developed by Versar, Inc., for Howard County, Department of Public Works, Stormwater Management Division, was reviewed for the expected County contributions. This plan described site assessment for watershed improvements for the Northern Little Patuxent River (NLP), the Southern Little Patuxent River (SLP), Dorsey Run (DOR), and Hammond Branch (SMP) watersheds.

Spatial data from the LPR Watershed Assessment was provided by Mr. Mark Richmond, P.E., and Ms. Christine Lowe, P.E., to locate which planned practices are currently proposed. The following practices were identified as shown in Table 8. The identified practices represent locations identified by field crews as potential sites and have not gone through a vetting process for project feasibility. Drainage areas and other design parameters have not been computed at this point.

Table 8: LPR Planned Watershed Practices (Howard County)

BMP ID	Type	Expected Treatment Area
NLP-NB-F502B	new BMP	*See below
NLP-NB-F502A	new BMP	2.2 acres (*combined with F502B)
NLP-BC-D543	BMP Conversion	unknown
NLP-OF-F654	outfall stabilization	2.0 acres
NLP-TP-F652	tree planting	unknown
NLP-TP-F513	tree planting	unknown
	Total →	**4.2 acres (known)**

As can be seen in Table 8, very few practices are proposed for this monitoring plan's watershed. Most NLP sites are proposed for areas south of I-70 down to Ellicott City, Maryland (west of US 29). Therefore, the discharge changes as outlined in Table 8 may not be achieved during this monitoring period.

2.3.3 Marriottsville Road Improvement Impacts

Howard County is proposing dualization of the Marriottsville Road over I-70. The primary objective of the Howard County Marriottsville Road project along the overpass of I-70 is to alleviate roadway congestion and provide accommodations for both present and future increases in traffic volume. Currently, both the bridge and approaching roadways have only two lanes. Under proposed conditions, the bridge will be widened to accommodate four traffic lanes and two bike lanes. Both entrance ramps to I-70 will also be expanded to aid in controlling increased traffic. As a result of the proposed bridge and road improvements, the watershed will experience an overall increase in impervious area that must be treated with SWM practices. Two bio-swales are proposed along the west side of Marriottsville north of the bridge and a micro-bioretention is proposed in the gore area north of the bridge along the east side of Marriottsville Road. Howard county also proposed facilities further south of the bridge, however they were omitted from this analysis because they are located outside of the overall drainage area. The plans for the proposed Howard County facilities is found in Appendix F.

In addition to Howard County's proposed facilities, SHA has proposed two grass swales, three dry swales, and one bioretention facility along I-70 that treat a total of 5.21 acres of impervious area. The bioretention facility is located in the gore area southeast of the Marriottsville bridge. Grass swales A and B are adjacent to one another, and flow to an inlet in the median. Combined, they span 1500 feet and stop approximately 850 feet past the 83-mile mark. The three dry swales east of the bridge are also directly adjacent to one another, and span a total of 1,626 ft. They also drain to inlets in the median and stop approximately half a mile past the 83-mile mark. Stormwater computations were performed independently from the design reports to maintain consistency in this planning level analysis between the proposed Howard County facilities and the proposed SHA facilities. The stormwater computations for each facility can be found in Appendix F. Table 9 below gives an overview of both SHA and Howard County proposed facilities.

Table 9: SWM Facility IART Overview

Facility Type	DA to Facility (Acres)	PE Treated (Inches)	Runoff Storage Volume (Cubic ft.)	Imp. Area Treated (Acres)	Imp. Area Credit (Acres)
Bioretention	4.44	1	3,529	1.78	1.78
Howard Co - Micro-Bioretention	1.05	2.6	2,916	0.56	0.78
Grass Swale A	2.83	0.77	9,239	0.96	0.74
Grass Swale B	0.77	0.76	2,150	0.25	0.19
Bio Swale A	0.96	2.6	1,395	0.31	0.43
Bio Swale B	2.52	2.6	3,837	0.9	1.27
Bio Swale C	2.41	2.6	4,602	1.01	1.41
Howard Co - Bio Swale A	0.66	1.77	990	0.38	0.45
Howard Co - Bio Swale B	0.48	1.9	1,016	0.3	0.37
Total	16.12	16.6	29,674	6.45	7.42
Area Weighted PE =		2.24			

**Facility design is in concept stage and subject to change. The volume and PE Treated may change as the design is approved and constructed.*

*** Impervious Area Credit is calculated using incentive for extra credit as described in MDE's Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated (2014)*

Because the total area being evaluated only occupies 16.12 acres of the 1,248.7-acre overall drainage area, modeling the impact of individual facilities may not produce observable results. Therefore, the existing impervious areas were updated using aerial imagery in combination with the proposed facility drainage areas given by. By revising the existing soil, land use, and land cover data to be more accurate, the effects of proposed alterations in context of the overall watershed can be modeled with increased accuracy. Adjusted curve numbers and facility dimensions were assigned to each sub-drainage area, and then were used to calculate surface storage and treatment volumes. In order to gain a more holistic perspective of the watershed, the drainage areas from each proposed facility were summed together to represent one large area that acts as a single ESD facility. Rainfall data for Howard County was obtained from TR-55 and then used in TR-20 to model the 2 and 10-year storm. In order to incorporate the effect of ESD facilities in the 2 and 10-year flows, TR-20 routing was performed through the proposed facilities. The POIs were routed through a proposed, hypothetical pond with a 1' depth that contained the full storage volume provided by the ESD practices within the POI.

The POI was evaluated using TR-20 to route the proposed DA through the proposed ESDv facilities. The volume included in the BSM was used for storage volume- this area was calculated as the Length x Weighted Average Width x Depth x Porosity. The entire surface storage provided was also used in the storage computations and the total sum of the surface storage provided was utilized. The total DA to the proposed facilities was routed through a theoretical pond of 1' depth, and a width equal to the sum of the proposed weir lengths for all facilities in the POI. Above a depth of 1', 3:1 side slopes were used to calculate the surface storage volumes stored. The DA through the proposed facilities was routed using a CN equal to the weighted average of the CN to each proposed facility.

The weighted CN's for the nine facilities were calculated by multiplying the land use areas by their respective CN's, then dividing the sum of those products by the total drainage area. The DA of remaining area that bypasses the facility was routed using a CN calculated using the overall CN in proposed conditions, re-weighted by subtracting the area going to the proposed facilities. Table 10 below breaks down the data used.

Table 10: Facility Design

Facility	Impervious (sq ft)	Lawn Good Condition (sq ft)	Total (sq ft)	Total (acres)	Weighted RCN
Grass Swale A	41,939	81,246	123,185	2.83	86.13
Grass Swale B	10,727	22,940	33,667	0.77	89.27
BioSwale A	13,456	28,553	42,008	0.96	85.77
BioSwale B	39,403	70,499	109,901	2.52	86.45
BioSwale C	43,989	60,840	104,829	2.41	87.55
Bioretention	77,597	115,838	193,435	4.44	86.51
Micro-Bioretention (HO)	24,393	21,274	45,667	1.05	89.61
BioSwale A (HO)	16,493	12,137	28,631	0.66	90.37
BioSwale B (HO)	13,056	7,651	20,707	0.48	90.87
Total	**281,053**	**420,977**	**702,030**	**16.12**	**87.2**

The computations and dimensions for the bioretention facility, which was the only facility with any preliminary design, were pulled directly from the NPDES Monitoring Plan apart from the filter bed depth and drainage area values. The filter bed depth was corrected from 2.5 feet to 2 feet and the drainage area

was corrected from 3.46 acres to 4.44 acres. Due to the lack other existing design plans, the computations in this assessment were reliant upon the assumptions listed below:

1. SHA facilities located in the median of I-70 were not separated into drainage areas of 1 acre or less because the classification of the work being done in that area is not "new construction"
2. Although classified as Micro-Bioretention, the proposed facility drainage area exceeds the limit of 20,000 square feet. Therefore, the dimensions were approximated to satisfy Pe requirements
3. Surface and subsurface storages (porous media) were incorporated into the routing of the hypothetical pond facility
4. Grass swales were assumed to have 50-foot spacing and 1-foot elevation

The implementation of ESD/BMP facilities along I-70 and Marriottsville Road impacted the overall drainage area by increasing the discharge 0.1 cfs from the 2-year and 10-year storm events. Table 11 below summarizes the pre- and post-development 2 and 10-year flows for the POI. The increase in runoff from the new impervious areas is almost entirely attenuated by the proposed facilities

Table 11: Flow Analysis

Storm	Existing Peak Discharge (cfs)	Proposed Peak Discharge (cfs)	Proposed Peak Discharge with Facilities (cfs)
2-yr	248.8	252.0	248.9
10-yr	569.1	576.5	569.2

2.4 Drainage Area Ratio

SHA evaluated 68 planned ESD facilities planned for TMDL implementation in Baltimore, Howard, and Anne Arundel Counties. Discharge points from the 68 individual ESD's were approximated (based on nearest practical outflow from proposed BMP) and a 'Pour Point' for each ESD was established to the nearest receiving 'blue line' stream in the National Hydrologic Dataset (NHD). This was established to infer straight-line distance from outfall to receiving stream. Since many BMP sites were inclusive in downstream 'Pour Points' and other ESD sites, multiple ESD sites were grouped by drainage basin but maintained the BMP discharge point to nearest 'blue line' stream. This reduced the original 68 individual BMP sites to 41 clustered projects, which may bias to a higher DA Ratio. The DA Ratio is the ratio of SHA treated drainage area to the total drainage area.

The following table (Table 12) outlines results of this analysis;

Table 12: Drainage Area Ratios

Maximum DA Ratio	37.13%
Minimum DA Ratio	0.00011%
Average DA Ratio	3.40%
Median DA Ratio	0.6247%

Of the 41 clustered sites, 37 had a DA Ratio of less than 10%.

In reviewing the distance from BMP outfall to 'blue line' stream, lengths varied from 0 to 2,417 LF. From the 41 clustered project sites, 34 had a distance greater than 100 LF.

SHA's effect on a receiving 'blue line' stream is only one of many variables causing geomorphic changes. A statewide perspective may show that SHA roads have a cumulative impact on channel stability but measurable impacts on "blue line" streams in the immediate vicinity of ESD implementations and SHA disturbances may prove difficult to measure.

3 MONITORING

3.1 Assessment Reach

The basis of physical monitoring of LPR downstream of the outfall locations is premised on anticipated incipient motion of channel bed material compared to the capability of channel flows to initiate that motion. This monitoring plan aims to quantify the channel geomorphological characteristics of LPR, quantify flow from the target catchments, and quantify overall flows at the receiving downstream channel. This will be accomplished through sediment mobility analysis (critical shear stress) as compared to hydraulic parameters (boundary shear stress). When boundary shear stress exceeds critical shear stress, degradation begins to occur. When boundary shear stress is lower than critical shear stress, aggradation begins to occur.

Therefore, an assessment reach analysis for LPR downstream of the proposed ESD facilities is proposed. The purpose of this assessment reach analysis is to estimate the sediment threshold and hydraulic parameters of the stream channels for LPR.

3.2 Physical Monitoring

The physical monitoring of LPR will be located downstream of HOGr1-JMT-040 outfall. Upon the first mobilization, a visual assessment of the reach will be made determining base level control reach (downstream), the assessment reach (at the outfall of HOGr1-JMT-040) and the supply reach (upstream of I-70). This visual assessment is intended to document and understand the nature of the LPR system upstream, downstream, and through the assessment reach. Photo documentation will be made and photos will be georeferenced. Field notes will be made and compiled for inclusion into the study reporting.

Once a general understanding of the system is determined, two cross sections plus a long profile of the assessment reach are proposed. Local survey benchmarks will be established on site so that all data collected will be referenced to Maryland State Plane, NAD 83, US Survey feet (horizontally) and NAVD 88 (vertically). A water surface profile at baseflow will be measured to determine the friction slope of the system. The cross sections will be permanently monumented and measured where appropriate based on engineering judgement during the first field mobilization. Wolman pebble counts will be made at each section/nearest riffle to establish critical shear stress values.

Measurement of the assessment reach will occur yearly (at minimum) to capture pre- and post-ESD installation conditions over term of the MS4 permit. Measurements may be taken after significant storm events and/or abrupt changes to the stream channel. All data will be compiled using the StreamMetrics spreadsheet to quantify the varying data and comparisons.

The National Weather Service (NWS) keeps rainfall records for gauges near the project site. These gauges are in Clarksville and Woodstock. See Table 13 for information relating to each site. Woodstock is physically closer but Clarksville is more geographically similar. At either of these sites the minimum 24-hour rainfall event is near 1.5 inches of rainfall. Channel measurements will be taken once a year at the beginning of the year and up to two more measurements per year may be taken as 24-hour accumulations exceed 1.5 inches. The team will mobilize after the first 1.5 inches or greater 24-hour accumulation and may choose to take channel measurements after a significant event larger than 1.5 inches.

Table 13: Rain Gauges

	Woodstock	Clarksville
Station ID	18-9750	18-1862
Latitude/Longitude	39.3333, -76.8667	39.2553, -76.9286
Daily Min, in	1.41	1.62
Daily Max, in	6.05	9.13
Daily Average, in	2.85	2.95
1-yr Frequency Estimate (NOAA 14), in	2.66	2.65

3.2.1 Sediment Mobility Assessment

The stable channel threshold, as defined in this plan, is when boundary shear stress is 20% higher than the critical shear stress as determined from the project site's bed material.

A major premise of the sediment mobility analysis is that threshold conditions defined by any critical shear stress method represent a condition of very low transport rate (Wilcock 1988). A second assumption is that statically armored riffles satisfy the conditions of near-equal mobility; that is, the largest sediments in a sediment mixture require slightly higher shear stresses than do smaller sizes. Very large particles from colluvial material or large fragments of bedrock plucked from the streambed or bank during infrequent high flows may not be mobile, although they can effectively hide or shelter other smaller particles. The largest particles (D_i) on the bars or in the sub-surface represent the maximum size present in the bedload.

Methods considered in this monitoring plan for the computation of the critical dimensionless shear stress condition for marginal transport of a specific size fraction in mixed-grain sediments (Andrews et al 1995) have the form:

$$\tau^*_{ci} = a\,(D_1/D_2)^b$$

where τ^*ci is the critical dimensionless shear stress for a very low transport rate for the specific size fraction in the matrix armor layer. This equation is used to estimate the conditions under which marginal transport will exist in the channel. An assumption is made that the minimum shear stress under bankfull conditions in the assessment riffle should be that which mobilizes the largest particles in the bedload. The variables D1 and D2 are representative sizes of the sediment samples. Using Andrews' 1995 equation, D1 is equal to Di identified below, and D2 is the mean diameter particle size of the riffle surface using the Wolman Pebble Count method. Coefficient 'a' and exponent 'b' are 0.0376 and –0.994, respectively, for the 1995 equation.

The critical shear stress for marginal transport rate of the largest size fraction in the bedload corresponding to τ^*ci, which relates shear stress to bedload material, is given as:

$$\tau_{ci} = \tau^*_{ci}\,(s\text{-}1)\,\gamma\,D_i$$

where τci is the critical shear stress required to mobilize Di , which represents the largest size fraction that is considered to be mobile; s is the specific gravity of the sediment (typically 2.65); and γ is the specific weight of water (62.4 psf). The average boundary shear stress produced by the threshold discharge over each assessment reach riffle was computed as described above.

The use of critical shear stress (τ_{ci}) and boundary shear stress (τ_b) methodologies provides a sound approach for estimating the threshold at the riffles studied. Our analysis for this monitoring plan aims to compare

sediment mobility and threshold/ bankfull parameters on LPR. The methodology used for this analysis was derived by Andrews from specific bed-load data sets for streams located in the western United States and therefore may not be directly applicable to LPR. However, it provides an estimate of the expected shear stress required for mobility of coarse, mixed-grain sediments.

For existing conditions, a sediment mobility analysis will be performed LPR as represented in cross sections in the monitoring plan exhibit downstream of the HOGr1-JMT-040 outfall. Bed material measurements will be made of particle sizes on the riffle surface.

The energy slope (friction slope), Sf, for LPR will be estimated for bankfull flow conditions based on field survey measurements. The slope is a critical parameter in determining threshold conditions. The range of slope over an assessment riffle is bound by, 1) the water surface slope over just the riffle feature itself (maximum threshold slope), and 2) the water surface slope from the head of the study riffle to the head of the next riffle downstream (minimum threshold slope), which includes the pool water surface slope immediately downstream of the study riffle. Threshold conditions will typically occur somewhere between the minimum threshold slope and the maximum threshold slope. The sediment mobility analysis is used to determine the specific slope at which threshold conditions are met.

Channel roughness is caused primarily by the roughness of the channel bed. Estimates of Manning roughness coefficient, n, are based on the Limerinos (1970) relation given here as:

$$n = R_h^{1/6} \frac{0.0926}{1.16 + 2\,\mathrm{Log}\frac{R_h}{D_{84riffle}}}$$

Where R_h is the hydraulic radius (feet) and D_{84} (feet) is the particle size for which 84 percent of the particles are smaller based on the pebble count of the riffle surface. As indicated by this relationship, the n value changes with flow conditions. A Wolman pebble counting method (Bunte et al 2001) will be used to describe the surface particle size distribution over the active channel portion of the riffle surface. Particle sizes necessary for roughness estimates ($D_{84riffle}$) and for evaluation of the bed surface mobility $D_{50riffle}$ will be measured through the pebble count analysis.

The average boundary shear stress produced by the bankfull discharge over each riffle was computed as:

$$\tau_b = \gamma\, R\, S_f$$

where τb is the cross section average boundary shear stress (psf) over the riffle, R is the hydraulic radius, and Sf is the bankfull energy slope. Because the channel width-to-depth ratio was much less than 10 (bank resistance considered major at bankfull conditions) and backwater effects on the steep riffles were minor, the average boundary stress was a good approximation for the average stress on the active channel bed.

3.3 Continuous Flow Measurements

Continuous flow measurements will be taken at three locations: one at the outfall of the bioretention (includes discharge from the median bioswales) and two at the receiving LPR stream channel (assessment reach) upstream and downstream of I-70. The objectives of these measurements are to capture peak discharge at each monitoring location. All measurements will be data logged for comparisons for pre- to post-installation measurements.

Additionally, a rain gauge will be established onsite for local rainfall depths and patterns. This will also be data logged and compared with available rainfall data from Baltimore-Washington International Thurgood Marshall (BWI) Airport and/or other local sources of continuously monitored rainfall depths.

A timeline of monitoring activities can be found in Appendix A.

3.4 Monitoring Locations

Measurements will be taken at 3 locations. These locations are defined in

Figure 3 below and in more detail in Monitoring plan schematic in Appendix A. The following is a summary of the locations and type of equipment used at each location:

1. A flow monitoring station will be established upstream of I-70 by recording the stage at the culvert opening by installing a battery powered depth logging sensor. This logger will use a pressure sensor to determine the stage inside the culvert and will be mounted near the culvert bottom. The pressure sensor will be corrected using a suspended pressure sensor used to record barometric pressure changes.
2. This discharge point will be monitored to capture peak discharge of all the treated and untreated discharge before released to the LPR. The discharge will be measured using a pressure sensor
3. A proposed cross section downstream of the I-70 culvert crossing will be chosen at the assessment cross section to measure flow using an area-velocity sensor. This sensor will measure both the depth of flow and average velocity. The surveyed cross section will be used to help back calculate discharge.

Additional Gages

1. A rain gauge will be placed in an unobstructed area near the assessment reach. The rain gauge will be battery powered and capable of logging bucket tips of rates up to 12.7 cm per hour or 5 inches per hour. A storm even that is greater than 5 inches per hour will be recorded but will not be as accurate. A time and date stamp will be provided with each tip to compare data with rainfall records at BWI.
2. A pressure logging device will be placed near the assessment reach to record barometric pressure. The changes in pressure will be used to correct the data collected by the other data loggers. One site will be sufficient for data corrections at all the proposed facilities.

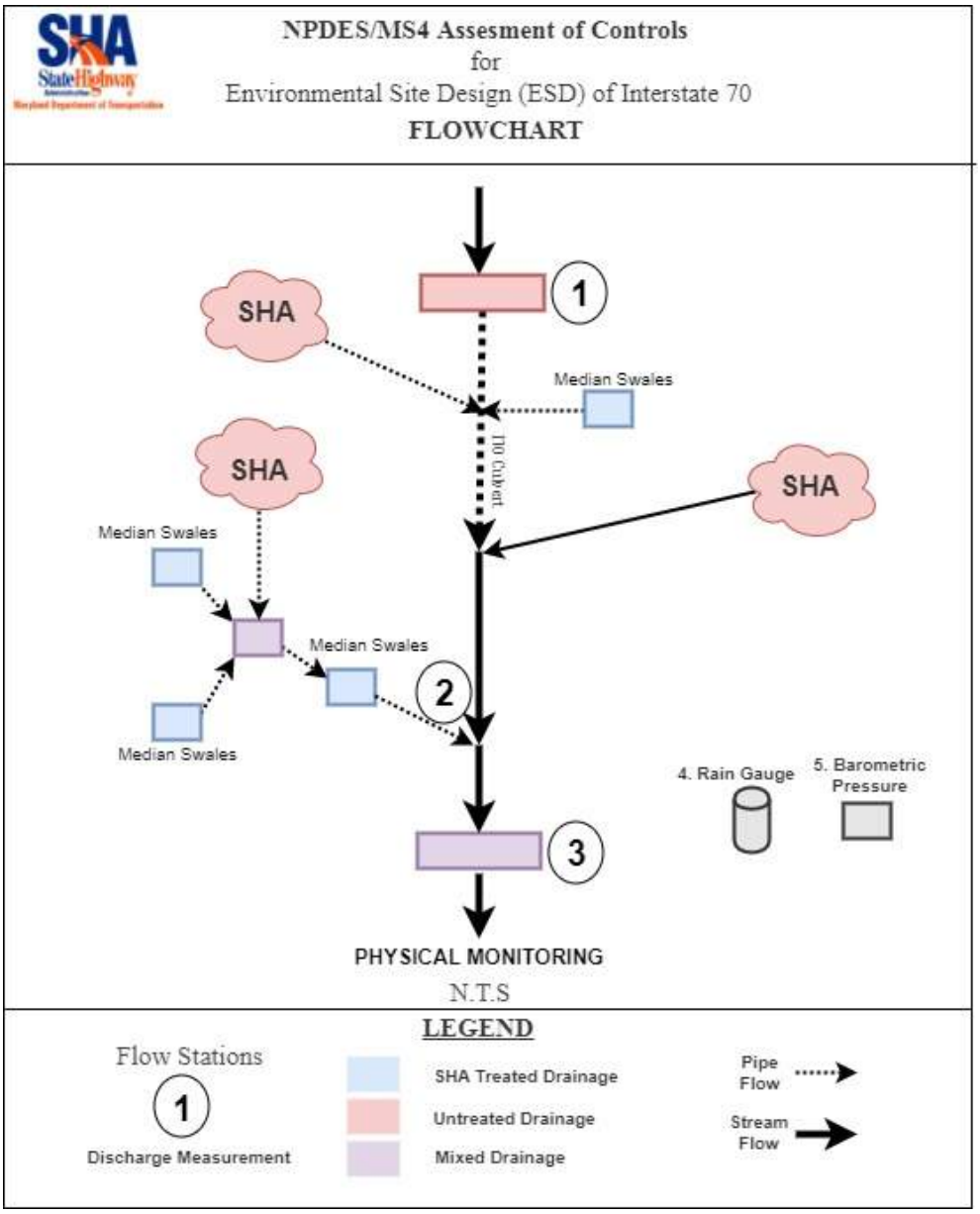


Figure* 3*. Monitoring Plan Flowchart

4 HYDROLOGIC AND HYDRAULIC MODELING

In the final year of monitoring, two models will be developed to validate measurements taken over the monitoring period.

A TR-20 model outlining runoff depths/flows, the structure of controls, reach routing of stream channels, etc., will be developed for the LPR watershed, stream channel and the two ESD facilities. Rainfall data collected on site will be compared to NOAA Atlas 14 hyetographs to simulate true hydrologic conditions. It is anticipated this will require several iterations to mimic measured data through a calibration effort.

A HEC RAS model will also be developed utilizing the MDFloodmaps.net data. MDE has a model established for LPR in this location. Since that data is georeferenced, more resolute data will be added as needed.

Results of both hydrologic and hydraulic modeling with comparisons to field collected data will be compiled into the monitoring plan report.

5 FIELD DOCUMENTATION

5.1 Field Data Collection Forms

For all mobilizations, field logbooks will be maintained, serving as a record of observations during collection activities. Pages will be numbered sequentially and entries will include:

- *Names of the field crew*
- *Sampling/Study location*
- *Date and time of data collection*
- *Reason for visit*
- *Data Location identification numbers*
- *Weather Conditions*
- *Physical Conditions*
- *Issues encountered*
- *Other observations*

Some of the data collection activities will require specific forms to be filled out. These activities include cross-sectional survey, bank profiles, longitudinal profile, and Wolman Pebble count. All the field forms can be found in Appendix E. All other observations and notes will be kept in field log books and data loggers. All handwritten notes and collected data will be saved and backed up on a server.

5.2 Documentation

All data collected at mobilization, whether for channel geometry or flow measurements, will be documented in a single log book. After each data collection event the new log pages will be photo copied for redundancy. In addition to hand written notes from each field visit as noted in section 5.1, data from loggers and other field equipment will be uploaded to, stored, and backed on computers.

Pressure data loggers will store the following data:

1. Date and time stamp
2. Pressure reading
3. Temperature Reading
4. Date collected
5. Battery

The rainfall data logger will store the following data:

1. Date and time stamp for each tip (0.01 inches per tip)

The area-velocity sensor will store the following data:

1. Date and time stamp

2. Level reading
3. Average velocity reading
4. Flow rate
5. Total flow
6. Input voltage
7. Temperature

A total station will be used to collect survey data for the channel stability assessment. The longitudinal profile and cross section data will be recorded by the total station and uploaded to a computer for analysis. Records of the raw data files will be kept separate from the analysis.

When necessary field notes will be kept for logging maintenance issues such as re-calibration, battery swaps, and other equipment malfunctions and errors. Detailed notes will be kept on the date and time, weather conditions, observations, sketches, issues encountered and what was done to remedy the situation. These notes will generally coincide with data collection notes but as necessary may occur more frequently.

6 DATA QUALITY OBJECTIVES AND REQUIREMENTS

A comprehensive and integrated QA program includes planning, control, assessment, reporting, and correction activities to ensure the quality of the data collected. Quality control will occur during after data collection and analysis. There should not be any uncertainty about the data that is being collected from the field from either survey measurements or from instrumentation.

The overall goal of the QA/QC procedures ensures that the data collected are complete, representative, comparable, and of known quality. A major component of the field QA/QC process will be collection and analysis of field duplicates.

All hand notes taken in the field book will be copied the same day that it is transcribed and stored on a backed-up server. To provide quality control the data will be entered into spreadsheets and plotted as needed. The plotted data will be verified first through visual inspection. Cross sections, pebble counts and longitudinal profiles will be plotted and can be quickly checked visually for accuracy. In addition to plots, an audit will be performed by checking random data entries to verify that the data was transcribed correctly. Additionally, the field procedures, as layed out below, have QC checks built into the data collection. For example, when collecting cross sectional data, a surveyor and recorder will check each other's work while during and after collection to ensure that the quality and integrity of the data remains intact.

For data that is uploaded to logging devices, the logs and data will be inspected for accuracy. Data anomalies may occur in the data that indicate low battery, clogged sensors and malfunctioning equipment. This data can be easily checked by having a designated person, in addition to the collection team, check the data at each collection. Data trends and outliers can be observed and vetted quickly through proper vendor training and experience with collection equipment.

6.1 Field Procedures and Quality Control

The data collection of cross sections and channel slopes for the physical monitoring will be done in accordance to the following procedures:

6.1.1 Cross-sections

1. Within the monitoring reach, choose a representative riffle area to install cross sections. The areas should be free from anthropogenic alterations and should reflect the local geology and stream geomorphology. The riffle should represent normal flow conditions representative of the monitoring reach.
2. Install and label rebar monuments with survey caps. Monuments should be located far enough away from the top of banks to prevent them from being lost to bank erosion. Monuments will be georeferenced and flagged. The GPS coordinates will be recorded on the cross-section data sheet.
3. Setup a laser level or other surveying equipment in a location so that the entire cross section can be viewed. The instrument should be placed at a location higher than the highest point. In the cross section.
4. Stretch a tape across the channel perpendicular to flow and starting at 0 on the left bank facing downstream. Both ends should be secured above the bank pins and the line should be taught. If a longitudinal profile is being done, then record the station where the cross section intersects the longitudinal profile in the cross-section data sheet.
5. Starting on the left bank, survey the top of pin then begin collecting ground points starting adjacent to the bank pin. Once each elevation is determined the station and elevation will be called out to a recorder. Elevation data will be recorded in hundredths of feet.
6. Continue surveying the cross section by obtaining readings at major breaks in slope and bed elevation. Typically, key features such as top of bank left/right, left/right bankfull, left/right edge of water, and thalweg are collected at each cross section. Other areas of interest may include significant depositional areas or areas with noticeable erosion and scour.
7. In the occurrence that banks are undercut or slumping, the survey rod and measuring rod or tape can be used to capture the data. The survey rod is held vertically in a location close enough to the bank to capture all the bank points with the measuring rod. The location of the survey rod in reference to the cross-section station will be recorded. A reading at will be taken at slope changes along the bank by measuring horizontally from the survey road and recording a height and length from the survey rod. A sketch should be recorded depicting the shape and other features of the bank.
8. At the end of the cross section, record the right top of pin elevation making sure to record that data point as top of pin.
9. Take photographs of the cross section and record the photo number and location info on the data sheet.
10. Once the data has been recorded, the rod man will perform a QC check on all of the data sheets. Any error will be crossed out with a single line and signed with the correctors initials.
11. Upon arriving back at the office, the cross-section data will be plotted and visually inspected for data anomalies. Any data inconsistencies will be checked against the log book and photographs. Errant data should be removed from the data collection and noted.

6.1.1 Longitudinal Profile

1. A stream reach will be chosen starting upstream of the cross-section location and will extend downstream from the cross-section. The longitudinal profile should start in a pool upstream and end in a pool section downstream to gather data for the full riffle. Typically, longitudinal profiles extend anywhere from 100 to 300 feet in length.
2. Starting downstream, lay the survey tape along the thalweg of the channel so that the downstream end starts at 0 and increases as you move upstream.
3. Place the survey instrument in a location where the downstream end of the tape can be viewed and as far upstream as possible without any view obstructions.

4. Starting downstream, record the thalweg station and elevation points by calling out values to a recorder. Elevation points will be recorded to the hundredth foot. In addition to ground points the water surface elevation will also be recorded. In areas of low velocity, the rod may be used to record water elevations.
5. The rod man will continue upstream capturing breaks in slope in the thalweg and identifying features that would alter the channel slope. Features such as riffle, run, glide and pool should be called out to the recorder.
6. Upon completion, the rod man will perform a QC data check of the recorded data. Any data anomalies that are found will be crossed out with a single line and initialed by the corrector. The data will then be plotted on a chart for visual inspection as soon as possible. Any errant data that is found upon return from the field will be discarded.

6.1.2 Wolman Pebble Count

The Wolman Pebble count method will be used in this monitoring study (Wolman 1954). Two people will be required for this procedure. One person will record while the other will take samples and counts. The recorder will tally the counts on the data sheet according the pebble size as dictated by the Wolman Pebble Count method. Tallying each count helps to visualize the distribution as it forms. As the tally visually converges close to a normal distribution then the count is finished. This method serves as a QC method to ensure that you have collected sufficient data.

Once back from the field the pebble count data will be plotted and entered into a spreadsheet and the final QC will be performed by checking the count data and charts for data inconsistencies.

7 SCHEDULE FOR MONITORING PROGRAM IMPLEMENTATION

A summary of tasks and a schedule for physical monitoring and analysis is provided. Please find the GANTT chart and project timeline outlining dates and durations for all monitoring phases in Appendix A.

8 DATA ANALYSIS

To meet the primary goals of this plan, an in-depth analysis of the data collected will be done to investigate causal relationships between the measured data.

The measured parameters identified as variables in this problem are the following:

- Peak Discharge (Total Watershed)
- Peak Discharge for BMP's
- Total Volume runoff (Total Watershed)
- Total Volume Runoff from BMP's
- Rainfall Intensity
- Rainfall Totals
- Cross Section survey
- Longitudinal Profile
- Water Temperature

Other variables that may be considered are as follows:

- Frequency of bankfull discharge
- Freeze thaw days
- Changes in development

- BMP functionality from BMP inspection reports

The Analysis will attempt to address the questions in Section 1 of this report using the following approaches and key indicators.

Will the peak discharge coming from controlled catchments be reduced once controls have been implemented?

Peak Discharges from the controlled catchments will be compared pre- and post-construction to identify whether the controls have been reducing the peak discharges. To compare the peak discharges from storms of various magnitude and length of time, the peak discharges will be normalized using the rainfall totals for each respective storm. The hydrologic response to the storm will be isolated by subtracting the baseflow, flow just prior to the rising limb of the runoff, from the peak discharge. Key indicators include peak discharge, rainfall totals, return interval, impervious area treated

Will there be geomorphological response to the Little Patuxent River once controls are in place?

The geomorphologic response to each storm will be measured by comparing the peak discharges, rainfall totals and change in cross sectional area. The peak discharges will be normalized to rainfall totals and the hydrologic response will be isolated similar to the controlled catchment method. Key indicators include, rainfall totals, return interval of storm, changes in cross sectional data and changes in longitudinal slope.

What are the thresholds for stream stability and do the catchment controls improve stream stability through peak discharge attenuation?

A comparison of stream runoff at a point upstream and downstream of the controlled catchment from pre- and post-conditions will be compared to identify whether the controls have decreased peak discharges. Key indicators include peak discharge, rainfall total, peak discharges from controlled catchments and baseflow conditions (pre-storm).

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Appendix A

Monitoring Plan and Schedule

MARYLAND DEPARTMENT OF TRANSPORTATION™

STATE HIGHWAY ADMINISTRATION

HOWARD CO. BIOSWALE B

HOWARD CO. MICROBIORETENTION

HOWARD CO. BIOSWALE A

BIO SWALE C

BIO SWALE B

BIO SWALE A

BIORETENTION HO Gr1-JMT-040

GRASS SWALE B

GRASS SWALE A

FLOW

FLOW

FLOW

FLOW

1. LITTLE PATUXENT UPSTREAM I-70 DISCHARGE MEASUREMENT

2. SHA ROW OUTFALL DISCHARGE MEASUREMENT

3. LITTLE PATUXENT DOWNSTREAM I-70 DISCHARGE MEASUREMENT

MONITORING REACH

Marriottsville Rd

N

0 50 100 200 300 400 Feet

Legend

- Property Outline
- Facility Drainage Areas
- Physical Monitoring Location
- SHA Drainage Structures
- SHA Drainage Conveyance
- Little Patuxent River
- Howard County Facilities
- Proposed Swales

MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

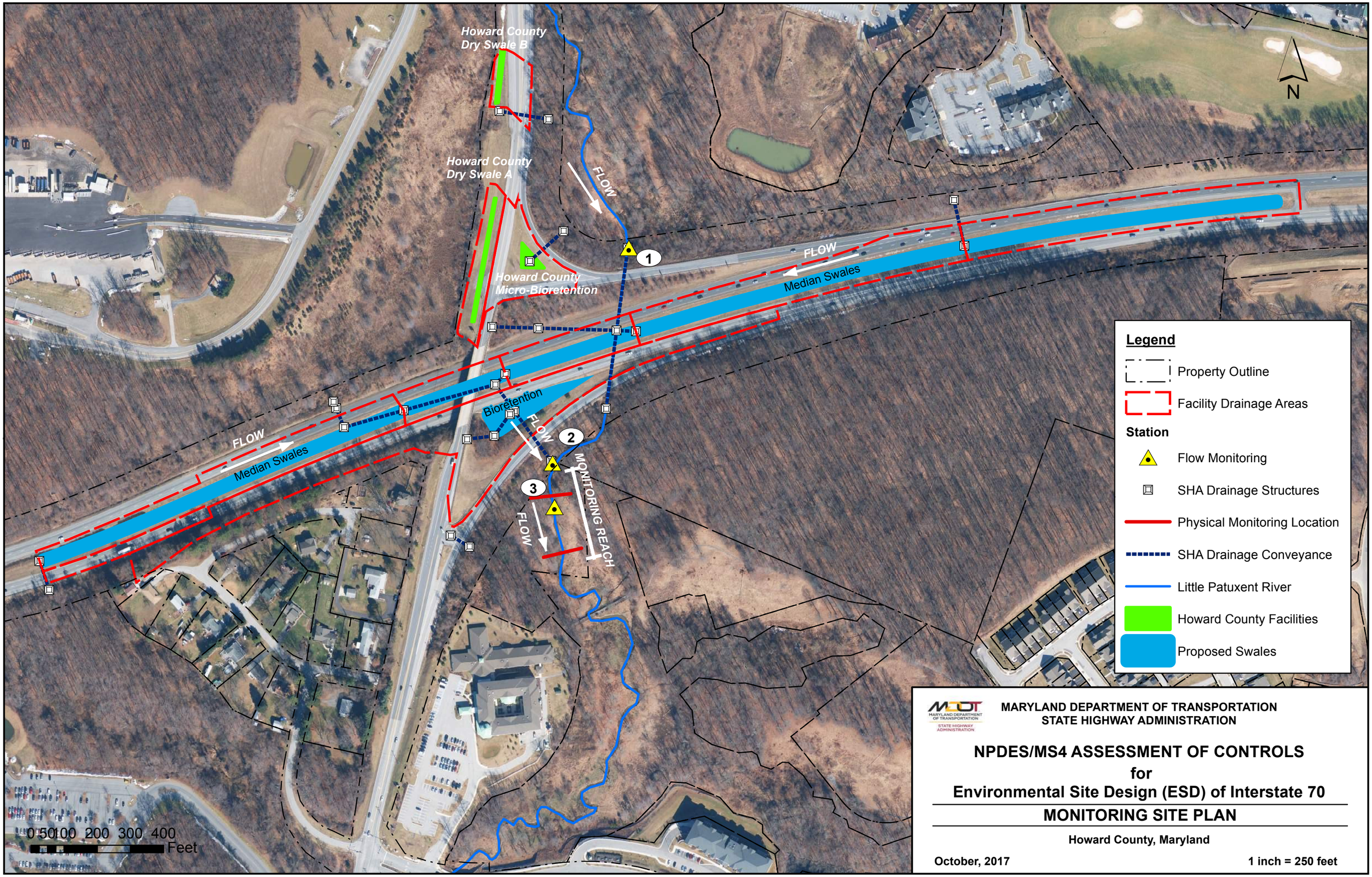
NPDES/MS4 ASSESSMENT OF CONTROLS for Environmental Site Design (ESD) of Interstate 70

MONITORING SITE PLAN - SCHEMATIC

Howard County, Maryland

October, 2017

1 inch = 250 feet



MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

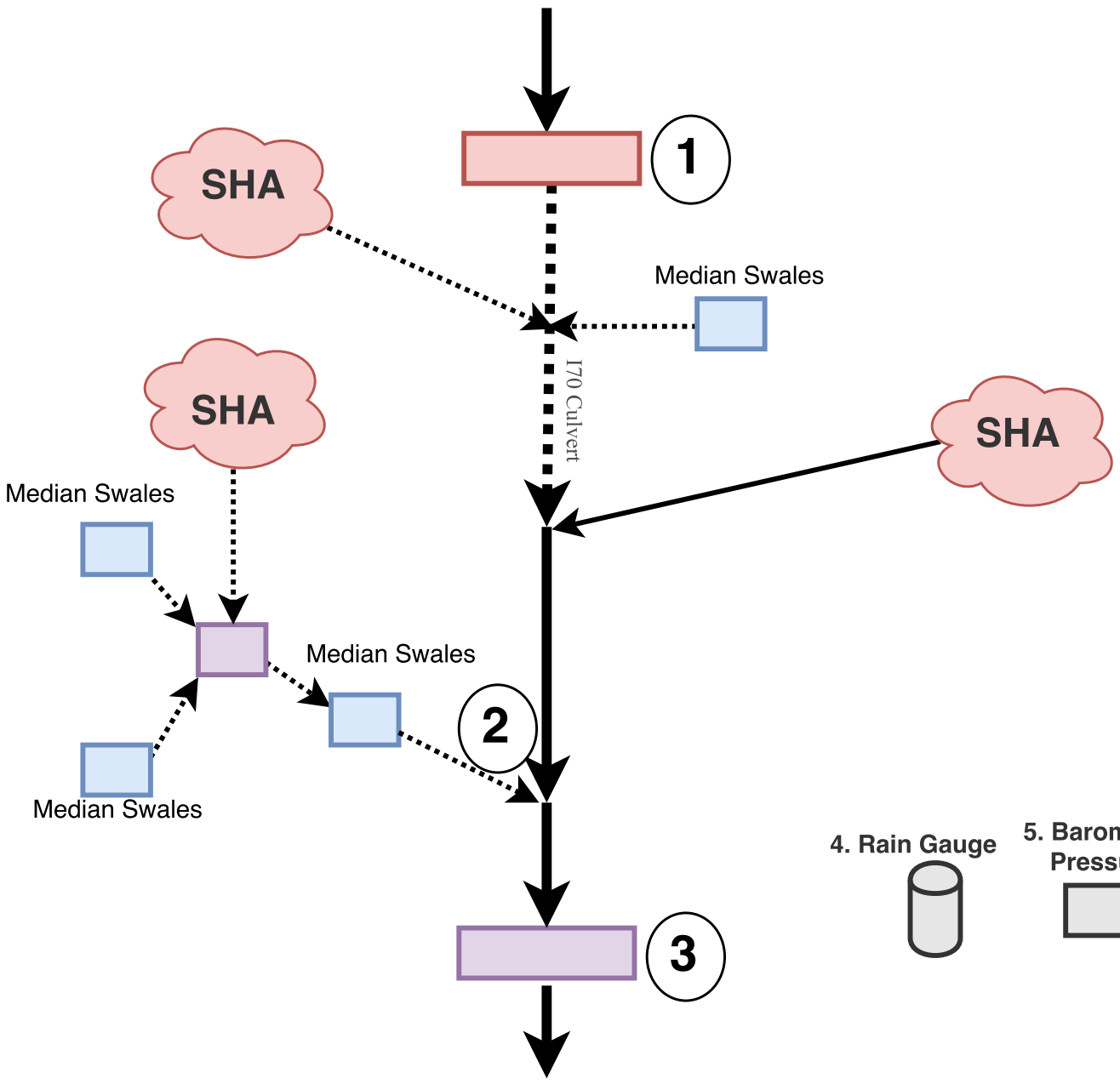
NPDES/MS4 ASSESSMENT OF CONTROLS
for
Environmental Site Design (ESD) of Interstate 70

MONITORING SITE PLAN

Howard County, Maryland

October, 2017 **1 inch = 250 feet**

NPDES/MS4 Assesment of Controls
for
Environmental Site Design (ESD) of Interstate 70
FLOWCHART



N.T.S

LEGEND

Flow Stations

1

Discharge Measurement

SHA Treated Drainage

Untreated Drainage

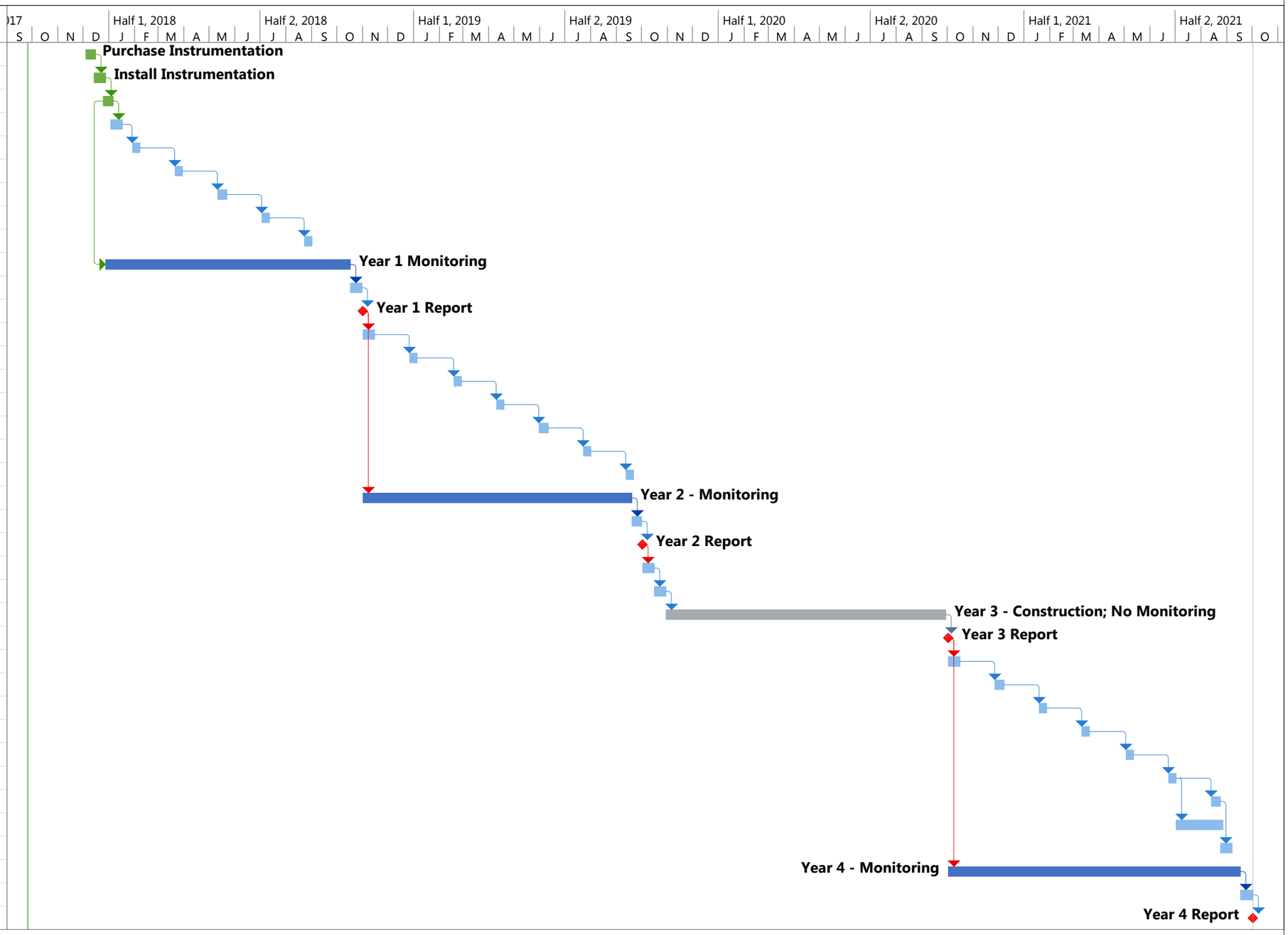
Mixed Drainage

Pipe Flow

Stream Flow

ESD Assessment of Controls - Project Timeline

ID	Task Name	Duration	Start
1	Purchase Instrumentation	10 days	Mon 12/4/17
2	Install Instrumentation	10 days	Thu 12/14/17
3	Calibrate and Test Equipment	10 days	Mon 12/25/17
4	Sediment Mobility Analysis	10 days	Wed 1/3/18
5	Year 1 - Data Collection and Maintenance	7 days	Mon 1/29/18
6	Year 1 - Data Collection and Maintenance	7 days	Wed 3/21/18
7	Year 1 - Data Collection and Maintenance	7 days	Fri 5/11/18
8	Year 1 - Data Collection and Maintenance	7 days	Tue 7/3/18
9	Year 1 - Data Collection and Maintenance	7 days	Thu 8/23/18
10	Year 1 Monitoring	209 days	Thu 12/28/17
11	Year 1 - Monitoring Report Update	10 days	Wed 10/17/18
12	Year 1 Report	0 days	Wed 10/31/18
13	Year 2 - Sediment Mobility Analysis	10 days	Thu 11/1/18
14	Year 2 - Data Collection and Maintenance	7 days	Thu 12/27/18
15	Year 2 - Data Collection and Maintenance	7 days	Mon 2/18/19
16	Year 2 - Data Collection and Maintenance	7 days	Wed 4/10/19
17	Year 2 - Data Collection and Maintenance	7 days	Fri 5/31/19
18	Year 2 - Data Collection and Maintenance	7 days	Tue 7/23/19
19	Year 2 - Data Collection and Maintenance	7 days	Thu 9/12/19
20	Year 2 - Monitoring	230 days	Thu 11/1/18
21	Year 2 - Monitoring Report Update	8 days	Thu 9/19/19
22	Year 2 Report	0 days	Tue 10/1/19
23	Year 2 Sediment Mobility Analysis	10 days	Wed 10/2/19
24	Year 3 - Monitoring Report Update	10 days	Wed 10/16/19
25	Year 3 - Construction; No Monitoring	239 days	Wed 10/30/19
26	Year 3 Report	0 days	Thu 10/1/20
27	Year 4 Sediment Mobility Analysis	10 days	Fri 10/2/20
28	Year 4 - Data Collection and Maintenance	7 days	Fri 11/27/20
29	Year 4 - Data Collection and Maintenance	7 days	Tue 1/19/21
30	Year 4 - Data Collection and Maintenance	7 days	Thu 3/11/21
31	Year 4 - Data Collection and Maintenance	7 days	Mon 5/3/21
32	Year 4 - Data Collection and Maintenance	7 days	Wed 6/23/21
33	Year 4 - Data Collection and Maintenance	7 days	Fri 8/13/21
34	Hydrologic and Hydraulic Modeling	40 days	Fri 7/2/21
35	Final Data Analysis	10 days	Tue 8/24/21
36	Year 4 - Monitoring	250 days	Fri 10/2/20
37	Year 4 - Final Monitoring Plan Update	11 days	Fri 9/17/21
38	Year 4 Report	0 days	Fri 10/1/21

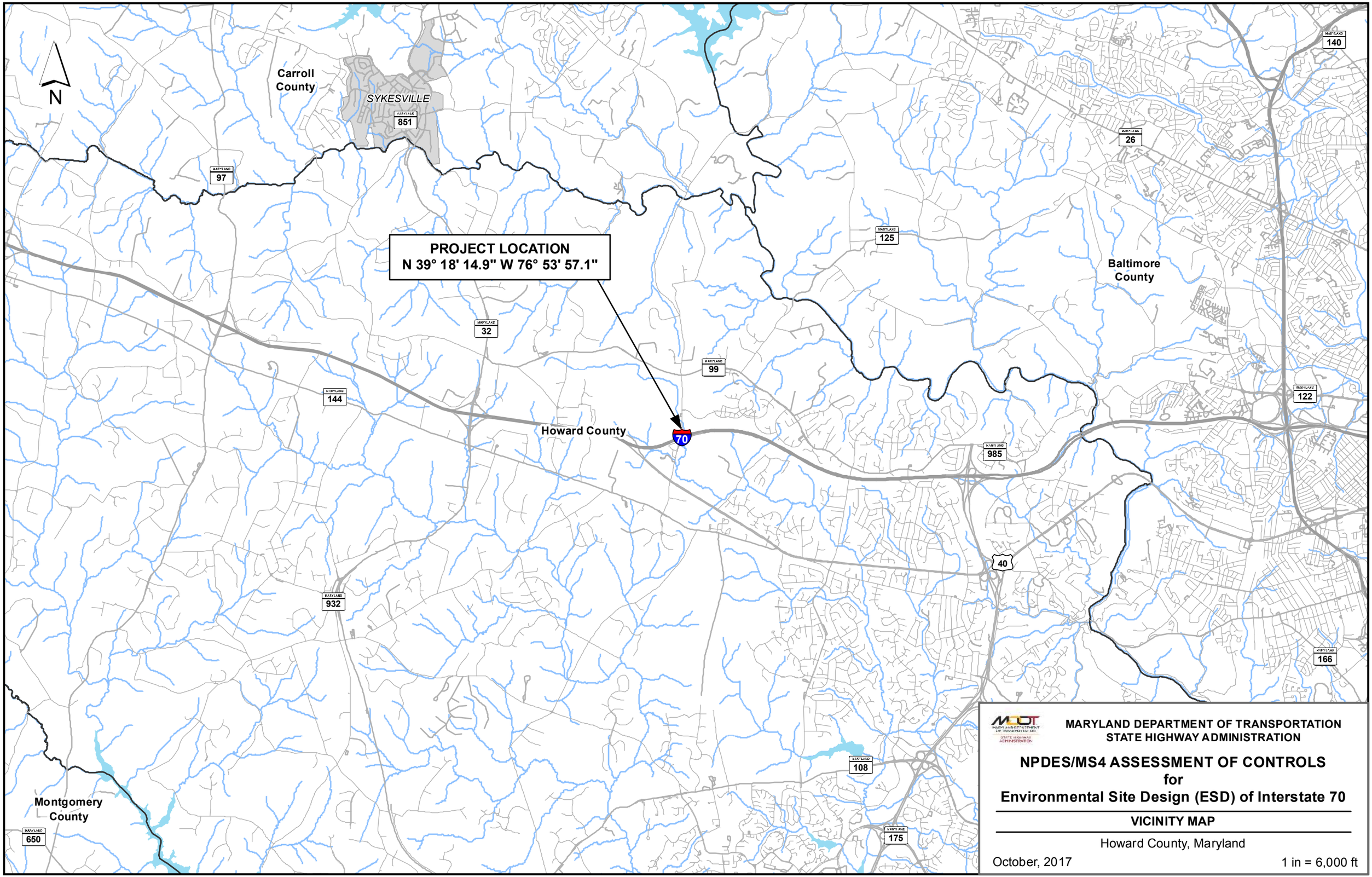


Appendix B

Little Patuxent River Watershed Mapping

MARYLAND DEPARTMENT OF TRANSPORTATION™

STATE HIGHWAY ADMINISTRATION



MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

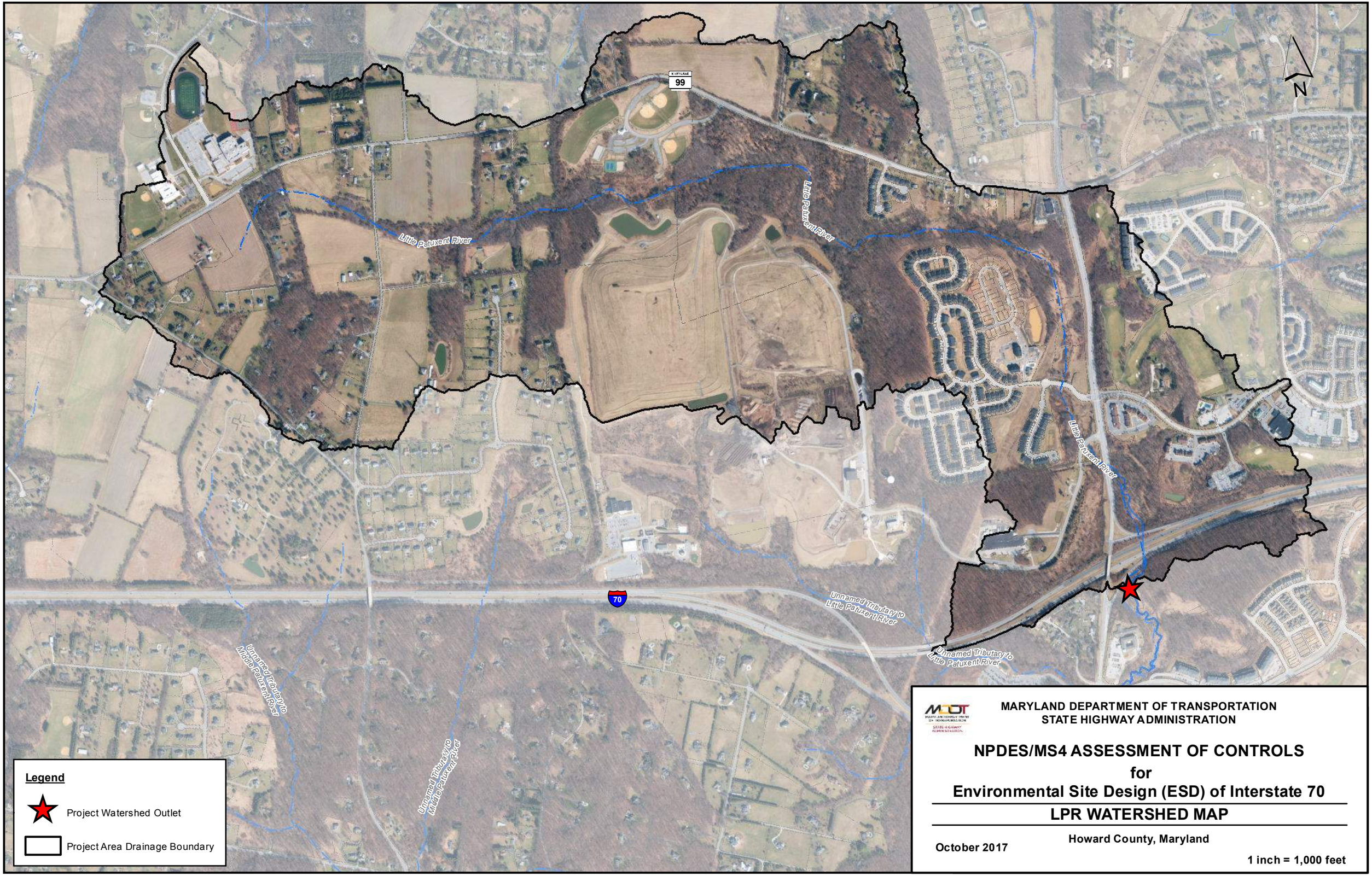
NPDES/MS4 ASSESSMENT OF CONTROLS for Environmental Site Design (ESD) of Interstate 70

VICINITY MAP

Howard County, Maryland

October, 2017

1 in = 6,000 ft



MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

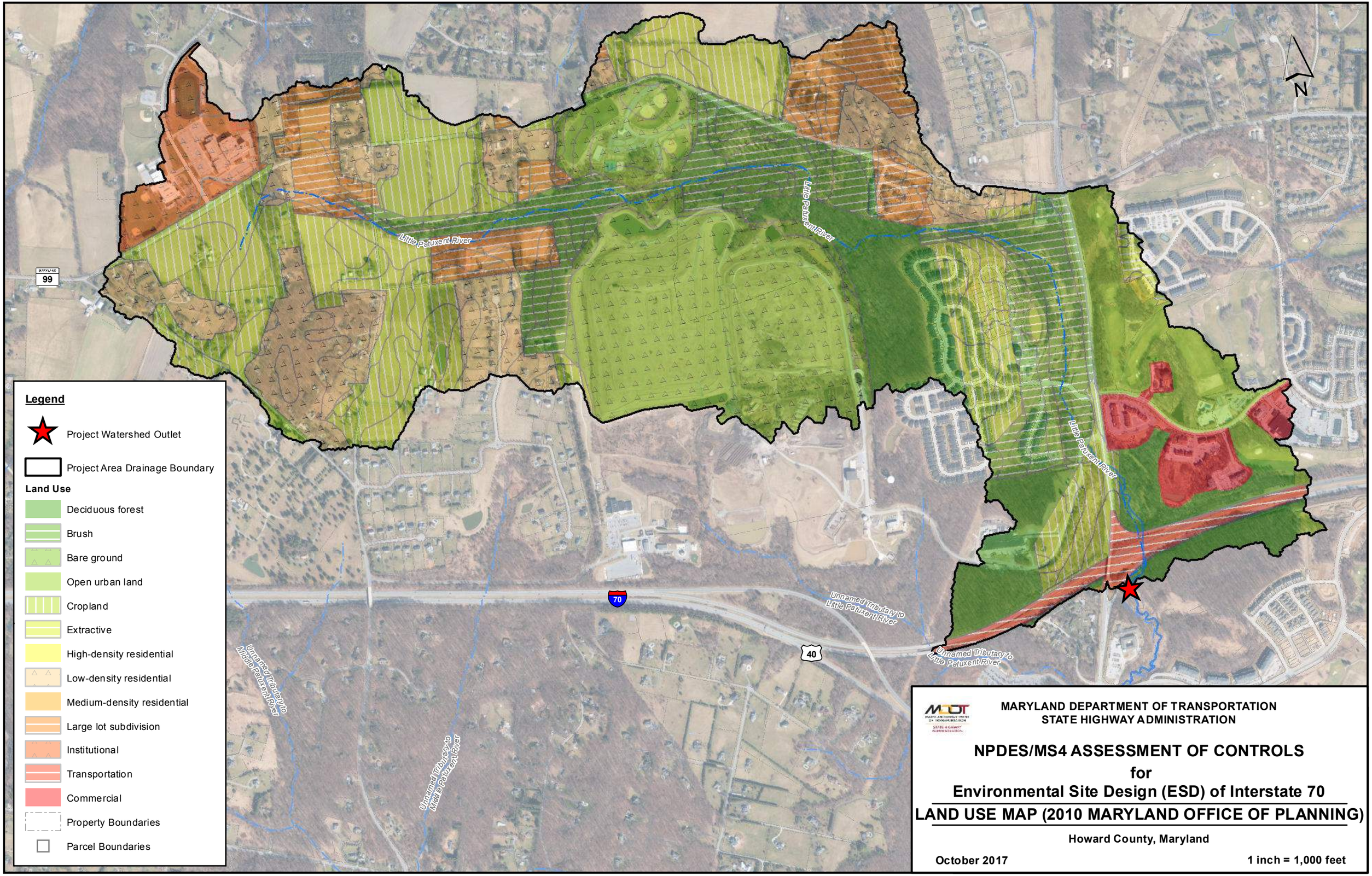
NPDES/MS4 ASSESSMENT OF CONTROLS
for
Environmental Site Design (ESD) of Interstate 70

LPR WATERSHED MAP

Howard County, Maryland

October 2017

1 inch = 1,000 feet



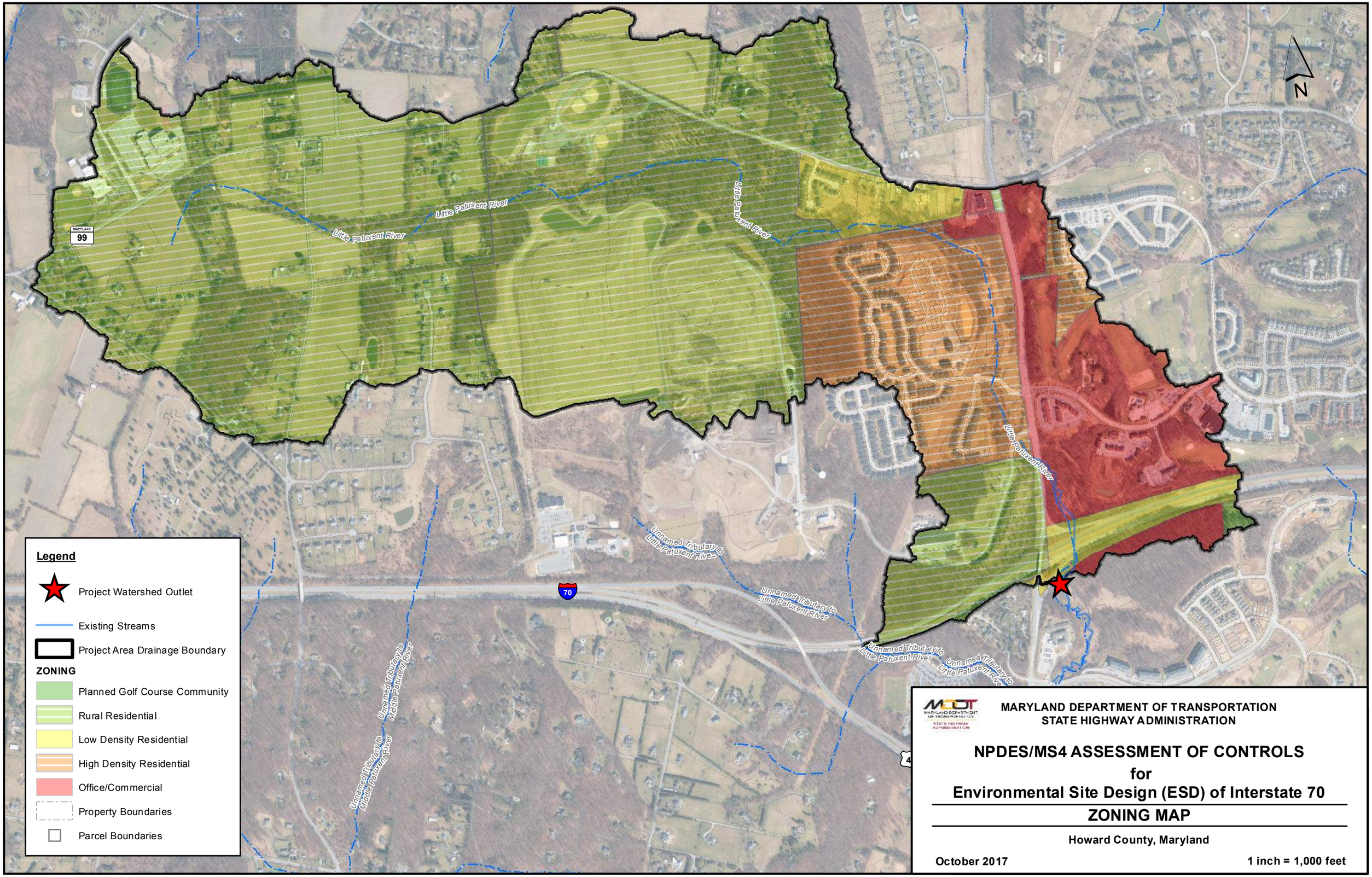
MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

NPDES/MS4 ASSESSMENT OF CONTROLS
for
Environmental Site Design (ESD) of Interstate 70
LAND USE MAP (2010 MARYLAND OFFICE OF PLANNING)

Howard County, Maryland

October 2017

1 inch = 1,000 feet



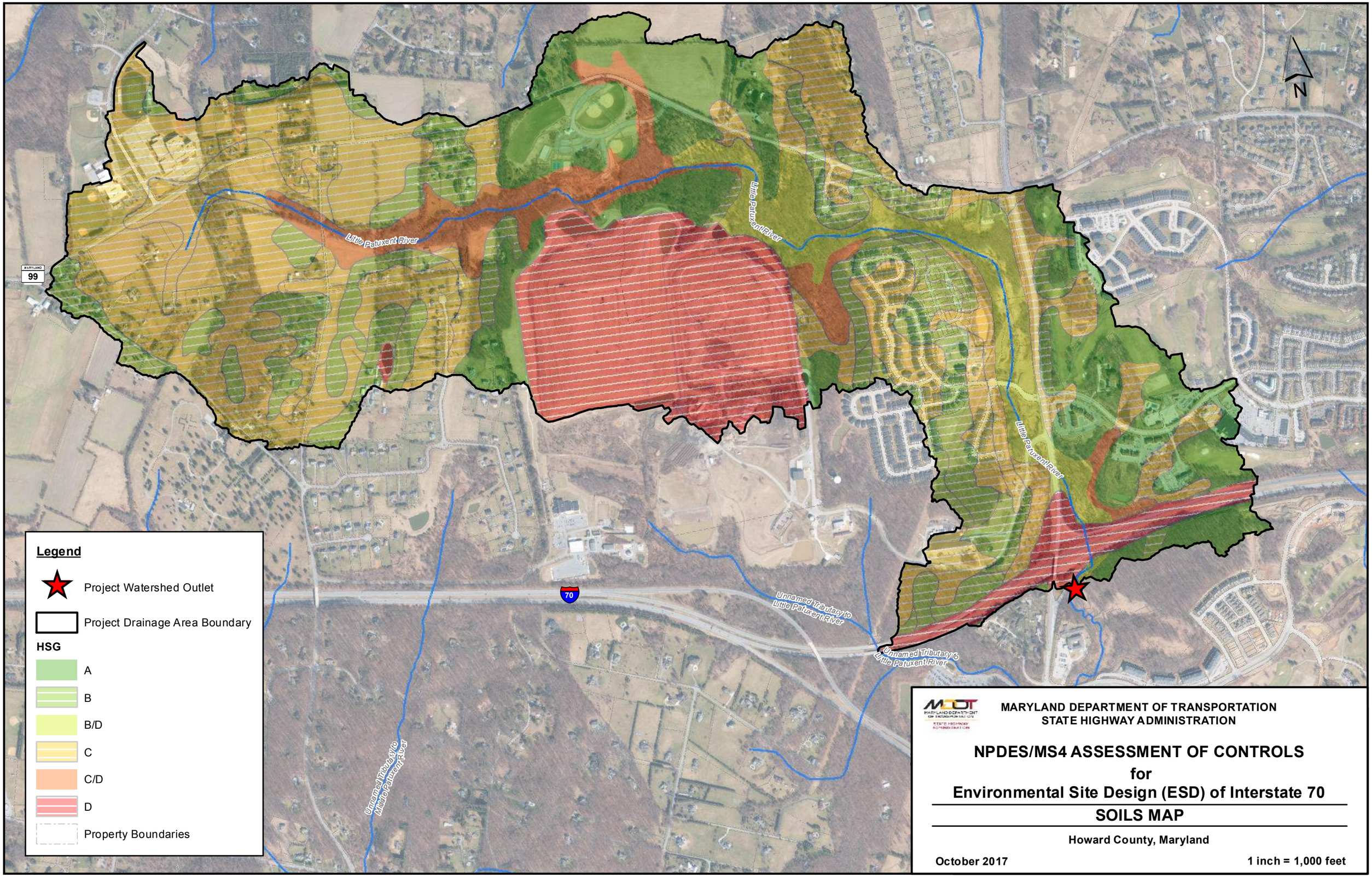
MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

NPDES/MS4 ASSESSMENT OF CONTROLS
for
Environmental Site Design (ESD) of Interstate 70

ZONING MAP

Howard County, Maryland

October 2017 **1 inch = 1,000 feet**



MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

NPDES/MS4 ASSESSMENT OF CONTROLS
for
Environmental Site Design (ESD) of Interstate 70

SOILS MAP

Howard County, Maryland

October 2017 **1 inch = 1,000 feet**

N

70

40

Legend

- Project Watershed Outlet
- Existing Grass Swales

SHA Tree Plantings

- Active Maintenance Contract
- Project Drainage Area Boundary

MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

NPDES / MS4 ASSESSMENT OF CONTROLS
for
Environmental Site Design (ESD) of Interstate 70

SHA TMDL EFFORTS

Howard County, Maryland

August 31, 2016

1 inch = 650 feet

Legend

Project Watershed Outlet

Project Drainage Area

Property Boundary

Classification

- Alpha Ridge Park
- Forest Conservation
- Golf Course
- Government and Institutional
- Landfill
- Parks, Open Space and Recreation
- Planned SHA
- Post2011
- Pre-2011 Commercial
- Pre-2011 HOA
- Pre-2011 Individual
- School
- Transportation
- Transportation, Communications and Utilities

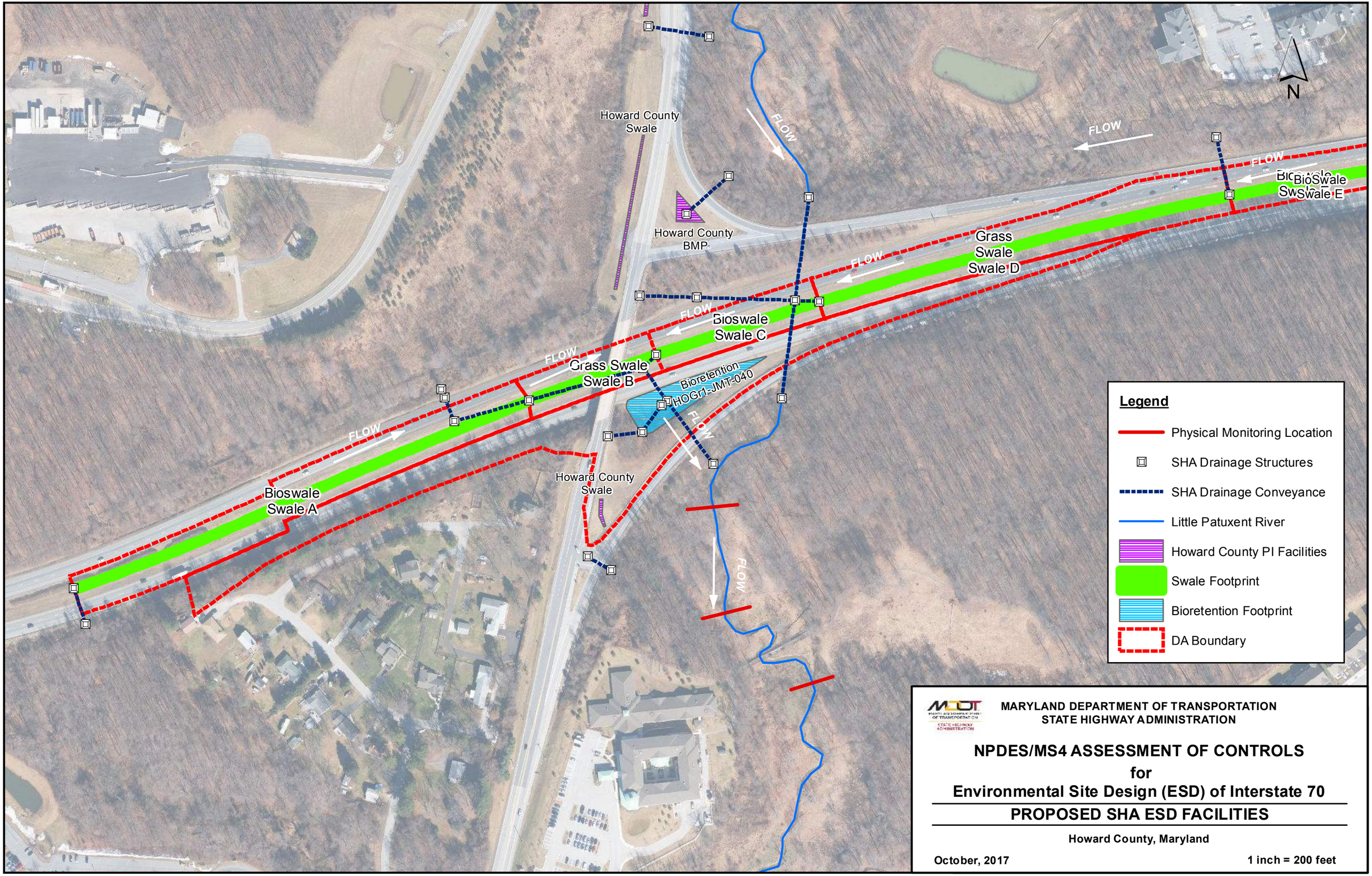
MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

NPDES/MS4 ASSESSMENT OF CONTROLS
for
Environmental Site Design (ESD) of Interstate 70
WATERSHED APPROACH - CLASSIFICATION MAP

Howard County, Maryland

October 2017

1 inch = 1,000 feet



MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

NPDES/MS4 ASSESSMENT OF CONTROLS for Environmental Site Design (ESD) of Interstate 70

PROPOSED SHA ESD FACILITIES

Howard County, Maryland

October, 2017

1 inch = 200 feet

Appendix C

Preliminary ESD Design Reports

MARYLAND DEPARTMENT OF TRANSPORTATION

STATE HIGHWAY ADMINISTRATION

SHA Water Programs Division
SWM New BMPs Planning Task
Howard County Group 1

CONCEPT DESIGN REPORT
SITE HOGr1-JMT-040

Prepared By: Johnson, Mirmiran and Thompson, Inc
May 2016

CONTENTS

1 Introduction
2 Vicinity Map
3 Concept Design Summary
4 Drainage Area Map
5 Hydrologic Computations
6 BMP Plan
7 BMP Design Computations
8 Construction Cost Estimate
9 FI Report

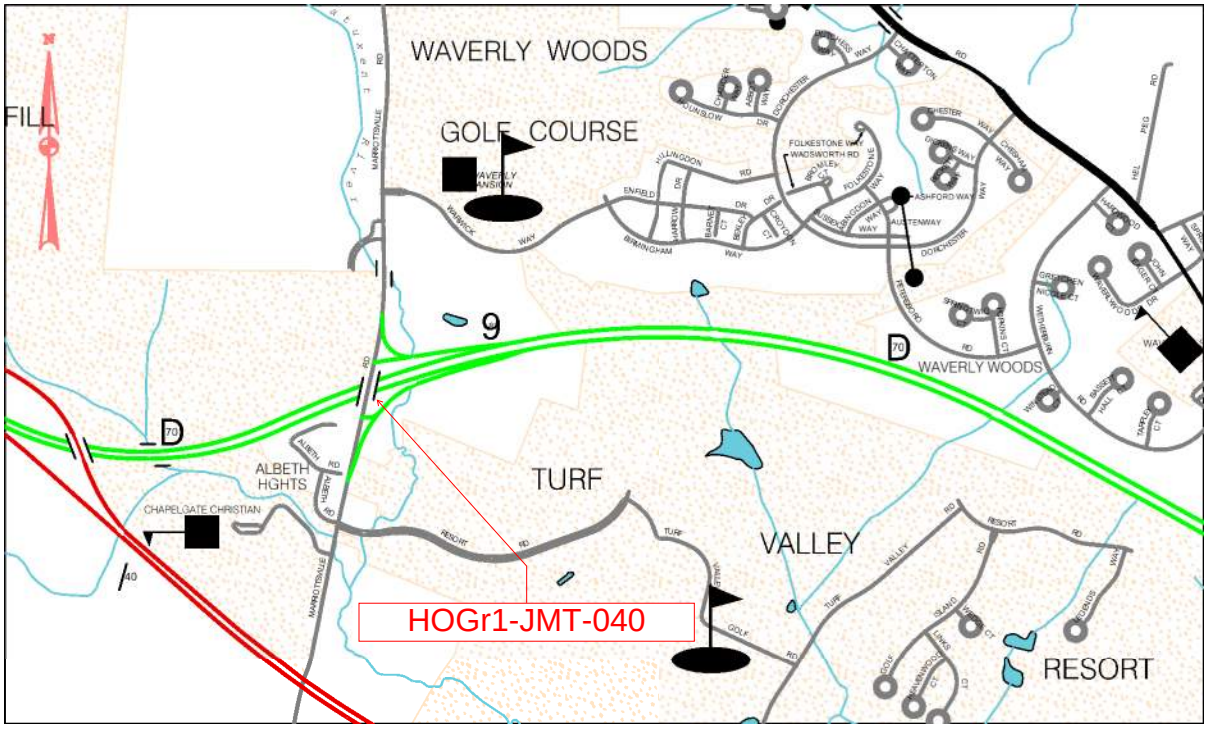
Section 1: INTRODUCTION

The Maryland State Highway Administration (SHA) is committed to meeting the requirements of the Chesapeake Bay through compliance with the requirements established in *Maryland's Watershed Implementation Plan for the Chesapeake Bay Total Maximum Daily Load* (WIP). Coverage under the Regulated Urban Stormwater sector includes both Phase I and Phase II National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) stormwater discharge permit for the SHA roadway network and maintenance facilities that have associated industrial stormwater discharge. SHA maintains MS4 permit coverage for the SHA roadway storm drain systems in the 11 Maryland TMDL counties holding MS4 permits.

SHA is required to bring Maryland highways into compliance with the Maryland WIP, the NPDES MS 4 Phase I and II permits, and local TMDLs by implementing stormwater and environmental best management practices (BMPs).

A key strategy of the SHA TMDL program is to install new qualitative stormwater management facilities to provide treatment for currently untreated SHA-owned impervious areas. As part of this program, Johnson, Mirmiran and Thompson, Inc. has been contracted by SHA to identify and analyze potential sites within Howard County to host these new BMPs. This report presents the results of the planning task to identify & investigate the potential to construct, and prepare concept level design for, a new BMP to treat existing untreated, SHA-owned impervious area at site HOGr1-JMT-040.

Section 2: Vicinity Map



Site Vicinity Map
Scale: 1”=2,000’

Section 3: Concept Design Summary

SHA Water Programs Division
SWM New BMPs Planning Task

CONCEPT DESIGN SUMMARY

SITE INFO:

HOWARD COUNTY, MARYLAND

SITE NUMBER: HOGr1-JMT-040 WATERSHED ID: 2131105

**** There IS a local TMDL requirement for this watershed.***

BMP INFO:

PROPOSED BMP TYPE: Bioretention BMP CLASS: RR

RUNOFF STORAGE VOLUME	PE TREATED	IMPERVIOUS AREA CREDIT
11097 CUBIC FEET	2.09 INCHES	1.82 ACRES

POLLUTANT LOAD REDUCTION ACHIEVED	Total Nitrogen (TN)	Total Phosphorus (TP)	Total Suspended Solids (TSS)
Pollutant Removal Rate	**70%**	**81%**	**87%**
Pollutant Load to BMP (lb/year)	**43.91**	**3.29**	**0.77**
EOS Pollutant Load Removal (lb/year)	**30.92**	**2.67**	**0.67**
DEL Pollutant Load Removal (lb/year)	**18.42**	**1.47**	**0.54**

HYDROLOGIC PARAMETERS:	*ADDITIONAL DESIGN CONSIDERATIONS:*
Drainage Area to BMP - 3.47 acres	**Estimated Project Limit of Disturbance - 0.78 acres**
SHA-Owned Impervious Area to BMP - 1.43 acres	
Total Impervious Area to BMP (ac) - 1.43 acres	*** There is NO additional Runoff Diverted to this Site Under Proposed Conditions.**

Overall Site Photo

Consultant Comments

The proposed access road was relocated to be accessed southwest of the facility and is proposed through the existing trees per direction from OED/WPD/MP. Tree removal will be required. The existing inlet is proposed to be removed and replaced with inlet I-2 with a top elevation of 457. The pretreament storage volume lower than the surface of the main body of the facility is not counted towards the overall treatment volume provided.

Section 4: Drainage Area Map

DRAINAGE AREA TO BMP
POST-DEVELOPMENT
WARFIELD CREEK
WARFIELDS RIDGE RD
WARFIELDS RIDGE RD
WARFIELDS RIDGE RD

Section 5: Hydrologic Computations

WinTR-55 Current Data Description

--- Identification Data ---

User: SMH
Project: HOCO Site Searches
SubTitle: HOGr1-JMT-040
State: Maryland
County: Howard NOAA_Atlas_14
Filename: Q:\SMD\100173_001_TMDL_SWM_Site_Search\Working Data\Concept Design\Computations\TR-55\WinTR55\H

Date: 5/16/2016
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Da to BMP	Drainage area to BMP 040 Outlet		3.46	87	.313

Total area: 3.46 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.21	4.12	4.93	6.17	7.27	8.52	2.65

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

HOCO Site Searches
HOGr1-JMT-040
Howard NOAA_Atlas_14 County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.21	4.12	4.93	6.17	7.27	8.52	2.65

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SMH

HOCO Site Searches
HOGr1-JMT-040
Howard NOAA_Atlas_14 County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
Da to BMP	3.46	0.313	87	Outlet	Drainage area to BMP 040

Total Area: 3.46 (ac)

HOCO Site Searches
HOGr1-JMT-040
Howard NOAA_Atlas_14 County, Maryland

Sub-Area Time of Concentration Details

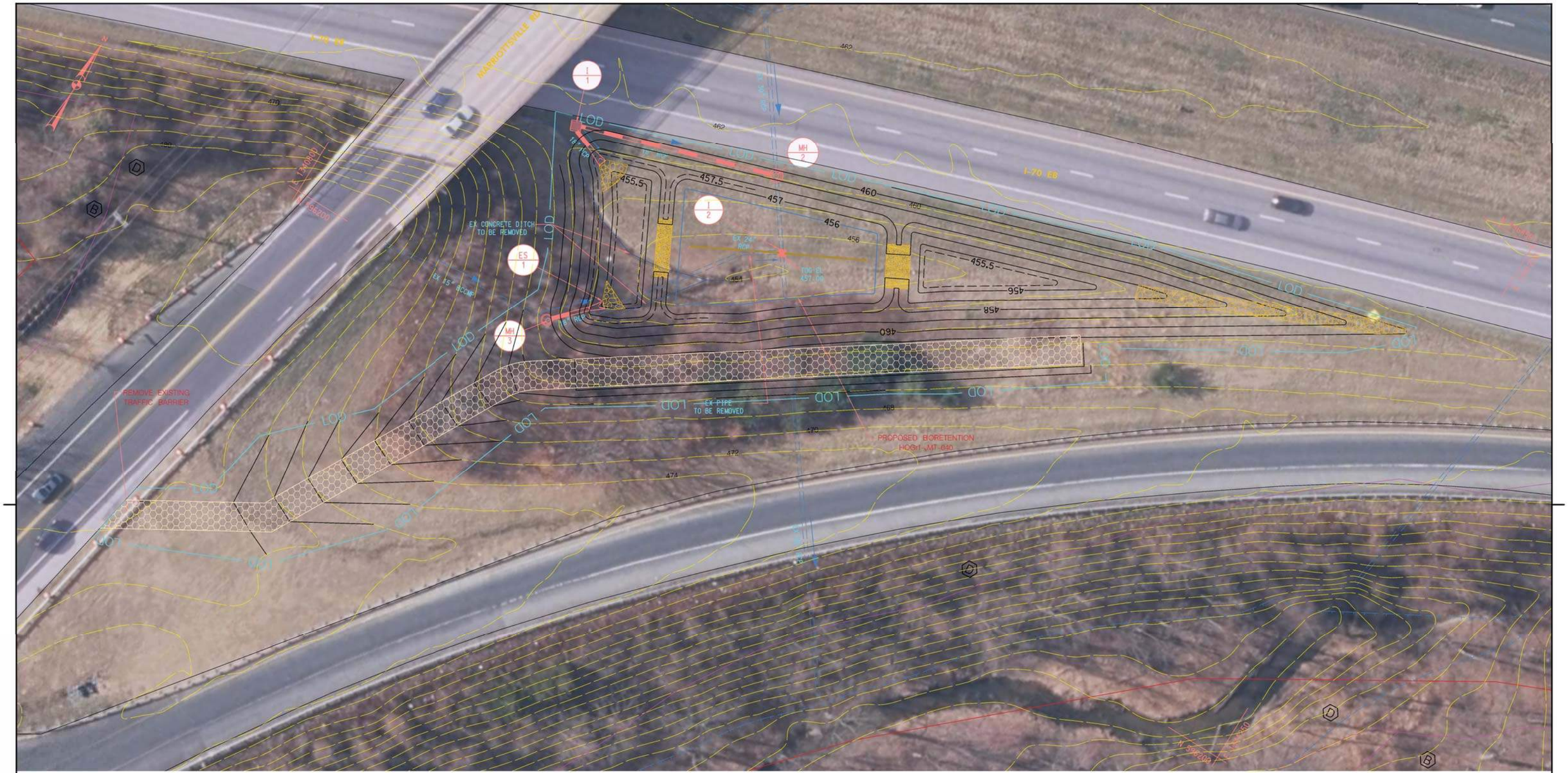
Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
Da to BMP							
SHEET	100	0.0200	0.011				0.020
SHALLOW	286	0.0217	0.025				0.027
CHANNEL	526					0.609	0.240
CHANNEL	326					3.474	0.026
					Time of Concentration		.313

HOCO Site Searches
HOGr1-JMT-040
Howard NOAA_Atlas_14 County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
Da to BMP	Open space; grass cover > 75%	(good)	D	1.505	80
	Paved; curbs and storm sewers		D	1.425	98
	Brush - brush, weed, grass mix	(good)	D	.155	73
	Woods	(good)	D	.38	77
	Total Area / Weighted Curve Number			3.46	87

Section 6: BMP Plan



LEGEND

- 328 EXISTING 2' CONTOUR
- EXISTING RIGHT OF WAY
- EXISTING DITCH
- FLOODPLAIN LINE
- EXISTING WETLANDS
- TMDL TREES
- EXISTING PIPE
- BMP SURFACE
- SOIL BOUNDARY
- (B) SOIL GROUP
- 330 PROPOSED CONTOUR
- LOD LIMIT OF DISTURBANCE

SUMMARY OF TREATMENT PROVIDED BY STORMWATER FACILITY

SITE NUMBER	SW BMP TYPE	DRAINAGE AREA TO BMP	IMPERVIOUS AREA TO BMP	Pe TREATED	RUNOFF VOLUME PROVIDED*	IMPERVIOUS ACRE CREDIT
HOGr1-JMT-040	BIORETENTION	3.47	1.43 AC.	2.10 IN.	11,097 CF.	1.82 AC.

*RUNOFF STORAGE VOLUME REFLECTS TOTAL ABOVE GROUND AND FILTER BED MEDIA STORAGE VOLUMES.

20' 0 20' 40'
SCALE: 1" = 20'

JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future®
72 Loveton Circle Sparks, MD 21152

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN – WATER PROGRAMS DIVISION
TMDL SWM – GROUP 1 – HOWARD COUNTY

STORMWATER DESIGN PLAN – HOGr1-JMT-040

SCALE 1" = 20' DATE MARCH 2016 CONTRACT NO.

DESIGNED BY SMH
DRAWN BY SMH
CHECKED BY TBD
F.A.P. NO. SEE TITLE SHEET
COUNTY HOWARD
LOGMILE

DRAWING NO. – OF SHEET NO. OF 2

PLOTTED: Thursday, May 26, 2016 AT 02:31 PM
FILE: $FILE$

Section 7: BMP Design Computations

Worksheet for HOGr1-JMT-040: 10-YR Headwater Computations

Project Description

Solve For	Headwater Elevation

Input Data

Discharge	13.69	ft³/s
Crest Elevation	457.00	ft
Weir Coefficient	3.47	US
Crest Length	9.46	ft

Results

Headwater Elevation	457.56	ft
Headwater Height Above Crest	0.56	ft
Flow Area	5.28	ft²
Velocity	2.59	ft/s
Wetted Perimeter	10.58	ft
Top Width	9.46	ft

SWM BMP Design Computations
Bioretention System

Design By: SMH
Checked By: SGC
Date: 6/24/2016

Project: SHA WPD SWM NBP Task

Design Phase: Concept

Site Name: HOGr1-JMT-040
Location: Howard County, Maryland
Watershed: Little Patuxent River (02131105)

Stream Use: **Use Class IV-P:** Recreational Trout Waters and Public Water Supply

See Maryland Department of Environment (MDE), 2000 Maryland Stormwater Management Design Manual Volumes I & II for referenced equations, acronyms, and definitions.

Site Area:	3.466	ac	0.005	m^2	
Total Impervious Area (A_I):	1.425	ac			
Percent Impervious (I):	0.411	=	**41.1**	%	I = Total Impervious Area / Site Area
Soil Type:	D				

RCN Post Development : 86.8 **T_c =** 0.314 hr Determine using WinTR55

Step 1: WQv Value

Step 1(a): *Compute volumetric Runoff Coefficient (R_v)*

$R_v = 0.05 + (0.009)\ I =$ 0.420 Equation Ref: Vol. I, Sec. 2.1

Step 1(b): *Rainfall Zone*

Eastern Rainfall Zone (P)	1.0	inches
Western Rainfall Zone (P)	0.9	inches
Minimum WQv (I≤ 15%)	0.2	inches
P_E Treated (P)	**2.10**	inches

Step 1(c): *Compute WQv* $WQv = \frac{(P)(Rv)(A)}{12}$ Equation Ref: Vol. I, Sec. 2.1

Required water quality for site impervious

$WQ_{V(I)}$ = 0.255 ac-ft = 11097.48 ft^3

Minimum water quality required 0.2 inches per acre of the drainage area (required for sites with less than 15% impervious drainage area)

$WQ_{V(Min)}$ = N/A ac-ft = N/A ft^3

Required WQv (largest computed WQv)

WQ_v required = **11097.48** **ft^3 =** **0.255** **ac-ft**

Step 2: Compute Recharge Volume (Re_v) Equation Ref: Vol. I, Sec. 2.2

Recharge volume is not required for this project as,
• there will not be any new impervious area created and
• there will not be loss of recharge as result of this project.

SWM BMP Design Computations
Bioretention System

Design By: SMH
Checked By: SGC
Date: 6/24/2016

Step 3: Pretreatment Volume

Pretreatment provided by a sedimentation basin, skip this step if a sediment basin/forebay is not required

Step 3(a) *Compute Required Sedimentation Basin Minimum Surface Area* — Equation Ref: Vol. I, Sec. 3.4.3

$$A_s = \frac{Q_o}{W} xE'$$

E' =	2.300	Sediment trapping efficiency constant (90%)	
$Q_0 = (WQ_v/24\ hr)$	0.128	ft^3	
W =	0.0004	ft/s	I ≤ 75%, 0.0004; I > 75%, 0.0033
A_s =	739	ft^2	

Step 3(b) *Required Sedimentation Basin Minimum Pretreatment Volume = 25%WQv* 2774 ft^3

Step 3(c) *Provided Sedimentation Basin Surface Area =* 1064.8 ft^3 **minimum surface area met**

Step 3(d) *Check Sedimentation Basin Storage Volume*

	Stage - Storage Data for Sedimentation Basin					
Elevation	Area	Avg Area	Height	Storage	Cum. Storage	Outfall Stone Window Opening
(ft)	(SF)	(SF)	(Ft)	(CF)	(CF)	
455.5	1064.8				0.000	
		1365.900	0.500	682.950		
456.0	1667.0				682.950	
		2437.600	1.000	2437.600		
457.0	3208.2				3120.550	

Total Pretreatment Volume = 3120.6 ft^3 **minimum pretreatment met**

SWM BMP Design Computations
Bioretention System

Design By: SMH
Checked By: SGC
Date: 6/24/2016

Step 4: Treatment

Step 4(a) *Compute the Required Filter Bed Area: (Af for 100% WQv)*

$$A_f = (WQ_v)(d_f) \Big/ [k \times (h_f + d_f) \times t_f)]$$

Design Filter Bed Depth (d_f) = 30 inches = 2.5 ft — See Bioretention Detail Vol I. Sec. 3.4

Filter Media Type: Bioretention Soil Mix
Coefficient of Permeability (k) = 2.000 ft/day

Filter Bed Drain Time (t_f) = 2 days

Design Temporary Ponding Height above the Filter Bed (h_f) = 1.00 ft

Design Average Height of Water above the Filter Bed (h_f) = 0.50 ft

Minimum required A_f = 2312 ft^2 A_f for 100% WQ_v

		Stage - Storage Data for Temporay Ponding				
Elevation	Area	Avg Area	Height	Storage	Cum. Storage	Inlet Opening
(ft)	(SF)	(SF)	(Ft)	(CF)	(CF)	
456.00	3035.1				0.000	
		3278.350	0.500	1639.175		
456.50	3521.6				1639.175	
		3779.700	0.500	1889.850		
457.00	4037.8				3529.025	weir top

Total Temporary Ponding Storage Above and Upstream of Filter Bed (V_{store}) = 5967 ft^3
(including forebay storage volume starting at elev. 456.00= (Forebay) 2437.6 cf + (Bioretention) 3529 cf)

SWM BMP Design Computations
Bioretention System

Step 5: Check

A_f/A_i = 4.9%

Required storage volume for full treatement of the WQv (%) = 53% **(From MDE Surface Storage Volume Tables using SHA BSM)**

Storage volume (%) provided above surface = 54%

Desgin Criteria Satisfication: **Yes, Design is treating 100% of the WQv**

Runoff Treatment Volume = **11097**

Step 6: Summary

Total Drainage Area	3.466	ac
Total Impervious Area	1.425	ac
Treatment Claimed	1.425	ac impervious area
Pe Credit	2.100	inch
Runoff Treatment Volume (RS)	11097	ft^3
Location Soil Type	D	

Pretreatment provided by	One Sedimentation Basin of	3120.6	ft^3
BMP Media Dimensions	**Area (SF)**	**Area (SY)**	**Depth (ft)**
Filter Chamber	3035	337	2.50
Coarse Sand	3035	337	0.33
No. 7 Aggregate	3035	337	0.33
No. 57 Aggregate with Underdrain	3035	337	1.00
Total Bioretention System	3035	337	4.17

Hydraulic Analysis Report

Project Data

Project Title:

Designer:

Project Date: Monday, February 29, 2016

Project Units: U.S. Customary Units

Notes:

Weir Analysis: Weir Analysis 040 west

Notes:

Input Parameters

Weir Type: Cipolletti

Coefficient: 3.3670

Length: 20.0000 ft

Flow: 13.6900 cfs

Result Parameters

Head: 0.3457 ft

Hydraulic Analysis Report

Project Data

Project Title:

Designer:

Project Date: Monday, February 29, 2016

Project Units: U.S. Customary Units

Notes:

Weir Analysis: Weir Analysis

Notes:

Input Parameters

Weir Type: Cipolletti

Coefficient: 3.3670

Length: 10.0000 ft

Flow: 13.6900 cfs

Result Parameters

Head: 0.5488 ft

Section 8: Construction Cost Estimate

SHA WATER PROGRAMS DIVISION
SWM New BMPs Planning Task
Construction Cost Estimate - Planning Use Only

Contract No.: BCS No. 2010-1 **County:** Howard Co **Prepared By:** PVC **Date:** 5/27/2016
Task No.: 1 **Group No.:** Group 1 **Checked By:** **Date:**
Prime Firm: JMT

Site: HOGr1-JMT-040

Item Number	Category Code	Description	Unit	Total Quantity	Unit Price	Total Cost
Cat. 100						
1001	110100	Clearing and Grubbing	LS	0.75	$2,500.00	$1,875.00
1002	110110	Removal of Trees	EA	5	$350.00	$1,750.00
1003	120500	Maintenance of Traffic	LS	1	$4,216.00	$4,216.00
					Sub-Total	***$7,841.00***
Cat. 200						
2001	201030	Class 1 Excavation	CY	700	$28.00	$19,600.00
	210027	Removal of Existing Paved Ditches	CY	176	$60.00	$10,560.00
					Sub-Total	***$19,600.00***
Cat. 300						
3001	300000	Erosion and Sediment Control	LS	1	$8,802	$8,801.73
3002	300000	Geotextile Class PE Type III	SY	338	$1.95	$659.10
3003	301210	Removal of Existing Pipe	LF	105	$30.00	$3,150.00
3004	301320	Clean Existing Pipe Any Size	LF	75	$15.00	$1,125.00
3005	302418	18 Inch Reinforced Concrete Pipe, Class IV	LF	110	$80.00	$8,800.00
3006	368818	18 Inch Standard Concrete End Section	EA	2	$1,000.00	$2,000.00
3007	380120	Standard Yard Inlet - Minimum Depth	EA	1	$3,000.00	$3,000.00
3008	380201	Adjust Existing Inlet	EA	1	$1,800.00	$1,800.00
3009	380600	48 Inch Diameter Manhole for 12" to 24" Pipes - Minimum Depth	EA	2	$3,500.00	$7,000.00
3010	390221	Class I Riprap Ditch	SY	73	$75.00	$5,475.00
3011	390321	Class I Riprap for Slope and Channel Protection	SY	17	$75.00	$1,275.00
3012	390620	No. 7 Aggregate for SWM Facilities	CY	37	$75.00	$2,775.00
3013	390630	No. 57 Aggregate for SWM Facilities	CY	112	$70.00	$7,840.00
3014	390640	6 Inch Subdrain Pipe	LF	71	$15.00	$1,065.00
3015	390650	Coarse Sand for SWM Facilities	CY	37	$78.00	$2,886.00
3016	390660	Bioretention Soil Mix	CY	281	$85.00	$23,885.00
3017	390665	Stormwater Management Facility As-built Certification	LS	1	$8,000.00	$8,000.00
3018	390670	Access Road with Cellular Confinement Load Support	SY	535	$40.00	$21,400.00
3019	391001	Bottom Cutoff Walls for Class I Riprap	LF	30	$30.00	$900.00
					Sub-Total	***$111,836.83***
Cat. 600						
6001	661540	Type K Traffic Barrier End Treatment	EA	2	$740.00	$1,480.00
					Sub-Total	***1,480.00***
Cat. 700						
7001	700000	Bioretention Soil Mix Meadow Establishment	SY	338	$2.00	$676.00
7002	704345	Placing Furnished Topsoil 4 Inch Depth	SY	3175	$6.50	$20,637.50
7003	705500	Turfgrass Establishment	SY	3175	$0.75	$2,381.25
7004	709100	Type A Soil Stabilization Matting	SY	3175	$2.00	$6,350.00
7005	709130	Type D Soil Stabilization Matting	SY	73	$4.90	$357.70
7006	710150	Tree, Shrub, And Perennial Installation And Establishment	LS	1.00	$20,334.00	$20,334.00
7007	715015	Shredded Hardwood Mulching 3 Inch Depth	SY	338	$3.50	$1,183.00
					Sub-Total	***$51,919.45***
					Site Total:	**$192,677.28**

Section 9: Field Investigation Report

SHA Water Programs Division
SWM New BMPs Planning Task
Howard County Group 1

FIELD INVESTIGATION REPORT
SITE HOGr1-JMT-040

Prepared By: JMT
1/19/2016

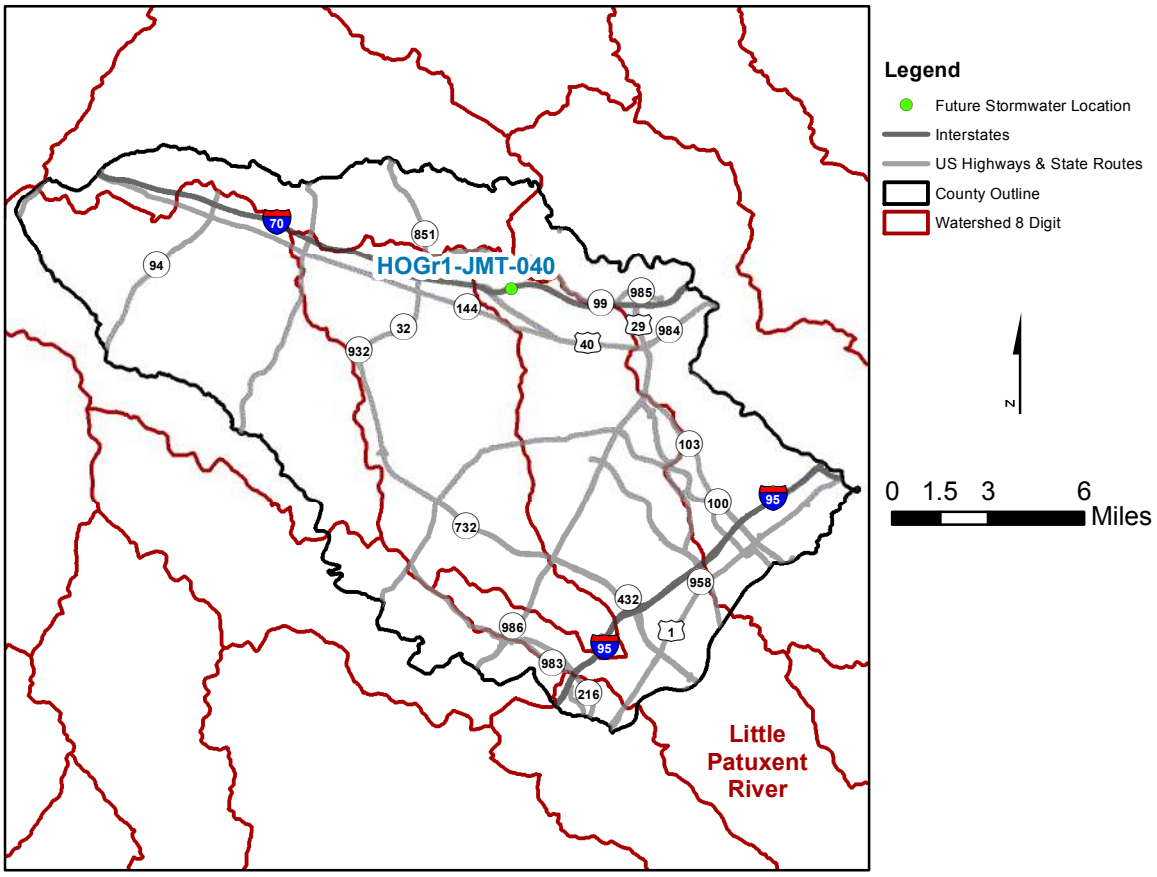
CONTENTS

1 County Location Map

2 FI Checklist

3 Field Map(s)

Section 1: County Location Map



Section 2: Field Checklist

SHA Water Programs Division
SWM New BMPs Planning Task

FIELD INVESTIGATION CHECKLIST

Pre-Investigation Data

County:	Howard County
Watershed ID (8-digit):	02131105
Site Number:	HOGr1-JMT-040
Location (route/intersection):	I-70EB/ Marriottsville Rd. ramp

Example: MD 320, east of Flower Ave

As-built plans available? (●) Yes ( ) No

If yes, Contract #: HO359-001-717;HO305-005-742

Potential BMP Type per DE:	Micro-Bioretention
Primary Hydrologic Soil Group:	D
Approximate SHA-Owned Impervious Area Treated per DE:	0.24 acres
Posted Speed Limit:	65 mph

Is site within...

...five miles of BWI or Martin State Airports, or four miles of any other airport?	( ) Yes (●) No
...the Chesapeake Bay Critical Area?	( ) Yes (●) No
...the FEMA 100-yr floodplain?	( ) Yes (●) No
Does site potentially conflict with Tree Planting Site Selection?	( ) Yes (●) No

Field Investigation

Consultant:	JMT
Inspector:	P. Crawford/C. Swetz
Date of Inspection:	01/13/2016

Has precipitation occured within the last three days? (●) Yes ( ) No

Overall Site Photo: (Photo # Ex: *YYYY-MM-DD-FullSite#-Photo#*)

Attach Photo Photo #: 01 Photo Description: Overview of site

Site Land Use: Open Space heavy vegetation

Should site be removed from consideration? ( ) Yes (●) No

If yes, why?...

Examples: Steep slopes, site is completely wooded, change in land use or ownership, major utility conflict

If there is an existing conveyance ditch at the site, does the configuration of the ditch (ie. flat bottom, shallow slope, etc.) have potential to qualify for grass channel credit? ( ) Yes (●) No ( ) N/A

Is ROW observed in the field consistent with the GIS ROW layer? (●) Yes ( ) No

if no... Attach Photo Photo #: Photo Description:

If no, describe observed ROW...

If BMP site is adjacent to Tree Assets...
Have trees been installed?

○ Yes ○ No ◉ N/A

If yes, describe the condition of the trees...and attach photo...

Attach Photo Photo #: Photo Description:

Construction & Maintenance Access:

☑ Access is good. (Unobstructed and direct from SHA ROW

Or, check any items below that may affect access:

☐ steep slopes ☐ private property

☐ guard rail ☐ fencing

☐ other...

Attach Photo Photo #: 02 Photo Description: Site access

Existing Utilities:

☑ existing utilities do not appear to be present at the site

Or, check any items below that apply:

☐ overhead lines above the anticipated project LOD

☐ overhead lines above the anticipated facility footprint

☐ surface features and/or underground utilities within anticipated project LOD

☐ surface features and/or underground utilities within anticipated facility footprint

☐ other...

If existing utilities are present, attach photo...

Attach Photo Photo #: Photo Description:

Environmental Features:

Wetlands and/or surface waters present?

- ○ Yes, within BMP footprint (permanent impact)
- ○ Yes, within anticipated site LOD, outside of BMP footprint
- ◉ No

If yes attach photo...

Attach Photo Photo #: Photo Description:

Steep slopes (15%+) present on site?

- ○ Yes, within BMP footprint
- ◉ Yes, within anticipated site LOD, outside of BMP footprint
- ○ No

If yes attach photo...

Attach Photo Photo #: 03 Photo Description: Steep slopes

Trees present on site?

- ○ Yes, within BMP footprint
- ○ Yes, within anticipated site LOD, outside of BMP footprint
- ◉ No

If yes attach photo...

Attach Photo Photo #: Photo Description:

Maintenance of Traffic Needs:

☐ M.O.T. is not required

Or, Select all that may apply:

☐ Lane Closure

☐ Detour

☐ Flagging operations (temporary construction vehicle movement on/off site)

☑ Shoulder Closure

Public Involvement:

Is this site in close proximity to or bordering any of the following land uses that may result in public concerns with noise, safety, and/or general quality of living?

- [x] No
- [ ] Business(es)
- [ ] Private Residence(s)
- [ ] Pedestrian Areas

Site Flow Conditions:

Inflow Conditions:

How does runoff from SHA impervious area enter the site? Note: Flow type and Stability.

Ditches west & NW inflow along the western end of site. Sheet flow directly from road to east side. Stable inflows.

Example: Sheetflow directly from roadway

Attach Photo Photo #: 04 Photo Description: Inflow

Outfall Conditions:

How does flow exit the proposed facility? Note: Flow type and Stability.

Flow will exit proposed facility via overflow inlet directly tied into SD. The current SD inlet is significantly eroded, but stable. Concentrated flow.

Example: Overflow inlet

Attach Photo Photo #: 05 Photo Description: Outfall

How does flow exit SHA ROW at POI? Note: Flow type and Stability.

Ditch running parallel to road eventually reaches rip rap/conc. channel into stream. Signs of erosion and sedimentation along ditch.

Example: Storm drain outfall to riprap channel

Attach Photo Photo #: 06 Photo Description: POI

Could site be a potential hot spot?

○ Yes ◉ No

Example: Site is adjacent to an existing fueling station, salt dome, etc.

If yes, description...

Additional Comments Otherwise Not Captured:

Consider splitting into two sites. The eastern portion can be converted to Grass Swale potentially. The western portion is recommended as Bioretention, and not as Micro Bioretention as stated by the DE.

It is recommended to replace the existing SD inlet with an overflow inlet.

Additional Photos:

Attach Photo	Photo #:	07	Photo Description:	outfall inlet condition
Attach Photo	Photo #:	08	Photo Description:	Prop grass swale area
Attach Photo	Photo #:	09	Photo Description:	Inflow from underpass
Attach Photo	Photo #:	10	Photo Description:	Conc channel inflow
Attach Photo	Photo #:	11	Photo Description:	Conc channel to outfall
Attach Photo	Photo #:		Photo Description:	
Attach Photo	Photo #:		Photo Description:	
Attach Photo	Photo #:		Photo Description:	

Please consider the following to ensure that the maximum Runoff Storage Volume (Rs) is provided at the site.

Is there potential to increase the runoff storage volume provided by expanding the size of the proposed facility beyond the apparent limits of SHA ROW in this location?

○ Yes ◉ No

If yes...

If yes attach photo...

Attach Photo Photo #: Photo Description:

Is there potential to adjust the existing storm drain configuration and/or existing drainage patterns to increase the impervious area contributing to a facility at this location?

○ Yes ◉ No

If yes...

If yes attach photo...

Attach Photo Photo #: Photo Description:

Post Field Investigation Results

Based on the results of the Field Investigation, what is the recommended proposed BMP type?

Bioretention

In order to construct the proposed BMP type, does it appear that ROW acquisition will be required ?	○ Yes ◉ No
If yes, approximately how much (acres)?:	
Overall drainage area to site (acres):	4.86
SHA-owned Impervious Area to site (acres):	2.17
Non SHA-owned impervious area to site (acres):	0

Print Report

Save Data

2016-01-13-HOGr1-JMT-040-Photo-01

Overview of the site from behind the outfall location

2016-01-13-HOGr1-JMT-040-Photo-02

Direct access to the site from the roadway, there is a full shoulder available to park on

2016-01-13-HOGr1-JMT-040-Photo-03

Steep slopes within the proposed site LOD

2016-01-13-HOGr1-JMT-040-Photo-04

Inflow to the site is sheet flow from the roadway and channel flow from the grass channel

2016-01-13-HOGr1-JMT-040-Photo-05

Concrete approach from both the east and west to the proposed site outfall inlet. The outfall is in need of maintenance

2016-01-13-HOGr1-JMT-040-Photo-06

POI

2016-01-13-HOGr1-JMT-040-Photo-07

Close up of the existing outfall inlet. The inlet and surrounding concrete approaches are in need of repair

2016-01-13-HOGr1-JMT-040-Photo-08

Inflow from the east via grass channel flow. This portion has the potential to be a grass channel area if the proposed site is split into two sites.

2016-01-13-HOGr1-JMT-040-Photo-09

Inflow from an existing BMP upstream that outfall to a concrete channel at the Marriottsville road overpass and to the proposed site location

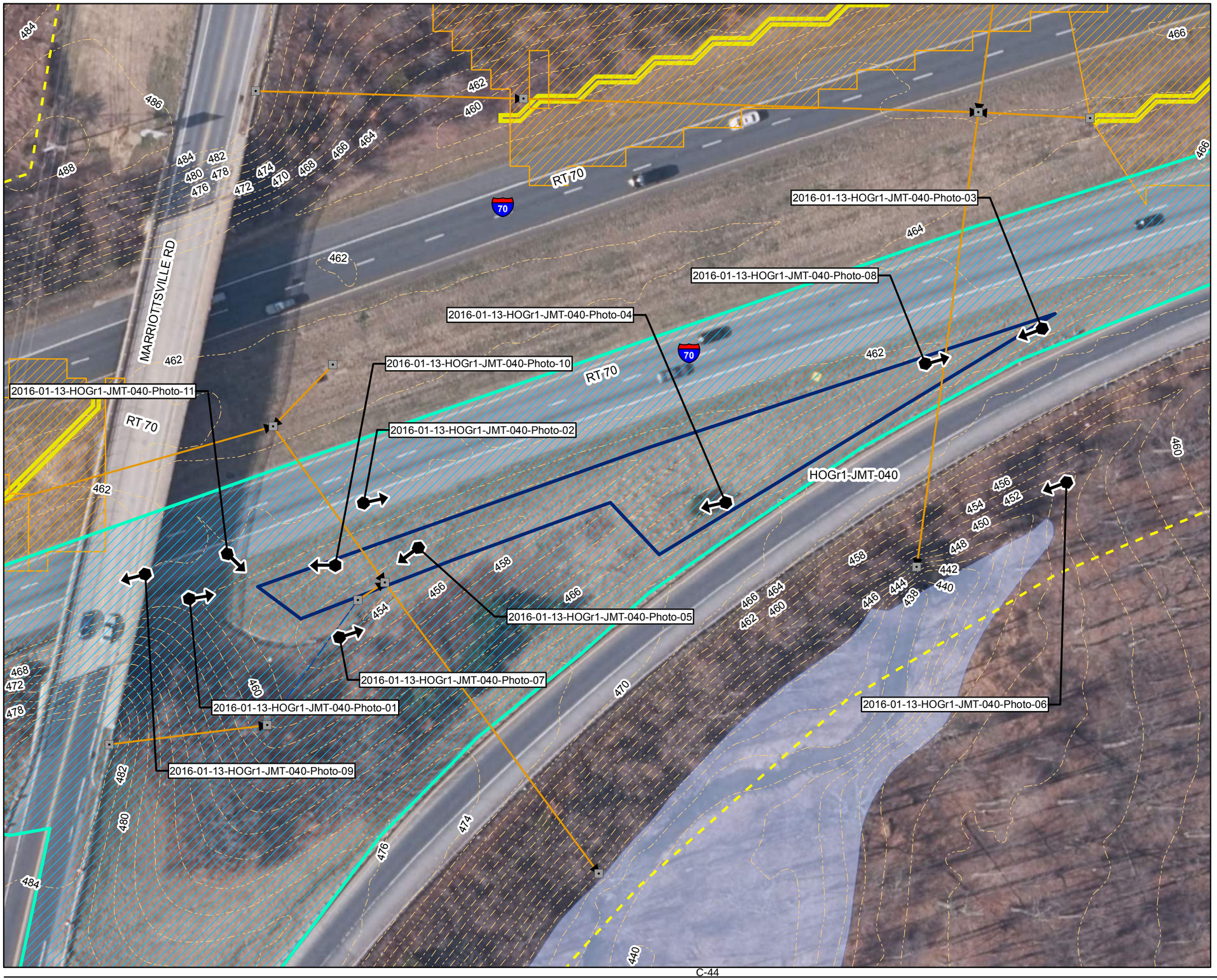
2016-01-13-HOGr1-JMT-040-Photo-10

Inflow from the west via concrete channel.

2016-01-13-HOGr1-JMT-040-Photo-11

Concrete channel to the site outfall, to be incorporated into the drainage to the site

Section 3: Field Map(s)



SHA TMDL SWM Field Investigation

Howard County, MD

HOGr1-JMT-040

Map Date: 3/3/2016

Legend

- Future Stormwater Location
- Planned Drainage Area
- SHA ROW
- SHA SWMFAC
- SWMFAC Drainage Area
- SHA Drainage Structure
- SHA Drainage Ditch
- SHA Stormdrain Pipe
- TMDL Tree Planting
- Critical Area
- NWI Wetlands 2011
- DNR Wetlands 2005
- Floodplains 2012
- Watershed 8 Digit
- Contour
- Photo Location and Direction

HOGr1-JMT-040
Total DA = 4.86 AC
Impervious Area = 2.17 AC

1 inch = 50 feet

0 25 50 100

Feet

N

JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future®

SHA TMDL SWM Field Investigation

Howard County, MD

HOGr1-JMT-040

Map Date: 3/3/2016

Possible to make two sites by making this portion a swale

Erosion at existing inlet, needs repair

Curbed section with guardrail

HOGr1-JMT-040

HOGr1-JMT-023

RT 70

MARRIOTTSVILLE RD

ALBETH RD

Legend

- Future Stormwater Location
- Planned Drainage Area
- SHA ROW
- SHA SWMFAC
- SWMFAC Drainage Area
- SHA Drainage Structure
- SHA Drainage Ditch
- SHA Stormdrain Pipe
- TMDL Tree Planting
- Critical Area
- NWI Wetlands 2011
- DNR Wetlands 2005
- Floodplains 2012
- Watershed 8 Digit
- Contour
- Photo Location and Direction

HOGr1-JMT-040
Total DA = 4.86 AC
Impervious Area = 2.17 AC

1 inch = 200 feet

0 100 200 400

Feet

N

JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future®

SHA Water Programs Division
SWM New BMPs Planning Task
Howard County Group 1

CONCEPT DESIGN REPORT
SITE HOGr1-JMT-023

Prepared By: Johnson, Mirmiran and Thompson, Inc
May 2016

CONTENTS

1 Introduction
2 Vicinity Map
3 Concept Design Summary
4 Drainage Area Map
5 Hydrologic Computations
6 BMP Plan
7 BMP Design Computations
8 Construction Cost Estimate
9 FI Report

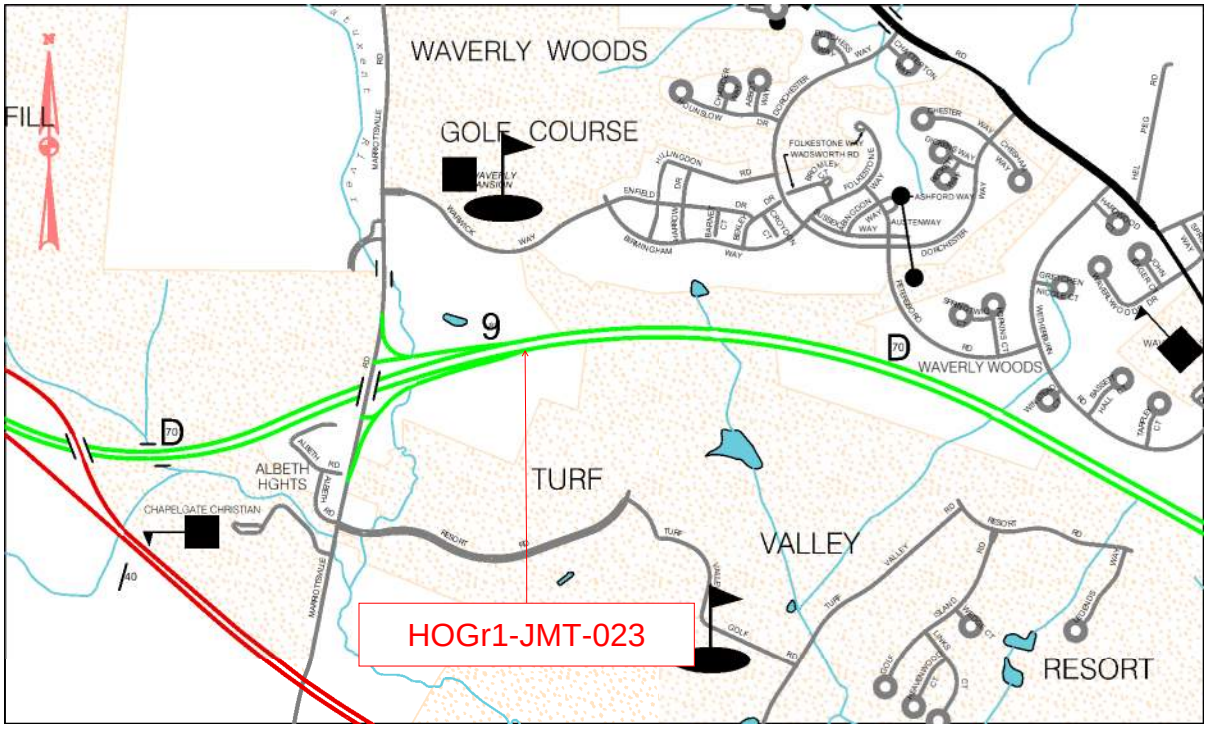
Section 1: INTRODUCTION

The Maryland State Highway Administration (SHA) is committed to meeting the requirements of the Chesapeake Bay through compliance with the requirements established in *Maryland's Watershed Implementation Plan for the Chesapeake Bay Total Maximum Daily Load* (WIP). Coverage under the Regulated Urban Stormwater sector includes both Phase I and Phase II National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) stormwater discharge permit for the SHA roadway network and maintenance facilities that have associated industrial stormwater discharge. SHA maintains MS4 permit coverage for the SHA roadway storm drain systems in the 11 Maryland TMDL counties holding MS4 permits.

SHA is required to bring Maryland highways into compliance with the Maryland WIP, the NPDES MS 4 Phase I and II permits, and local TMDLs by implementing stormwater and environmental best management practices (BMPs).

A key strategy of the SHA TMDL program is to install new qualitative stormwater management facilities to provide treatment for currently untreated SHA-owned impervious areas. As part of this program, Johnson, Mirmiran and Thompson, Inc. has been contracted by SHA to identify and analyze potential sites within Howard County to host these new BMPs. This report presents the results of the planning task to identify & investigate the potential to construct, and prepare concept level design for, a new BMP to treat existing untreated, SHA-owned impervious area at site HOGr1-JMT-023.

Section 2: Vicinity Map



Site Vicinity Map
Scale: 1”=2,000’

Section 3: Concept Design Summary

SHA Water Programs Division
SWM New BMPs Planning Task

CONCEPT DESIGN SUMMARY

SITE INFO:

HOWARD COUNTY, MARYLAND

SITE NUMBER: HOGr1-JMT-023_01 WATERSHED ID: 02131105

**** There IS a local TMDL requirement for this watershed.***

BMP INFO:

PROPOSED BMP TYPE: Bio-Swale BMP CLASS: RR

RUNOFF STORAGE VOLUME	PE TREATED	IMPERVIOUS AREA CREDIT
2268 CUBIC FEET	0.88 INCHES	0.65 ACRES

POLLUTANT LOAD REDUCTION ACHIEVED	Total Nitrogen (TN)	Total Phosphorus (TP)	Total Suspended Solids (TSS)
Pollutant Removal Rate	**54%**	**62%**	**67%**
Pollutant Load to BMP (lb/year)	**14.09**	**1.35**	**0.34**
EOS Pollutant Load Removal (lb/year)	**7.59**	**0.84**	**0.23**
DEL Pollutant Load Removal (lb/year)	**4.52**	**0.46**	**0.18**

HYDROLOGIC PARAMETERS:	*ADDITIONAL DESIGN CONSIDERATIONS:*
Drainage Area to BMP - 1.00 acres	**Estimated Project Limit of Disturbance - 1.35 acres**
SHA-Owned Impervious Area to BMP - 0.73 acres	
Total Impervious Area to BMP (ac) - 0.73 acres	*** There is NO additional Runoff Diverted to this Site Under Proposed Conditions.**

Overall Site Photo

Consultant Comments

Due to a DA greater than the max allowed 1 acre, two bioswales are proposed to split up the overall DA at this site. Bioswale 1 is 664 ft long, 4 ft wide and 1.6 ft deep with 4:1 side slopes. An inlet is proposed at the downstream end to capture all runoff from bioswale 1. Bioswale 2 is located just downstream of the proposed inlet. A bypass ditch, 1.5 ft deep, is proposed on the south side of the bioswales to divert the large offsite DA from the woods. Proposed slopes for the bypass ditch and to tie into the existing grades are 2:1.

SHA Water Programs Division
SWM New BMPs Planning Task

CONCEPT DESIGN SUMMARY

SITE INFO:

HOWARD COUNTY, MARYLAND

SITE NUMBER: HOGr1-JMT-023_02 WATERSHED ID: 2131105

**** There IS a local TMDL requirement for this watershed.***

BMP INFO:

PROPOSED BMP TYPE: Bio-Swale BMP CLASS: RR

RUNOFF STORAGE VOLUME	PE TREATED	IMPERVIOUS AREA CREDIT
804 CUBIC FEET	0.82 INCHES	0.23 ACRES

POLLUTANT LOAD REDUCTION ACHIEVED	Total Nitrogen (TN)	Total Phosphorus (TP)	Total Suspended Solids (TSS)
Pollutant Removal Rate	**52%**	**61%**	**65%**
Pollutant Load to BMP (lb/year)	**5.26**	**0.51**	**0.13**
EOS Pollutant Load Removal (lb/year)	**2.76**	**0.31**	**0.08**
DEL Pollutant Load Removal (lb/year)	**1.64**	**0.17**	**0.07**

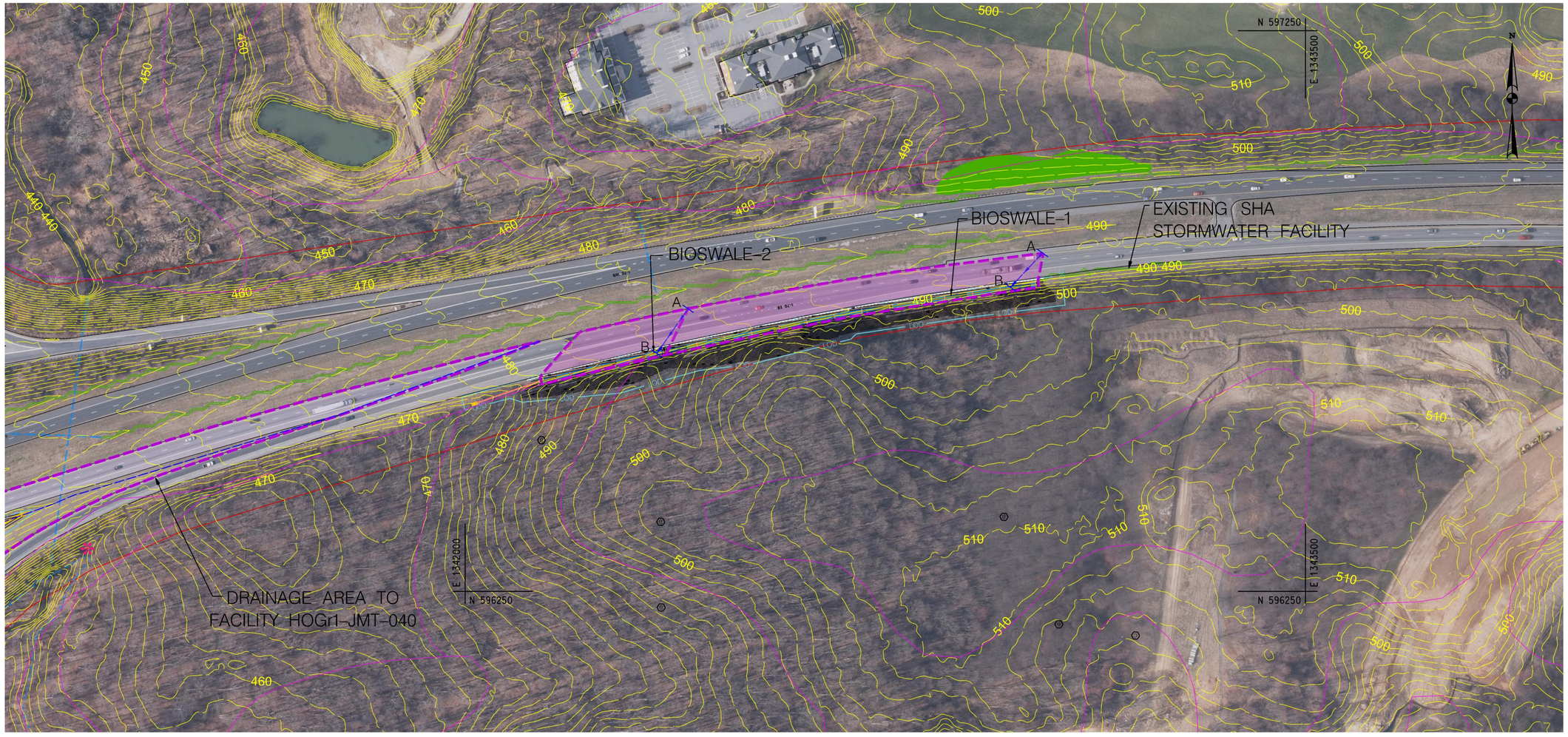
HYDROLOGIC PARAMETERS:	*ADDITIONAL DESIGN CONSIDERATIONS:*
Drainage Area to BMP - 0.37 acres	**Estimated Project Limit of Disturbance - 1.35 acres**
SHA-Owned Impervious Area to BMP - 0.28 acres	
Total Impervious Area to BMP (ac) - 0.28 acres	*** There is NO additional Runoff Diverted to this Site Under Proposed Conditions.**

Overall Site Photo

Consultant Comments

Due to a DA greater than the max allowed 1 acre, two bioswales are proposed to split up the overall DA at this site. Bioswale 2 is 221 ft long, 4 ft wide and 1.5 ft deep with 4:1 side slopes. An inlet is proposed at the downstream end to capture all runoff from bioswale 2. A bypass ditch, 1.5 ft deep, is proposed on the south side of the bioswales to divert the large offsite DA from the woods. Proposed slopes for the bypass ditch and to tie into the existing grades are 2:1.

Section 4: Drainage Area Map



LEGEND

- EXISTING 2' CONTOUR
- EXISTING RIGHT OF WAY
- EXISTING DITCH
- FLOODPLAIN LINE
- EXISTING WETLANDS
- TMDL TREES
- EXISTING PIPE
- BMP SURFACE
- PROPOSED DRAINAGE AREA TO BMP
- POINT OF INVESTIGATION (POI)
- SOIL BOUNDARY
- SOIL GROUP
- PROPOSED Tc PATH
- IMPERVIOUS AREA
- PROPOSED CONTOUR
- LIMIT OF DISTURBANCE

	HYDROLOGIC SUMMARY TABLE		
FACILITY	DRAINAGE AREA TO BMP	IMPERVIOUS AREA TO BMP	Tc
BIOSWALE-1	1.00 AC.	0.73 AC.	0.100 HR.
BIOSWALE-2	0.37 AC.	0.28 AC.	0.100 HR.

NOTE: EXISTING AND PROPOSED DRAINAGE AREAS ARE THE SAME FOR THIS FACILITY.

NOTES:

1. DRAINAGE AREA DIVIDES AND Tc PATHS HAVE BEEN VERIFIED VIA FIELD INVESTIGATION AND AS-BUILT PLANS.
2. CONVEYANCE SYSTEMS AND STRUCTURES ARE BASED ON GIS DATA AND ARE APPROXIMATE.
3. CONVEYANCE PERTINENT TO THE SITE HAVE BEEN FIELD VERIFIED AND INCONSISTENCIES RECORDED WHERE POSSIBLE.

100' 0 100' 200'
SCALE: 1" = 100'

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STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN – WATER PROGRAMS DIVISION
TMDL SWM – GROUP 1 – HOWARD COUNTY

DRAINAGE AREA MAP – HOGr1-JMT-023

SCALE 1" = 100' DATE MARCH 2016 CONTRACT NO.

DESIGNED BY PVC
DRAWN BY PVC
CHECKED BY SC
F.A.P. NO. SEE TITLE SHEET

COUNTY HOWARD
LOGMILE

DRAWING NO. DA - 1 OF 1
SHEET NO. OF 2

PLOTTED: Friday, April 22, 2016 AT 08:28 AM
FILE: $FILEL$

Section 5: Hydrologic Computations

WinTR-55 Current Data Description

--- Identification Data ---

User: PVC
Project: HO Co Gr1
SubTitle: HOGr1-JMT-023 (1)
State: Maryland
County: Howard NOAA_Atlas_14
Filename: Q:\SMD\100173_001_TMDL_SWM_Site_Search\Working Data\Concept Design\Computations\TR-55\WinTR55\H

Date: 5/16/2016
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
BIOSWALE1	DRAINAGE AREA TO BMP	Outlet	1	88	0.1

Total area: 1 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.21	4.12	4.93	6.17	7.27	8.52	2.65

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

HO Co Gr1
HOGr1-JMT-023 (1)
Howard NOAA_Atlas_14 County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.21	4.12	4.93	6.17	7.27	8.52	2.65

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

PVC

HO Co Gr1
HOGr1-JMT-023 (1)
Howard NOAA_Atlas_14 County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
BIOSWALE1	1.00	0.100	88	Outlet	DRAINAGE AREA TO BMP

Total Area: 1 (ac)

PVC

HO Co Gr1
HOGr1-JMT-023 (1)
Howard NOAA_Atlas_14 County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
BIOSWALE1							
SHEET	100	0.0238	0.011				0.019
					Time of Concentration		0.1

HO Co Gr1
HOGr1-JMT-023 (1)
Howard NOAA_Atlas_14 County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
BIOSWALE1	Open space; grass cover > 75% (good)	B	.27	61
	Paved parking lots, roofs, driveways	D	.73	98
	Total Area / Weighted Curve Number		1	88
			=	==

WinTR-55 Current Data Description

--- Identification Data ---

User: PVC
Project: HO Co Gr1
SubTitle: HOGr1-JMT-023 (2)
State: Maryland
County: Howard NOAA_Atlas_14
Filename: Q:\SMD\100173_001_TMDL_SWM_Site_Search\Working Data\Concept Design\Computations\TR-55\WinTR55\H

Date: 5/16/2016
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
BIOSWALE2	DRAINAGE AREA TO BMP2	Outlet	0.37	89	0.1

Total area: .37 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.21	4.12	4.93	6.17	7.27	8.52	2.65

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

HO Co Gr1
HOGr1-JMT-023 (2)
Howard NOAA_Atlas_14 County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.21	4.12	4.93	6.17	7.27	8.52	2.65

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

PVC

HO Co Gr1
HOGr1-JMT-023 (2)
Howard NOAA_Atlas_14 County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
BIOSWALE2	.37	0.100	89	Outlet	DRAINAGE AREA TO BMP2

Total Area: .37 (ac)

HO Co Gr1
HOGr1-JMT-023 (2)
Howard NOAA_Atlas_14 County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
BIOSWALE2							
SHEET	100	0.0238	0.011				0.019
					Time of Concentration		0.1

HO Co Gr1
HOGr1-JMT-023 (2)
Howard NOAA_Atlas_14 County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
BIOSWALE2	Open space; grass cover > 75% (good)	B	.09	61
	Paved parking lots, roofs, driveways	D	.28	98
	Total Area / Weighted Curve Number		.37	89
			===	==

Section 6: BMP Plan

LEGEND

- 500 EXISTING 2' CONTOUR
- EXISTING RIGHT OF WAY
- EXISTING DITCH
- FLOODPLAIN LINE
- EXISTING WETLANDS
- TMDL TREES
- EXISTING PIPE
- BMP SURFACE
- SOIL BOUNDARY
- (B) SOIL GROUP
- 484 PROPOSED CONTOUR
- LOD LIMIT OF DISTURBANCE

SUMMARY OF TREATMENT PROVIDED BY STORMWATER FACILITY

SITE NUMBER	SW BMP TYPE	DRAINAGE AREA TO BMP	IMPERVIOUS AREA TO BMP	Pe TREATED	RUNOFF VOLUME PROVIDED*	IMPERVIOUS ACRE CREDIT
HOGr1-JMT-023(1)	BIO-SWALE	1.00 AC.	0.73 AC.	0.88 IN.	2,268 CF.	0.64 AC.
HOGr1-JMT-023(2)	BIO-SWALE	0.37 AC.	0.28 AC.	0.82 IN.	804 CF.	0.23 AC.

NOTES:

1. CONVEYANCE SYSTEMS AND STRUCTURES ARE BASED ON GIS DATA AND ARE APPROXIMATE.
2. CONVEYANCE ITEMS PERTINENT TO THE SITE HAVE BEEN FIELD VERIFIED AND INCONSISTENCIES RECORDED WHERE POSSIBLE.

40' 0 40' 80'
SCALE: 1" = 40'

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STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF ENVIRONMENTAL DESIGN – WATER PROGRAMS DIVISION
TMDL SWM – GROUP 1 – HOWARD COUNTY

STORMWATER DESIGN PLAN – HOGr1-JMT-023

SCALE 1" = 40' DATE MARCH 2016 CONTRACT NO.

DESIGNED BY PVC
DRAWN BY PVC
CHECKED BY SC
F.A.P. NO. SEE TITLE SHEET

COUNTY HOWARD
LOGMILE

DRAWING NO. SW - 1 OF 1 SHEET NO. OF 2

PLOTTED: Thursday, April 21, 2016 AT 03:57 PM
FILE: $FILEL$

Section 7: BMP Design Computations

Worksheet for HOGr1-JMT-023 (1): 10-YR Headwater Computations

Project Description

Solve For	Headwater Elevation

Input Data

Discharge	5.36	ft³/s
Crest Elevation	482.63	ft
Weir Coefficient	3.10	US
Crest Length	9.67	ft

Results

Headwater Elevation	482.95	ft
Headwater Height Above Crest	0.32	ft
Flow Area	3.07	ft²
Velocity	1.75	ft/s
Wetted Perimeter	10.30	ft
Top Width	9.67	ft

Worksheet for HOGr1-JMT-023 (2): 10-YR Headwater Computations

Project Description

Solve For	Headwater Elevation

Input Data

Discharge	2.04	ft³/s
Crest Elevation	482.63	ft
Weir Coefficient	3.10	US
Crest Length	9.67	ft

Results

Headwater Elevation	482.80	ft
Headwater Height Above Crest	0.17	ft
Flow Area	1.61	ft²
Velocity	1.27	ft/s
Wetted Perimeter	10.00	ft
Top Width	9.67	ft

Structure			Pipe										REMARKS	
FROM	TO	Q* (CFS)	Size (IN)	Type	n MANNING Coef.	INV US	INV DS	So Slope (%)	L Length (FT)	Vo Vel. (FT/SEC)	Time in Pipe (MIN)	Capacity Full (CFS)	Normal Depth (IN)	% FULL
I-1	I-2	5.36	15	PVC	0.013	474.91	473.17	0.75%	232	5.22	0.74	5.61	11.7	95.6%
I-2	EW-1	7.40	18	RCP	0.013	472.97	472.25	0.62%	116	5.35	0.36	8.30	13.1	89.2%

*See Appendix VIII for TR-55 calculations used to calculate discharges for a 10-year storm event.

BMP ID: Bioswale # HOGr1-JMT-023 (1)

Bioswale Water Quality Credit Analysis

By PVC Check

Date 3/7/2016 Date

TMDL WQ Volume Requirements		
Drainage Area (A), ac	1.00	
Impervious Area (Ai), ac	0.73	
P, in	1.00	
Impervious Cover I, %	73.0	I = (Ai / A) x 100
Rv	0.71	Rv = 0.05 + 0.09 x I
WQv Required, ac-ft	**0.0592**	WQv = P x Rv x A/12
WQv Required, cf	**2,579**	
Bioswale Information		
Bioswale Length (L), ft	664	Length of Bioswale Filter Media
Bottom Width (B), ft	4.00	
Ditch Slope, ft/ft	0.010	
Lt. Side Slope (Z1)	4.0	
Rt. Side Slope (Z2)	4.0	
Check Dam Information		
Check Dam Height (D), in	6.0	
Check Dam Height (D), ft	0.50	
Minimum Check Dam Cell Length (Lc), ft	50.0	Minimum Spacing Between Check Dams (Check Dam Height/ Ditch Slope)
Check Dam Cell Length, ft	50.0	As shown on Contract Documents
Surface Storage (Behind Each Check Dam), cf	66.67	Surface Storage = $(D^2 \times Lc\ (Z1 + Z2) + 3 \times B \times D \times Lc)/6$
Maximum No. of Check Dams Allowed	13	Bioswale Length/ Check Dam Cell Length (Rounded Down)
No. of Check Dams Provided	13	Note: If the Maximum number of Check Dams is exceeded, surface storage will be located outside of the filter area. Surface storage credit is applicable for storage over the filter area.
Partial Storage in Upstream Cell	**No**	If 'Yes', then storage is present outside of filter media and partial storage credit in upstream cell will be computed
Bioswale Analysis		
Total Surface Storage Provided Behind Check Dams, cf	866.7	Storage Volume Behind Each Check Dam x No. of Check Dams Provided
Upstream Cell: Partial Storage Computations		
Length of Storage Outside Filter Media (Lp), ft	N/A	[Check Dam Cell Length (Lc) x No. of Check Dams Provided] - Bioswale Length (L)
Flow Depth Where Storage is Outside of Filter Media (Dp), ft	N/A	Storage Length Outside of Filter Media x Ditch Slope
Surface Storage Outside Of Filter Media, cf	N/A	Surface Storage = $(Dp^2 \times Lp\ (Z1 + Z2) + 3 \times B \times Dp \times Lp)/6$
Total Surface Storage Over Filter Media, cf	**866.7**	Total Storage Behind Check Dams - Surface Storage Outside Filter Media (Used in % Surface Volume Provided computation)
% Surface Volume Provided	33.61%	(Total Surface Volume Provided / WQv Required) x 100
Filter Area Provided (Af), sf	2,656	Filter Area = Bioswale Length x Bioswale Width
Af/ Ai, %	8.35%	Af / Ai = (Filter Area / Impervious Area) x 100
MDE P_E Credit	**0.88**	From MDE TMDL P_E Credit Chart 7/16/12
Impervious Area Credit, ac	**0.64**	
WQv Provided, cf	**2268**	WQv Provided = MDE Pe Credit * WQv Required

Channel Analysis for ESDv			
Manning's N Value	0.15		
Flow Depth (d), in	3.84	Iterate value til Q_t value equal or slight greater then Q_p	Depth < 6 in, OK
Cross Section Flow Area A, sf	155.41		
Hydraulic Radius R (ft)	0.17	$Q = \frac{1.49 \times A \times R^{\frac{2}{3}} \times S^{\frac{1}{2}}}{n}$ *A , V = Q/A	
Q_t, cfs	47.86		
Flow Velocity (V), fps	0.31	Velocity < 1 fps, OK	

10-year Conveyance			
10-Yr, Peak Discharge, cfs	5.36		
10-Yr, Channel Flow Depth, in	9.84	Iterate value until the $Q_{t,10\text{-}yr}$ equal or slight greater then the 10-Yr Peak Dischar	
Minimum Channel Depth, in	19.2		
Manning's N Value	0.064		
Cross Sectional Flow Area (A_{10}), sf	5.970		
Hydraulic Radius R_{10}, ft	0.555		
$Q_{t,10\text{-}yr}$, cfs	5.36	$Q = \frac{1.49 \times A \times R^{\frac{2}{3}} \times S^{\frac{1}{2}}}{n}$ *A , V = Q/A	
10-YR Flow Velocity (V), fps	1.57	Velocity <4, OK	
Check Dam Top Length (L_{CD}), ft	8.00	L = B+(D/12)*(Z1+Z2)	
Weir Flow Head (H), ft	0.36	H = [Q_{10}/3.1/L_{CD}]^(1/1.5)	
FreeBoard (FB) from Channel Flow, in	**9**	Freeboard > 9 Inch, OK	
FB From Check Dam Weir Flow, in (=Min. Channel Depth - D -H)	**9**	Freeboard > 9 Inch, OK	

BMP ID: Bioswale # HOGr1-JMT-023 (2)

Bioswale Water Quality Credit Analysis

By PVC Check

Date 3/7/2016 Date

TMDL WQ Volume Requirements		
Drainage Area (A), ac	0.37	
Impervious Area (Ai), ac	0.28	
P, in	1.00	
Impervious Cover I, %	75.7	I = (Ai / A) x 100
Rv	0.73	Rv = 0.05 + 0.09 x I
WQv Required, ac-ft	**0.0225**	WQv = P x Rv x A/12
WQv Required, cf	**980**	
Bioswale Information		
Bioswale Length (L), ft	221	Length of Bioswale Filter Media
Bottom Width (B), ft	4.00	
Ditch Slope, ft/ft	0.019	
Lt. Side Slope (Z1)	4.0	
Rt. Side Slope (Z2)	4.0	
Check Dam Information		
Check Dam Height (D), in	6.0	
Check Dam Height (D), ft	0.50	
Minimum Check Dam Cell Length (Lc), ft	26.3	Minimum Spacing Between Check Dams (Check Dam Height/ Ditch Slope)
Check Dam Cell Length, ft	27.0	As shown on Contract Documents
Surface Storage (Behind Each Check Dam), cf	35.07	Surface Storage = (D^2 x Lc (Z1 + Z2) + 3 x B x D x Lc)/6
Maximum No. of Check Dams Allowed	8	Bioswale Length/ Check Dam Cell Length (Rounded Down)
No. of Check Dams Provided	8	Note: If the Maximum number of Check Dams is exceeded, surface storage will be located outside of the filter area. Surface storage credit is applicable for storage over the filter area.
Partial Storage in Upstream Cell	**No**	If 'Yes', then storage is present outside of filter media and partial storage credit in upstream cell will be computed
Bioswale Analysis		
Total Surface Storage Provided Behind Check Dams, cf	280.6	Storage Volume Behind Each Check Dam x No. of Check Dams Provided
Upstream Cell: Partial Storage Computations		
Length of Storage Outside Filter Media (Lp), ft	N/A	[Check Dam Cell Length (Lc) x No. of Check Dams Provided] - Bioswale Length (L)
Flow Depth Where Storage is Outside of Filter Media (Dp), ft	N/A	Storage Length Outside of Filter Media x Ditch Slope
Surface Storage Outside Of Filter Media, cf	N/A	Surface Storage = (Dp^2 x Lp (Z1 + Z2) + 3 x B x Dp x Lp)/6
Total Surface Storage Over Filter Media, cf	**280.6**	Total Storage Behind Check Dams - Surface Storage Outside Filter Media (Used in % Surface Volume Provided computation)
% Surface Volume Provided	28.63%	(Total Surface Volume Provided / WQv Required) x 100
Filter Area Provided (Af), sf	884	Filter Area = Bioswale Length x Bioswale Width
Af/ Ai, %	7.25%	Af / Ai = (Filter Area / Impervious Area) x 100
MDE P_E Credit	**0.82**	From MDE TMDL P_E Credit Chart 7/16/12
Impervious Area Credit, ac	**0.23**	
WQv Provided, cf	**804**	WQv Provided = MDE Pe Credit * WQv Required

Channel Analysis for ESDv			
Manning's N Value	0.15		
Flow Depth (d), in	2.00	Iterate value til Q_t value equal or slight greater then Q_p	Depth < 6 in, OK
Cross Section Flow Area A, sf	26.23		
Hydraulic Radius R (ft)	0.11	$Q = \frac{1.49 \times A \times R^{\frac{2}{3}} \times S^{\frac{1}{2}}}{n}$ *A , V = Q/A	
Q_t, cfs	8.26		
Flow Velocity (V), fps	0.31	Velocity < 1 fps, OK	

10-year Conveyance			
10-Yr, Peak Discharge, cfs	2.04		
10-Yr, Channel Flow Depth, in	8.04	Iterate value until the $Q_{t,10\text{-yr}}$ equal or slight greater then the 10-Yr Peak Dischar	
Minimum Channel Depth, in	18.0		
Manning's N Value	0.090		
Cross Sectional Flow Area (A_{10}), sf	4.480		
Hydraulic Radius R_{10}, ft	0.470		
$Q_{t,10\text{-yr}}$, cfs	2.04	$Q = \frac{1.49 \times A \times R^{\frac{2}{3}} \times S^{\frac{1}{2}}}{n}$ *A , V = Q/A	
10-YR Flow Velocity (V), fps	1.38	Velocity <4, OK	
Check Dam Top Length (L_{CD}), ft	8.00	L = B+(D/12)*(Z1+Z2)	
Weir Flow Head (H), ft	0.19	H = [Q_{10}/3.1/L_{CD}]^(1/1.5)	
FreeBoard (FB) from Channel Flow, in	**10**	Freeboard > 9 Inch, OK	
FB From Check Dam Weir Flow, in (=Min. Channel Depth - D -H)	**10**	Freeboard > 9 Inch, OK	

Hydraulic Analysis Report

Project Data

Project Title:

Designer:

Project Date: Tuesday, March 01, 2016

Project Units: U.S. Customary Units

Notes:

Weir Analysis: Bioswale 023 10-YR Headwater Comp

Notes:

Input Parameters

Weir Type: Cipolletti

Coefficient: 3.3670

Length: 8.0000 ft

Flow: 5.3600 cfs

Result Parameters

Head: 0.3408 ft

Hydraulic Analysis Report

Project Data

Project Title:

Designer:

Project Date: Tuesday, March 01, 2016

Project Units: U.S. Customary Units

Notes:

Weir Analysis: Bioswale 023 (2) 10-YR Headwater Comp

Notes:

Input Parameters

Weir Type: Cipolletti

Coefficient: 3.3670

Length: 8.0000 ft

Flow: 2.0400 cfs

Result Parameters

Head: 0.1790 ft

Hydraulic Analysis Report

Project Data

Project Title:

Designer:

Project Date: Tuesday, March 01, 2016

Project Units: U.S. Customary Units

Notes:

Channel Analysis: ByPass Ditch

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Channel Width: 2.0000 ft

Longitudinal Slope: 0.0110 ft/ft

Manning's n: 0.1300

Flow: 6.1300 cfs

Result Parameters

Depth: 1.3135 ft

Area of Flow: 6.0777 ft^2

Wetted Perimeter: 7.8742 ft

Hydraulic Radius: 0.7718 ft

Average Velocity: 1.0086 ft/s

Top Width: 7.2541 ft

Froude Number: 0.1942

Critical Depth: 0.5485 ft

Critical Velocity: 3.6091 ft/s

Critical Slope: 0.3603 ft/ft

Critical Top Width: 4.19 ft

Calculated Max Shear Stress: 0.9016 lb/ft^2

Calculated Avg Shear Stress: 0.5298 lb/ft^2

Section 8: Construction Cost Estimate

SHA WATER PROGRAMS DIVISION
SWM New BMPs Planning Task
Construction Cost Estimate - Planning Use Only

Contract No.: BCS No. 2010-1 **County:** Howard Co **Prepared By:** PVC **Date:** 5/27/2016
Task No.: 1 **Group No.:** Group 1 **Checked By:** **Date:**
Prime Firm: JMT

Site: HOGr1-JMT-023

Item Number	Category Code	Description	Unit	Total Quantity	Unit Price	Total Cost
Cat. 100						
1001	110100	Clearing and Grubbing	LS	1.33	$2,500.00	$3,325.00
1002	110110	Removal of Trees	EA	25	$350.00	$8,750.00
1003	120500	Maintenance of Traffic	LS	1	$19,671.60	$19,671.60
					Sub-Total	***$31,746.60***
Cat. 200						
2001	201030	Class 1 Excavation	CY	2888	$28.00	$80,864.00
					Sub-Total	***$80,864.00***
Cat. 300						
3001	300000	Erosion and Sediment Control	LS	1	$12,742	$12,742.20
3002	300000	Geotextile Class PE Type III	SY	6	$1.95	$11.70
3003	302415	15 Inch Reinforced Concrete Pipe, Class IV	LF	232	$78.00	$18,096.00
3004	302418	18 Inch Reinforced Concrete Pipe, Class IV	LF	110	$80.00	$8,800.00
3005	368818	18 Inch Standard Concrete End Section	EA	1	$1,000.00	$1,000.00
3006	380120	Standard Yard Inlet - Minimum Depth	EA	2	$3,000.00	$6,000.00
3007	380122	Standard Yard Inlet - Vertical Depth	LF	7	$200.00	$1,400.00
3008	390321	Class I Riprap for Slope and Channel Protection	SY	6	$75.00	$450.00
3009	390620	No. 7 Aggregate for SWM Facilities	CY	44	$75.00	$3,300.00
3010	390630	No. 57 Aggregate for SWM Facilities	CY	131	$70.00	$9,170.00
3011	390640	6 Inch Subdrain Pipe	LF	885	$15.00	$13,275.00
3012	390660	Bioretention Soil Mix	CY	328	$85.00	$27,880.00
3013	390665	Stormwater Management Facility As-built Certification	LS	1	$8,000.00	$8,000.00
3014	391001	Bottom Cutoff Walls for Class I Riprap	LF	10	$30.00	$300.00
					Sub-Total	***$110,424.90***
Cat. 600						
6001	660482	Traffic Barrier W Beam Using 6 Foot Post	LF	942	$17.00	$16,014.00
6002	661540	Type K Traffic Barrier End Treatment	EA	2	$740.00	$1,480.00
					Sub-Total	***17,494.00***
Cat. 700						
7001	700000	Bioretention Soil Mix Meadow Establishment	SY	393	$2.00	$786.00
7002	704345	Placing Furnished Topsoil 4 Inch Depth	SY	6032	$6.50	$39,208.00
7003	705500	Turfgrass Establishment	SY	6426	$0.75	$4,819.50
7004	709100	Type A Soil Stabilization Matting	SY	6032	$2.00	$12,064.00
7005	709130	Type D Soil Stabilization Matting	SY	393	$4.90	$1,925.70
					Sub-Total	***$58,803.20***
					Site Total:	**$299,332.70**

Section 9: Field Investigation Report

SHA Water Programs Division
SWM New BMPs Planning Task
Howard County Group 1

FIELD INVESTIGATION REPORT
SITE HOGr1-JMT-023

Prepared By: JMT
1/19/2016

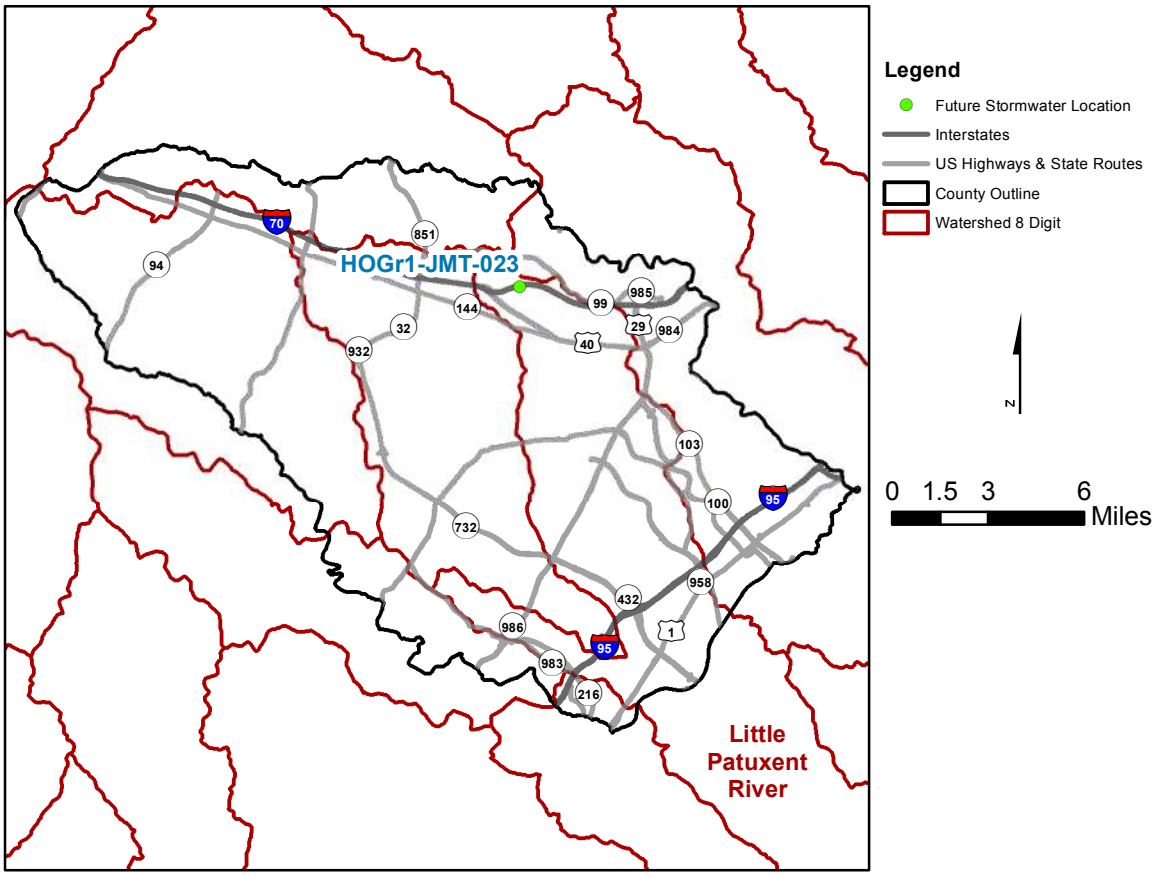
CONTENTS

1 County Location Map

2 FI Checklist

3 Field Map(s)

Section 1: County Location Map



Section 2: Field Checklist

SHA Water Programs Division
SWM New BMPs Planning Task

FIELD INVESTIGATION CHECKLIST

Pre-Investigation Data

County:	Howard Countv
Watershed ID (8-digit):	02131105
Site Number:	HOGr1-JMT-023
Location (route/intersection):	I-70EB west Marriottsville Rd ramp Example: MD 320, east of Flower Ave
As-built plans available?	(•) Yes ( ) No
If yes, Contract #:	HO359-001-717;HO305-005-742
Potential BMP Type per DE:	Infiltration trench
Primary Hydrologic Soil Group:	B. D
Approximate SHA-Owned Impervious Area Treated per DE:	1.54 acres
Posted Speed Limit:	65 mph
Is site within...	
...five miles of BWI or Martin State Airports, or four miles of any other airport?	( ) Yes (•) No
...the Chesapeake Bay Critical Area?	( ) Yes (•) No
...the FEMA 100-yr floodplain?	( ) Yes (•) No
Does site potentially conflict with Tree Planting Site Selection?	( ) Yes (•) No

Field Investigation

Consultant:	JMT
Inspector:	P. Crawford/C. Swetz
Date of Inspection:	01/13/2016

Has precipitation occured within the last three days? (●) Yes ( ) No

Overall Site Photo: (Photo # Ex: *YYYY-MM-DD-FullSite#-Photo#*)

Attach Photo Photo #: 01 Photo Description: Overview of site

Site Land Use: Open Space

Should site be removed from consideration? (●) Yes ( ) No

If yes, why?... This site may already qualify for grass swale credit. See additional comments for more.

Examples: Steep slopes, site is completely wooded, change in land use or ownership, major utility conflict

If there is an existing conveyance ditch at the site, does the configuration of the ditch (ie. flat bottom, shallow slope, etc.) have potential to qualify for grass channel credit? (●) Yes ( ) No ( ) N/A

Is ROW observed in the field consistent with the GIS ROW layer? (●) Yes ( ) No

if no... Attach Photo Photo #: Photo Description:

If no, describe observed ROW...

If BMP site is adjacent to Tree Assets... Have trees been installed?

○ Yes ◉ No ○ N/A

If yes, describe the condition of the trees...and attach photo...

Trees have not been installed

Attach Photo Photo #: Photo Description:

Construction & Maintenance Access:

☑ Access is good. (Unobstructed and direct from SHA ROW

Or, check any items below that may affect access:

☐ steep slopes ☐ private property

☐ guard rail ☐ fencing

☐ other...

Attach Photo Photo #: Photo Description:

Existing Utilities:

☑ existing utilities do not appear to be present at the site

Or, check any items below that apply:

☐ overhead lines above the anticipated project LOD

☐ overhead lines above the anticipated facility footprint

☐ surface features and/or underground utilities within anticipated project LOD

☐ surface features and/or underground utilities within anticipated facility footprint

☐ other...

If existing utilities are present, attach photo...

Attach Photo Photo #: Photo Description:

Environmental Features:

Wetlands and/or surface waters present?

- ○ Yes, within BMP footprint (permanent impact)
- ○ Yes, within anticipated site LOD, outside of BMP footprint
- ◉ No

If yes attach photo...

Attach Photo Photo #: Photo Description:

Steep slopes (15%+) present on site?

- ○ Yes, within BMP footprint
- ◉ Yes, within anticipated site LOD, outside of BMP footprint
- ○ No

If yes attach photo...

Attach Photo Photo #: 02 Photo Description: Steep slopes

Trees present on site?

- ○ Yes, within BMP footprint
- ○ Yes, within anticipated site LOD, outside of BMP footprint
- ◉ No

If yes attach photo...

Attach Photo Photo #: Photo Description:

Maintenance of Traffic Needs:

☐ M.O.T. is not required

Or, Select all that may apply:

- ☑ Lane Closure
- ☐ Detour
- ☑ Flagging operations (temporary construction vehicle movement on/off site)
- ☑ Shoulder Closure

Public Involvement:

Is this site in close proximity to or bordering any of the following land uses that may result in public concerns with noise, safety, and/or general quality of living?

- [x] No
- [ ] Business(es)
- [ ] Private Residence(s)
- [ ] Pedestrian Areas

Site Flow Conditions:

Inflow Conditions:

How does runoff from SHA impervious area enter the site? Note: Flow type and Stability.

Sheet flow from SHA Impervious, stable. Sheet flow from offsite drainage from wooded area. Stable sheet flow.

Example: Sheetflow directly from roadway

Attach Photo Photo #: 03 Photo Description: Inflow

Outfall Conditions:

How does flow exit the proposed facility? Note: Flow type and Stability.

Current site outfalls into ditch running parallel to the roadway. Appears stable, however there is signifigant erosion/sedimentation within the channel.

Example: Overflow inlet

Attach Photo Photo #: 04 Photo Description: Ex Outfall

How does flow exit SHA ROW at POI? Note: Flow type and Stability.

Ditch parallel to road that reaches a rip rap/conc. ditch falling to surface stream. Signs of erosion and sedimentation along the ditch for the entire length.

Example: Storm drain outfall to riprap channel

Attach Photo Photo #: 05 Photo Description: POI

Could site be a potential hot spot? ○ Yes ◉ No

Example: Site is adjacent to an existing fueling station, salt dome, etc.

If yes, description...

Additional Comments Otherwise Not Captured:

Infiltration trench not recommended for this site. The comments mention keeping the ex drainage channel to capture off site drainage & putting an infiltration trench on the roadway side to capture SHA Impervious drainage. There does not appear to be enough room to place the infiltration trench between the roadway edge & the drainage ditch bottom. Additionally, significant re-grading of the hill slope would be necessary. Overall, the effort to construct an infiltration trench would be very great compared with evaluating the current site for grass swale credit and making modifications.

Additional Photos:

Attach Photo	Photo #:	06	Photo Description:	Woods near site
Attach Photo	Photo #:	07	Photo Description:	Tree asset across road
Attach Photo	Photo #:		Photo Description:	
Attach Photo	Photo #:		Photo Description:	
Attach Photo	Photo #:		Photo Description:	
Attach Photo	Photo #:		Photo Description:	
Attach Photo	Photo #:		Photo Description:	
Attach Photo	Photo #:		Photo Description:	

Please consider the following to ensure that the maximum Runoff Storage Volume (Rs) is provided at the site.

Is there potential to increase the runoff storage volume provided by expanding the size of the proposed facility beyond the apparent limits of SHA ROW in this location?

○ Yes ◉ No

If yes...

If yes attach photo...

Attach Photo Photo #: Photo Description:

Is there potential to adjust the existing storm drain configuration and/or existing drainage patterns to increase the impervious area contributing to a facility at this location?

○ Yes ◉ No

If yes...

If yes attach photo...

Attach Photo Photo #: Photo Description:

Post Field Investigation Results

Based on the results of the Field Investigation, what is the recommended proposed BMP type?

Bioswale

In order to construct the proposed BMP type, does it appear that ROW acquisition will be required ?	○ Yes ◉ No
If yes, approximately how much (acres)?:	
Overall drainage area to site (acres):	10.91
SHA-owned Impervious Area to site (acres):	1.32
Non SHA-owned impervious area to site (acres):	0

Print Report

Save Data

2016-01-13-HOGr1-JMT-023-Photo-01

Overall view to the proposed site

2016-01-13-HOGr1-JMT-023-Photo-02

Steep slopes

2016-01-13-HOGr1-JMT-023-Photo-03

Inflow to the proposed site is sheet flow

2016-01-13-HOGr1-JMT-023-Photo-04

Existing site outfall is the ditch along the roadway

2016-01-13-HOGr1-JMT-023-Photo-05

POI

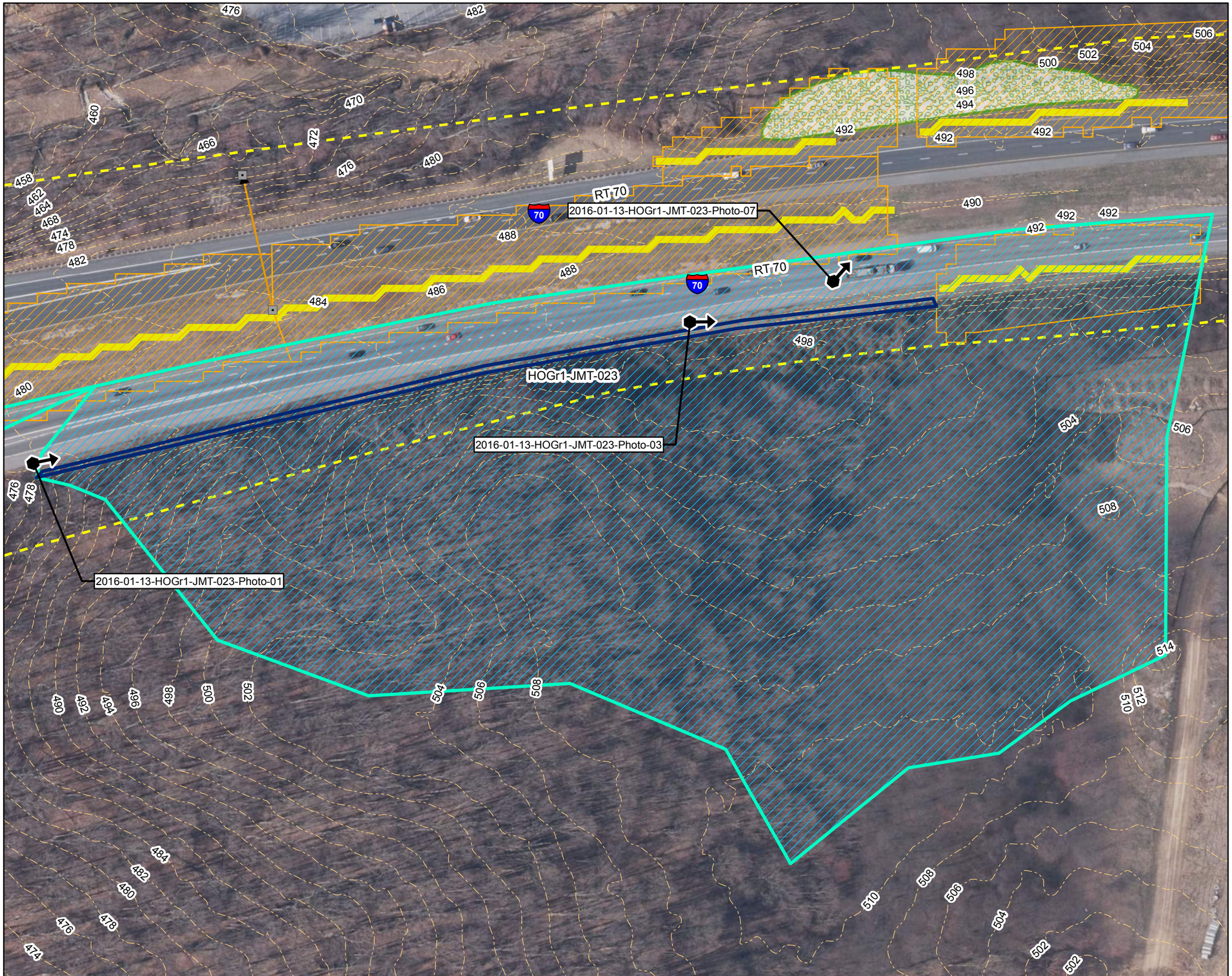
2016-01-13-HOGr1-JMT-023-Photo-06

Highly wooded area adjacent to the entire site

2016-01-13-HOGr1-JMT-023-Photo-07

TMDL trees on the opposing side of the highway, look to be in good condition

Section 3: Field Map(s)



SHA TMDL SWM Field Investigation

Howard County, MD

HOGr1-JMT-023

Map Date: 3/3/2016

Legend

- Future Stormwater Location
- Planned Drainage Area
- SHA ROW
- SHA SWMFAC
- SWMFAC Drainage Area
- SHA Drainage Structure
- SHA Drainage Ditch
- SHA Stormdrain Pipe
- TMDL Tree Planting
- Critical Area
- NWI Wetlands 2011
- DNR Wetlands 2005
- Floodplains 2012
- Watershed 8 Digit
- Contour
- Photo Location and Direction

HOGr1-JMT-023
Total DA = 10.91 AC
Impervious Area = 1.32 AC

1 inch = 100 feet

0 50 100 200

Feet

N

JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future®

SHA TMDL SWM Field Investigation

Howard County, MD

HOGr1-JMT-023

Map Date: 3/3/2016

Legend

- Future Stormwater Location
- Planned Drainage Area
- SHA ROW
- SHA SWMFAC
- SWMFAC Drainage Area
- SHA Drainage Structure
- SHA Drainage Ditch
- SHA Stormdrain Pipe
- TMDL Tree Planting
- Critical Area
- NWI Wetlands 2011
- DNR Wetlands 2005
- Floodplains 2012
- Watershed 8 Digit
- Contour
- Photo Location and Direction

HOGr1-JMT-023
Total DA = 10.91 AC
Impervious Area = 1.32 AC

1 inch = 200 feet

0 100 200 400

Feet

N

JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future®

Appendix D

Hydrology Computations

"Stable Channel Discharge" Pg 1

Project SW Assessment of Controls **By** BM **Date** 2/2/2017

Checked **Date**

See Stream Response to Stormwater Management Best Management Practices in Maryland for methods

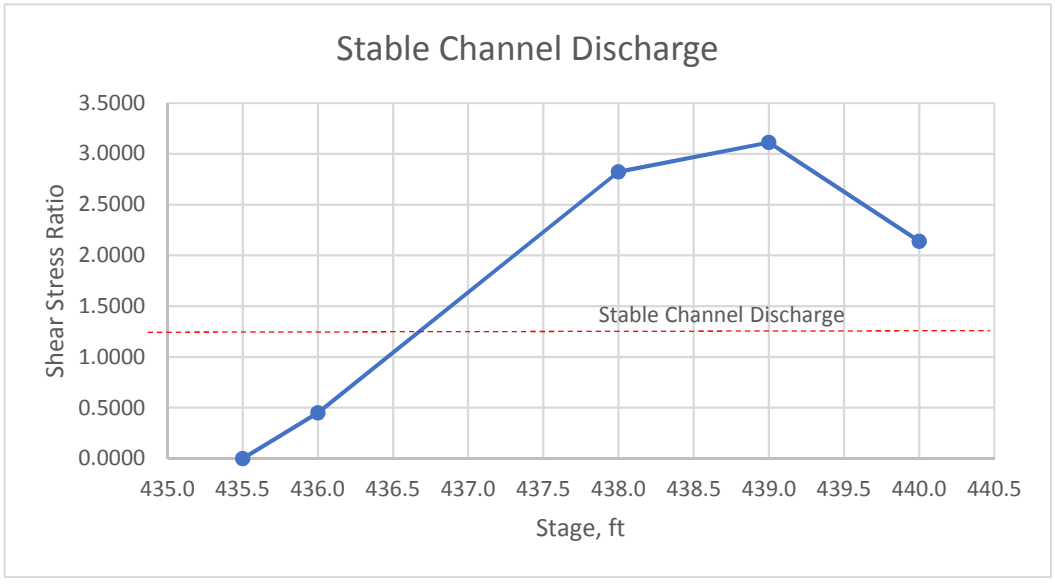
Parameters				
θ	0.047	R	Variable	
	62.42 lbs/ft³	S	0.0030 ft/ft	
	105.00 lbs/ft³	D	0.052 ft	16mm
	2.65 slugs/ft³	Critical Shear	0.1041	
	1.00 lbs/ft³			

See Flowmaster Comps (SW Assessment of Controls XS)

Stage (ft)	R (ft)	Q (cfs)	Shear (psf)	SS Ratio
435.5	0.00	0.00	0.0000	0.0000
436.0	0.25	1.84	0.0468	0.4498
438.0	1.57	75.43	0.2940	2.8249
439.0	1.73	142.61	0.3239	3.1127
440.0	1.19	1385.79	0.2228	2.1411

Stable Channel stage **436.63 ft**

Stable Channel Discharge **25.08 cfs**



The shear stress ratio is used as an indicator of stability at various stages (or depth) within the channel. The shear stress ratio is the ratio of the average boundary shear stress to the critical shear stress and can be defined by the equation (Johnson, et. al, 1999):

$$\tau_e = \tau_o / \tau_c$$

where τ_e = the shear stress ratio, τ_o = the average boundary shear stress, and τ_c = the critical shear stress at which grain movement is initiated. The average boundary shear stress is defined by:

$$\tau_o = \gamma RS$$

where γ = the specific weight of water, R = the hydraulic radius, and S = channel slope. In reference to Table 2, the average boundary shear (τ_o) is calculated at different depths in the channel. The WINXSPRO program can calculate hydraulic radius by using the channel cross-section data, and the cross-sectional area and wetted perimeter are computed at different depths. The critical shear stress (τ_c) is then calculated using the Shields equation for critical shear stress (Johnson et. al, 1999):

$$\tau_c = \theta(\gamma_s - \gamma)D$$

where τ_c is critical shear stress, θ = Shields parameter, γ_s = specific weight of sediment, γ = specific weight of water, and D is particle size. The Shield's parameter is a function of particle size and the density of particle arrangement. Particle size at each cross-section was collected in the field according to the procedure in Wolman, 1954 and reported in MDE, 1999. The median size of bed materials, D_{50}, is used as the representative diameter (Gordon et. al, 1992).

```
WinTR-20 Printed Page File      Beginning of Input Data List
C:\Users\bmartinez\Documents\RAS Projects\SW Assessments\TR-20\tr20in.inp

WinTR-20: version 3.10                  0         0                   0
I-70 SW AoC

SUB-AREA:
          Existing  OUTLET              1.9518    75.784    4.027     Y
          Proposed  OUTLET              1.9518    75.661    4.027     Y
          Forest    OUTLET              1.9518    62.3      4.027     Y
          1         OUTLET              1.9518    73.28     4.027     Y
          2         OUTLET              1.9518    70.74     4.027     Y
          3         OUTLET              1.9518    70.34     4.027     Y
          4         OUTLET              1.9518    69.19     4.027     Y
          5         OUTLET              1.9518    65.68     4.027     Y
          6         OUTLET              1.9518    65.58     4.027     Y
          7         OUTLET              1.9518    63.04     4.027     Y
          8         OUTLET              1.9518    62.81     4.027     Y
          9         OUTLET              1.9518    62.30     4.027     Y


STORM ANALYSIS:
          1.12yr-BF           0.0       2.34      Rain  1   2




RAINFALL DISTRIBUTION:
          Rain  1               0.10000
                           0.0   0.00310   0.00620   0.00930   0.01240
                       0.01550   0.01850   0.02160   0.02470   0.02780
                       0.03090   0.03400   0.03710   0.04020   0.04330
                       0.04640   0.04940   0.05250   0.05560   0.05870
                       0.06180   0.06490   0.06800   0.07110   0.07420
                       0.07730   0.08030   0.08340   0.08650   0.08960
                       0.09270   0.09810   0.10350   0.10890   0.11440
                       0.11980   0.12520   0.13060   0.13600   0.14140
                       0.14680   0.15220   0.15770   0.16310   0.16850
                       0.17390   0.17820   0.18260   0.18690   0.19130
                       0.19560   0.20560   0.21550   0.22550   0.23540
                       0.24530   0.26550   0.28560   0.31780   0.36890
                       0.50000   0.63110   0.68220   0.71440   0.73450
                       0.75470   0.76460   0.77450   0.78450   0.79440
                       0.80440   0.80870   0.81310   0.81740   0.82180
                       0.82610   0.83150   0.83690   0.84230   0.84780
                       0.85320   0.85860   0.86400   0.86940   0.87480
                       0.88020   0.88560   0.89110   0.89650   0.90190
                       0.90730   0.91040   0.91350   0.91660   0.91970
                       0.92270   0.92580   0.92890   0.93200   0.93510
                       0.93820   0.94130   0.94440   0.94750   0.95060
                       0.95360   0.95670   0.95980   0.96290   0.96600
                       0.96910   0.97220   0.97530   0.97840   0.98150
                       0.98450   0.98760   0.99070   0.99380   0.99690
                       1.00000




Global Output:
                                 0.100
```

I-70 SW AoC

Name of printed page file:
C:\Users\bmartinez\Documents\RAS Projects\SW Assessments\TR-20\tr20in.out

STORM 1.12yr-BF

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Existing	1.952		0.590		8.94	140.1	71.77
Proposed	1.952		0.585		8.95	138.8	71.09
Forest	1.952		0.177		9.83	34.7	17.77
1	1.952		0.493		9.09	113.4	58.10
2	1.952		0.405		9.18	89.8	46.02
3	1.952		0.392		9.19	86.5	44.32
4	1.952		0.356		9.22	77.3	39.60
5	1.952		0.257		9.52	53.0	27.16
6	1.952		0.254		9.52	52.4	26.84
7	1.952		0.193		9.82	38.3	19.61
8	1.952		0.188		9.82	37.1	19.03
9	1.952		0.177		9.83	34.7	17.77
OUTLET	23.422		0.339		9.19	884.4	37.76

I-70 SW AoC

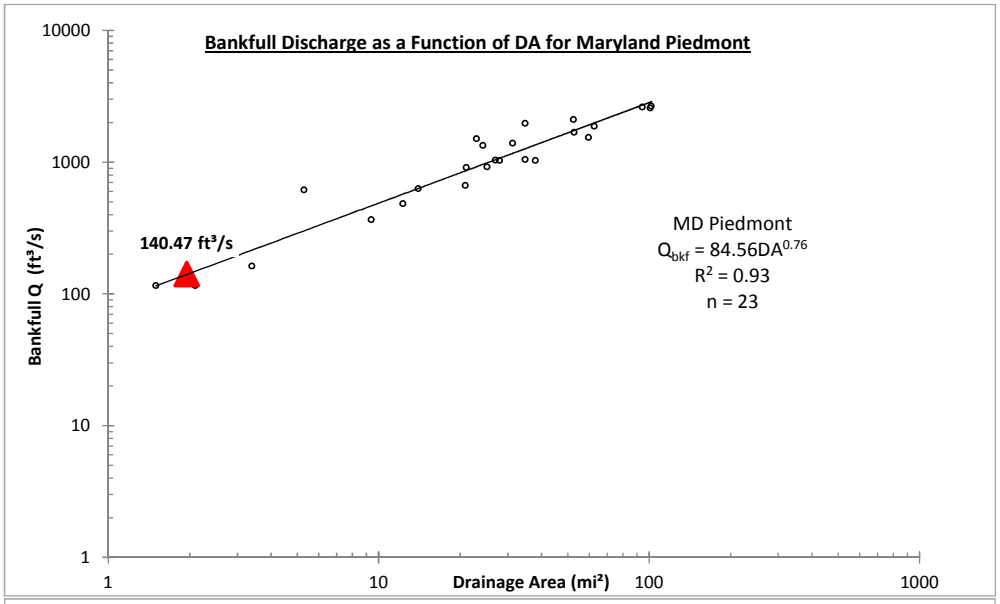
Area or Reach Identifier	Drainage Area (sq mi)	Peak Flow by Storm 1.12yr-BF (cfs)	(cfs)	(cfs)	(cfs)	(cfs)
Existing	1.952	140.1				
Proposed	1.952	138.8				
Forest	1.952	34.7				
1	1.952	113.4				
2	1.952	89.8				
3	1.952	86.5				
4	1.952	77.3				
5	1.952	53.0				
6	1.952	52.4				
7	1.952	38.3				
8	1.952	37.1				
9	1.952	34.7				
OUTLET	23.422	884.4				

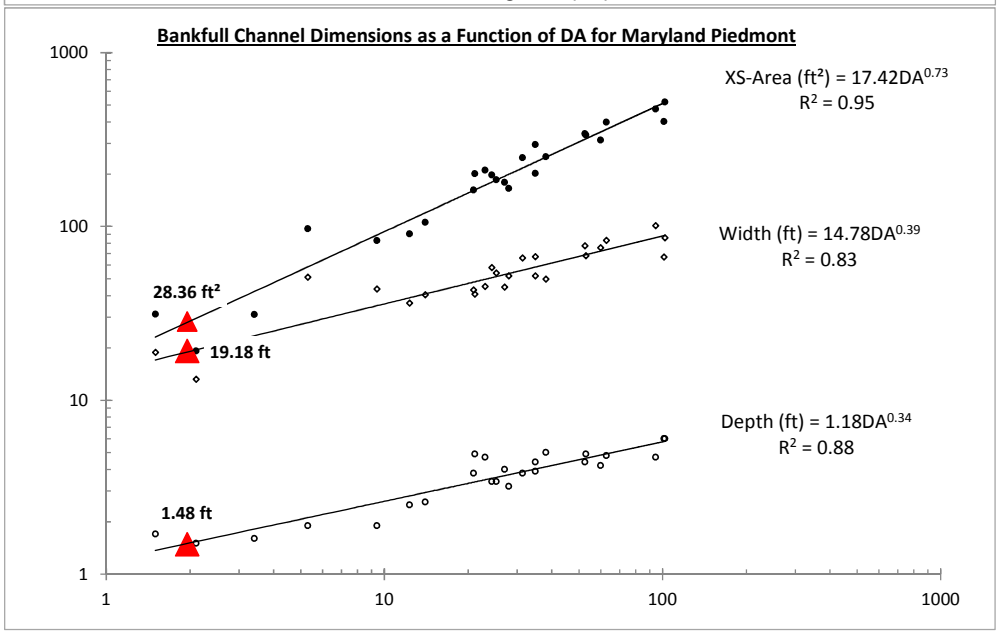
81 Mosher Street
Baltimore, MD 21217

Project:	**SW Assessment of Controls - LPR**
Project #:	
RKK Project #:	**11110 SHANEPA**
Date:	**February 3, 2017**

Bankfull Discharge and Dimension per FWS CBFO-S02-01

Drainage Area =	**1.95 mi²**
Bankfull Discharge =	**140.47 ft³/s**
Bankfull XS Area =	**28.36 ft²**
Bankfull Width =	**19.18 ft**
Bankfull Mean Depth	**1.48 ft**





Taken From:
McCandless, T.L. and R.A. Everett. 2002. Maryland stream survey: Bankfull discharge and channel characteristics in the Piedmont hydrologic region. U.S. Fish and Wildlife Service, Annapolis, MD. CBFO-S02-02.

\\balsrv02\v2011\2011\11110_SHANEPA\Task41_TMDL Support\Assessmt_of_Cntrls\SW\GIS\LUInvestigation\[USFWS Bankfull Dimensions.xlsx]Sheet2

Watershed-wide Approach on Stable Channel Discharge Pg 1

Project SW Assessment of Cor **By** BM **Date** 2/2/2017

Checked **Date**

Drainage Area	1.95	sq-mi	
USFWS Bankfull	140.47	cfs	See 'USFWS Bankfull Dimensions.xslx'
Return Interval	1.12	yrs	
valent Rainfall Depth	2.35	inches	<-Derived from iterating WinTR-20 model for Existing Conditions

Bankfull Q - 1.12-yr	**RCN**	**Description of Watershed Focus**
140.5 cfs	75.78	Existing Conditions
138.8 cfs	75.66	Proposed Conditions
113.4 cfs	73.28	Assumed Treatment from post 2011 Developments
89.8 cfs	70.74	Howard County Participation
86.5 cfs	70.34	Subdivision Participation
77.3 cfs	69.19	Business Participation
53.0 cfs	65.68	All Resident Participation
52.4 cfs	65.58	Conversion of all Open Space
38.3 cfs	63.04	All Roadways and Associated Easements
37.1 cfs	62.81	Golf Course
34.7 cfs	62.30	Landfill (All Woods in good Condition)

Appendix E

Field Forms

MARYLAND DEPARTMENT OF TRANSPORTATION™

STATE HIGHWAY ADMINISTRATION

MARYLAND STREAM STUDY

LONGITUDINAL PROFILE

STREAM:							DATE:			CREW:			
USGS #			ALL MEASUREMENTS IN FEET UNLESS OTHERWISE NOTED.										
FWS #			REFERENCE POINT ELEVATION AND DESCRIPTION:										
Identifier	Backsight	Height of Instrument	Station	Bed Surface Foresight	Bed Surface Elevation	Water Surface Foresight	Water Surface Elevation	Bankfull Foresight	Bankfull Elevation	Top of Bank Foresight	Top of Bank Elevation	Other Foresight	Other Elevation

MARYLAND STREAM STUDY

CROSS SECTION

STREAM	DATE
USGS #	CREW
FWS #	

Begin on left, facing downstream (all measurements are in feet unless otherwise noted)

NOTE	DIST.	ELEV. / DEPTH	NOTE	DIST.	ELEV. / DEPTH

MARYLAND STREAM STUDY
REACH AVERAGE PEBBLE COUNT

STREAM		**DATE**	
USGS #		**CREW**	
FWS #		**PARTICLE TALLY COUNTS BY TRANSECT**	

FEET	PARTICLE	MILLIMETERS		1	2	3	4	5	6	7	8	9	10	TOT#	ITEM%	%CUM
	Silt/Clay	< .062	S/C													
	Very Fine	.062 - .125	S													
	Fine	.125 - .25	A													
	Medium	.25 - .50	N													
	Coarse	.50 - 1.0	D													
	Vry Coarse	1.0 - 2	S													
	Very Fine	2 - 4														
	Fine	4 - 6	G													
	Fine	6 - 8	R													
	Medium	8 - 12	A													
	Medium	12 - 16	V													
	Coarse	16 - 24	E													
	Coarse	24 - 32	L													
	Vry Coarse	32 - 48	S													
	Vry Coarse	48 - 64														
0.21-0.31	Small	64 - 96	C													
0.31-0.42	Small	96 - 128	O													
0.42-0.63	Large	128 - 192	B													
0.63-0.84	Large	192 - 256	L													
0.84-1.26	Small	256 - 384	B													
1.26-1.68	Small	384 - 512	L													
1.68-3.36	Medium	512 - 1024	D													
3.36-6.72	Lrg	1024 - 2048	R													
6.72-13.43	Vry Lrg	2048-4096														
	Bedrock	>4096	BDRK													
	CHANNEL WIDTH AT TRANSECT															

	LENGTH	PROPORTION	NO. UNITS	SAMPLED
REACH				
POOL				
RIFFLE				
RUN				

TRANSECT	FEATURE	LENGTH	LOCATION	COUNT
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Worksheet 6-2. Bank profile and bank erosion summary data form.

Bank Profile Form

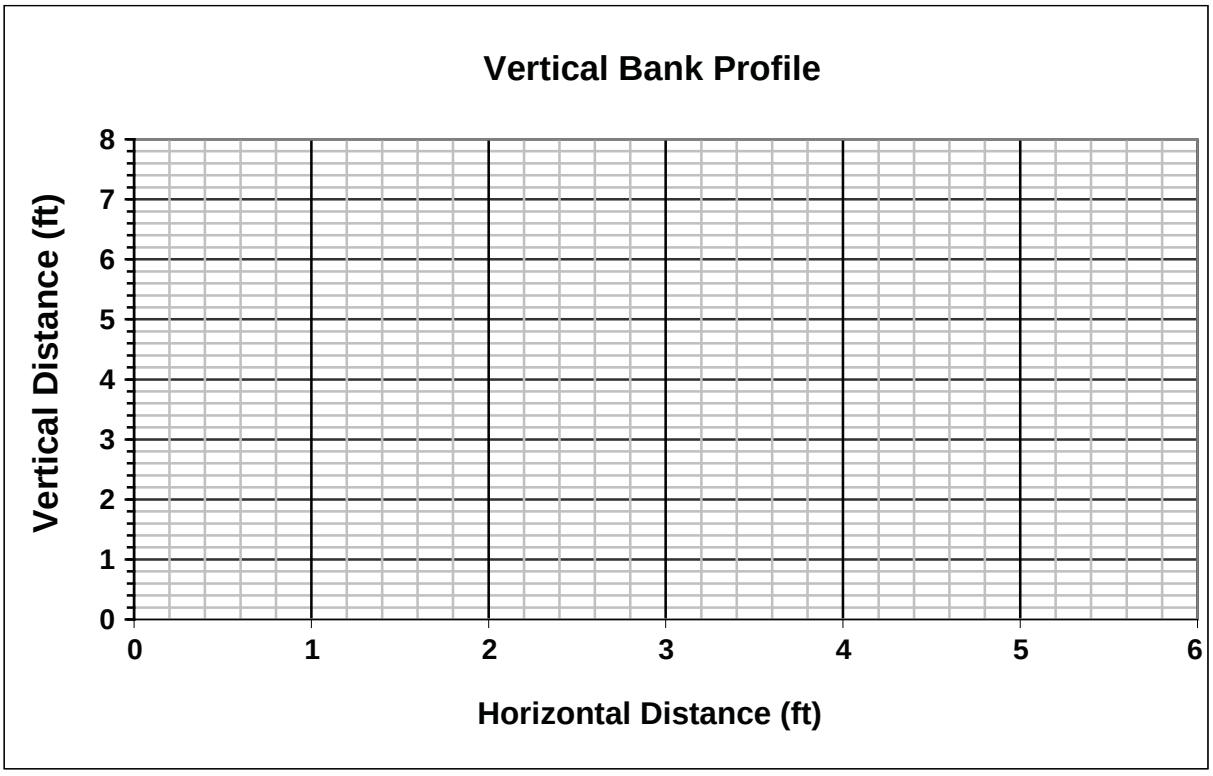
Stream:	Observers:
Location:	Date:
Cross-Section:	BEHI Adjective Rating:
Bank:	NBS Adjective Rating:
Toe-Pin Station (ft):	Predicted Erosion (ft):
Toe-Pin Elevation (ft):	Measured Erosion (ft):

Date:

Horizontal	Vertical	Notes

Date:

Horizontal	Vertical	Notes



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Worksheet 6-2. Bank profile and bank erosion summary data form.

Bank Profile Form

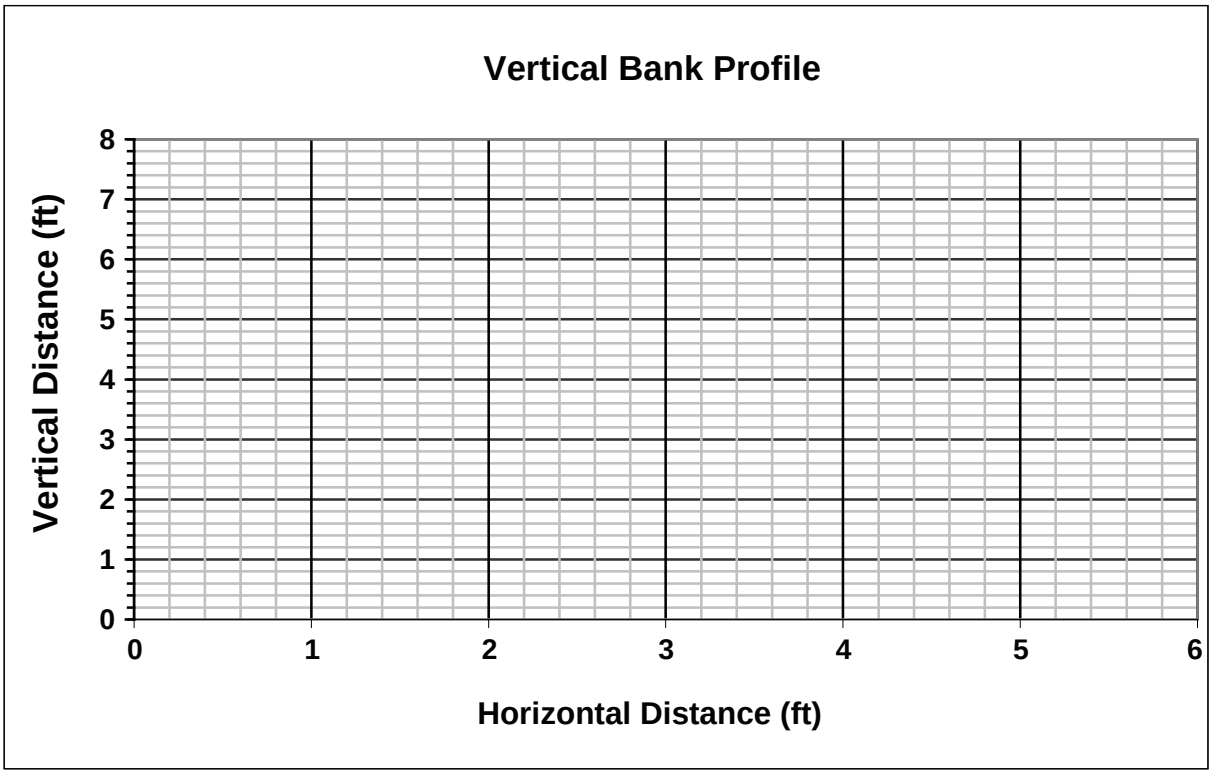
Stream:	Observers:
Location:	Date:
Cross-Section:	BEHI Adjective Rating:
Bank:	NBS Adjective Rating:
Toe-Pin Station (ft):	Predicted Erosion (ft):
Toe-Pin Elevation (ft):	Measured Erosion (ft):

Date:

Horizontal	Vertical	Notes

Date:

Horizontal	Vertical	Notes



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Appendix F

Howard County Data and Planning

F.1 – TR-20 Analysis and Supporting Documentation

F.2 – Marriottsville Road Improvement Plans

F.3 – Little Patuxent Watershed Plan

MARYLAND DEPARTMENT OF TRANSPORTATION™

STATE HIGHWAY ADMINISTRATION

Appendix F

Howard County Data and Planning

F.1 – TR-20 Analysis and Supporting Documentation

MARYLAND DEPARTMENT OF TRANSPORTATION™

STATE HIGHWAY ADMINISTRATION

Project:	NPDES/MS4 Assessment of Controls	Designed By:	
		Checked By:	SBP
County/Gr:	Howard County	Approved By:	
Watershed:		Date:	10/3/2017
SHA Project Number:			
RKK Project Number:		**POI:**	
Design Phase:	Concept	**Facility No:**	**Bioretention**
		Location:	

F-6: Bioretention Design Calculations (TMDL only)

Step 1: Determine Contributing Area Data:

Input Cell

ESD_v Target (P_E) =	1.0	*in.*	= Target P_E (1.0 to 2.6 inches) ---> will be iterative based on site constraints	
Contributing Area (A) =	193435	*sf.*	---------->	4.44 *ac.*
Contributing Impervious Area (A_i) =	77597	*sf.*	---------->	1.78 *ac.*
Percent Impervious Area ($\%_{IMP}$) =	40.1	% → use	45%	
Volumetric Runoff Coefficient (R_v) =	0.411		= 0.05 + 0.009 * ($\%_{IMP}$) (pg 5-18 of the MDE manual)	
ESDv Required (ESD_v) =	6626	*cf.*	= (P_E * A * R_v) / 12 (pg 5-18 of the MDE manual)	

Step 2: Determine Bioretention Dimensions:

Filter bed depth (d_f)=	2.0	*ft.*	
Coefficient of Permeability (k)=	2.0	*ft/day*	
Average height above filter bed (h_f)=	0.5	*ft.*	= average ponding depth, maximum 12" for ESD_v
Filter bed draindown time (t_f)=	2.0	*days*	
Filter Bed Area Required =	1325	*sf.*	= (WQ_v) (d_f) / [(k) (h_f + d_f) (t_f)] (pg 3.40 of MDE Manual)
Side Slope =	0.25	*ft/ft*	= 3:1 or flatter
Filter Bed Area Provided (A_f) =	2312	*sf.*	

Facility footprint is adequate.

Step 3: Determine Storage Requirements:

Percent Impervious Area ($\%_{IMP}$) =	45.0%		= impervious area divided by total contributing drainage area (A_i/A)
A_f/A_i =	3.0%		= filter bed area divided by impervious area (A_f/A_i)
ESD_v Required (ESD_v) =	6626	*cf.*	= (P_E * A * R_v) / 12
Percent Storage Required Above Surface ($V_{\%-S}$) =	52.7%	*of* ESD_v	= Surface Storage tables based on P_E, $\%_{IMP}$, and A_f/A_i
Min. Surface Storage Required (V_S)=	3492	*cf.*	= $V_{\%-R}$ * ESD_v

Tables to be used with State Highway Administration (SHA) Bioretention Soil Mix (BSM)

Storage Volume (% of ESDv) required above surface for Pe = 1.0 inches

%Imp	Af/Ai 2%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
5%	44%	39%	32%	26%	21%	18%	16%	14%	12%	11%	10%
10%	47%	41%	32%	27%	23%	20%	18%	16%	14%	13%	12%
15%	50%	43%	35%	30%	26%	24%	21%	19%	18%	16%	14%
20%	52%	45%	38%	33%	29%	26%	24%	22%	20%	19%	17%
25%	52%	46%	39%	34%	30%	27%	24%	23%	21%	19%	17%
30%	53%	46%	39%	35%	31%	28%	25%	23%	21%	19%	17%
35%	53%	47%	40%	35%	31%	28%	26%	23%	22%	20%	18%
40%	54%	48%	41%	36%	32%	29%	26%	24%	22%	20%	18%
45%	55%	48%	42%	37%	33%	30%	27%	25%	22%	20%	18%
50%	56%	49%	42%	38%	34%	30%	28%	25%	23%	21%	19%
55%	56%	50%	43%	38%	34%	31%	28%	26%	23%	21%	19%
60%	57%	50%	44%	39%	35%	31%	28%	26%	23%	21%	19%
65%	57%	50%	44%	39%	35%	31%	28%	26%	23%	21%	19%
70%	57%	50%	44%	39%	35%	31%	28%	26%	23%	21%	19%
75%	57%	50%	44%	39%	35%	31%	28%	26%	23%	21%	19%
80%	57%	50%	44%	39%	35%	31%	28%	26%	23%	21%	19%
85%	57%	50%	44%	39%	35%	31%	28%	26%	23%	21%	19%
90%	57%	50%	44%	39%	35%	31%	28%	26%	23%	21%	19%
95%	57%	50%	44%	39%	35%	31%	28%	26%	23%	21%	19%
100%	57%	50%	44%	39%	35%	31%	28%	26%	23%	21%	19%

Step 4: Determine Surface Storage Provided by Bioretention:

Project: NPDES/MS4 Assessment of Controls
County/Gr: Howard County
Watershed:
SHA Project Number:
RKK Project Number:
Design Phase: Concept

Designed By:
Checked By: SBP
Approved By:
Date: 10/3/2017

POI:
Facility No: Bioretention
Location:

Stage Storage Table

Elevation [ft.]	Area [ft²]	Area [acre]	Change in Elevation [ft]	Average Area [acre]	Incremental Volume [acre·ft]	Cumulative Volume [acre·ft]	Cumulative Volume [ft³]
456.00	3,035.10	0.0697				0.0000	0.00
456.50	3521.60	0.0808	0.5	0.0753	0.0376	0.0376	1,639.18
457.00	4,037.80	0.0927	0.5	0.0868	0.0434	0.0810	3,529.03

Step 5: Determine Treatment Provided by the Bioretention:

Min. Surface Storage Required (V_S)=	3492	*cf.*	*= Surface Storage tables based on P_E, $\%_{IMP}$, and A_f/A_i*
Surface Storage Provided (V_S)=	3529	*cf.*	*= total volume from stage storage table*
Percent Surface Storage Provided ($V_{\%-S}$)=	53%		*= percent surface storage provided based on a Pe of 1 inch*

Because the proposed facility is providing more than enough surface storage, iterations will need to be done to determine the larger Pe treated.

			Percent Storage		*Actual > Required*
From	P_E	ESD_v	Required	Actual	
	in.	cf.	%	%	Y/N
Table	1.00	6626	52.71%	53.26%	Yes
Iteration	1.00	6626	52.71%	53.26%	Yes
Table	1.10	7288	53.04%	48.42%	No

The Pe credited is 1 in. and the ESDv credited is 6626 cf.

The PE treated is based on providing a surface storage volume that is a certain percent of the ESDv, but the ESDv changes depending on the Pe. Therefore, determing the Pe treated is an iterative process. The table shown demonstrates this process. The user should input the highest Pe value possible that still meets the required percent surface storage.

Step 6: Determine the Impervious Area Treated by the Bioretention:

Contributing Impervious Area	P_E treated	Impervious Acre Credit*
ac.	in.	ac.
1.78	1.00	1.78

** Impervious Acre Credit is based on Table 3 (page 12) of the MDE Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated from August 2014.*

Step 7: Determine if Underdrain is Required:

Primary HSG Soil Group under filter media =	D		*underdrain is not required in A/B soils*

Underdrain is Required.

Step 8: Check Freeboard:

Q_{10} =	2	*cfs*	*= 10-yr discharge from TR-55*
Weir Length (L) =	20	*ft.*	
Discharge Coefficient (C) =	3.1		*= typically 3.1*
Hydraulic Head (H) =	0.10	*ft.*	*$=(Q_{10} / (CL))^{2/3}$*
Lowest SHA roadway elevation =	605	*ft.*	
Facility Control Elevation =	603	*ft.*	*= control elevation where highest 10-yr WSE will occur (typically outfall weir)*
Highest WSE of 10-yr storm =	604.2	*ft.*	*= highest 10-yr WSE will typically occur on top outfall weir*
Freeboard =	0.80	*ft.*	*= roadway elevation - WSE of 10-yr storm, freeeboard ≥ 9 inches*

Freeboard Requirements are Met.

Project:	NPDES/MS4 Assessment of Controls	Designed By:	
		Checked By:	SBP
County/Gr:	Howard County	Approved By:	
Watershed:		Date:	10/3/2017
SHA Project Number:			
RKK Project Number:		**POI:**	
Design Phase:	Concept	**Facility No:**	**Bio-swale A**
		Location:	

M-8: Bio-swale Design Calculations (TMDL only)

Step 1: Determine Contributing Area Data:

Input Cell

ESD_v Target (P_E) =	2.6	*in.*	= Target P_E (1.0 to 2.6 inches) ---> will be iterative based on site constraints	
Contributing Area (A) =	42008	*sf.*	---------->	0.96 *ac.*
Contributing Impervious Area (A_i) =	13456	*sf.*	---------->	0.31 *ac.*
Percent Impervious Area ($\%_{IMP}$) =	32.0	% → use	35%	
Volumetric Runoff Coefficient (R_v) =	0.338		= 0.05 + 0.009 * ($\%_{IMP}$) (pg 5-18 of the MDE manual)	
ESDv Required (ESD_v) =	3079	*cf.*	= (P_E * A * R_v) / 12 (pg 5-18 of the MDE manual)	

Step 2: Assume Bio-swale Dimensions:

Bioswale Length (L) =	206	*ft.*		
Bioswale Bottom Width (W) =	8	*ft.*		A_f/A =
Bioswale Surface Area (A_f) =	1648	*sf.*	= Surface Area must be ≥ 2% of the contributing Area ---->	12%
Left Side Slope (S_{S1}) =	0.25	*ft/ft*	= 3:1 or flatter	
Right Side Slope (S_{S2}) =	0.25	*ft/ft*	= 3:1 or flatter	
Bioswale Slope (S_L) =	0.0094	*ft/ft*	= 4% maximum longitudinal slope	

Step 3: Determine Storage Requirements:

Percent Impervious Area ($\%_{IMP}$) =	35.0%		= impervious area divided by total contributing drainage area (A_i/A)
A_f/A_i =	12.2%		= filter bed area divided by impervious area (A_f/A_i)
ESD_v Required (ESD_v) =	3079	*cf.*	= (P_E * A * R_v) / 12
Percent Storage Required Above Surface ($V_{\%-S}$) =	45.2%	*of* ESD_v	= Surface Storage tables based on P_E, $\%_{IMP}$, and A_f/A_i
Min. Surface Storage Required (V_S) =	1392	*cf.*	= $V_{\%-R}$ * ESD_v

Tables to be used with State Highway Administration (SHA) Bioretention Soil Mix (BSM)

Storage Volume (% of ESDv) required above surface for Pe = 2 - 2.6 inches

%Imp	Af/Ai										
	2%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
5%	46%	43%	39%	36%	32%	28%	26%	23%	21%	19%	18%
10%	50%	46%	41%	36%	32%	29%	27%	25%	23%	21%	20%
15%	53%	49%	43%	39%	35%	32%	30%	28%	26%	25%	24%
20%	55%	51%	45%	41%	38%	35%	33%	31%	29%	28%	26%
25%	55%	51%	46%	42%	39%	36%	34%	32%	30%	28%	27%
30%	56%	52%	46%	42%	39%	37%	35%	32%	31%	29%	28%
35%	56%	52%	47%	43%	40%	38%	35%	33%	31%	30%	28%
40%	57%	53%	48%	44%	41%	38%	36%	34%	32%	31%	29%
45%	58%	54%	48%	45%	42%	39%	37%	35%	33%	31%	30%
50%	58%	54%	49%	45%	42%	40%	38%	36%	34%	32%	30%
55%	59%	55%	50%	46%	43%	41%	38%	36%	34%	33%	31%
60%	59%	55%	50%	46%	44%	41%	39%	37%	35%	33%	31%
65%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
70%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
75%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
80%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
85%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
90%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
95%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
100%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%

Revised 6/14/2016

Step 4: Determine Surface Storage Provided by Bio-swale:

Check Dam Top Width (CD_W) =	1.00	*ft.*

Project:	NPDES/MS4 Assessment of Controls	Designed By:	
		Checked By:	SBP
County/Gr:	Howard County	Approved By:	
Watershed:		Date:	10/3/2017
SHA Project Number:			
RKK Project Number:		**POI:**	
Design Phase:	Concept	**Facility No:**	**Bio-swale A**
		Location:	

Check Dam Slope (S_{CD}) =	0.17	ft/ft	= max. slope 6:1 in clear zone and 3:1 outside the clear zone
Check Dam Height (CD_H) =	1.00	ft.	= max. 6" in the clear zone and 12" outside the clear zone
Maximal Length of Storage (L_{max}) =	106.38	ft.	= CD_H / S_L, If less than 50 ft. a minimum of 50 ft is used.
Length of Storage (L_S) =	50.00	ft.	= Length must be ≥ 50 ft and < L_{max}
Check Dam Length (CD_L) =	13.00	ft.	= 2 * CD_H / S_{CD} + CD_W
Check Dam Spacing (CD_S) =	63.00	ft.	= L_S + CD_L
Number of cells (C) =	3.00		= L / CD_S
Minimal Storage Depth (d_{min}) =	0.53	ft.	= S_L * (L_{max} - L_S)

Surface Storage Per Cell (V_C) = CD_H^3 / (6 * S_L* S_{S1}) + CD_H^3 / (6 * S_L* S_{S2}) + CD_H^2 * W / (2 * S_L)
- d_{min}^3 / (6 * S_L* S_{S1}) - d_{min}^3 / (6 * S_L* S_{S2}) - d_{min}^2 * W / (2 * S_L)

= 426.73 cf.

Total Surface Storage Provided (V_T) = 1395.38 cf. = V_C * C + ((L - CD_S * C) * V_C / CD_S)

Step 5: Determine Treatment Provided by the Bio-swale:

Min. Surface Storage Required (V_{S-R}) =	1392	cf.	= Surface Storage tables based on P_E, $\%_{IMP}$, and A_f/A_i
Surface Storage Provided (V_{S-P}) =	1395.4	cf.	= total volume from step 3
Percent Surface Storage Provided ($V_{\%-S}$) =	45%		= percent surface storage provided based on a Pe of 2.6 inches

Because the proposed facility is providing more than enough surface storage, iterations will need to be done to determine the larger Pe treated.

			Percent Storage		Actual >
From	P_E	ESD_v	Required	Actual	Required
	in.	cf.	%	%	Y/N
Table	2.60	3079	45.20%	45.32%	Yes
Iteration	2.60	3079	45.20%	45.32%	Yes
Table	0.00	0	0.00%	#DIV/0!	#DIV/0!

The PE treated is based on providing a surface storage volume that is a certain percent of the ESDv, but the ESDv changes depending on the Pe. Therefore, determing the Pe treated is an iterative process. The table shown demonstrates this process. The user should input the highest Pe value possible that still meets the required percent surface storage.

Because the proposed facility is providing a Pe greater than 2.6 in., the Pe credited is 2.6 in. and the ESDv credited is 3079.

Step 6: Determine the Impervious Area Treated by the Bio-swale:

Contributing Impervious Area	P_E treated	Impervious Acre Credit*
ac.	in.	ac.
0.31	2.60	0.43

** Impervious Acre Credit is based on Table 3 (page 12) of the MDE Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated from August 2014.*

Step 7: Determine if Underdrain is Required:

Primary HSG Soil Group under filter media = D — underdrain is not required in A/B soils

Underdrain is Required.

Step 8: Check Freeboard:

Q_{10} =	2	cfs	= 10-yr discharge from TR-55
Weir Length (L) =	6	ft.	
Discharge Coefficient (C) =	3.1		= typically 3.1
Hydraulic Head (H) =	0.23	ft.	=(Q_{10} / (CL))$^{2/3}$
Lowest SHA roadway elevation =	605	ft.	
Facility Control Elevation =	603	ft.	= control elevation where highest 10-yr WSE will occur
Highest WSE of 10-yr storm =	604.2	ft.	= highest 10-yr WSE will typically occur on top of most downstream checkdam
Freeboard =	0.8	ft.	= roadway elevation - WSE of 10-yr storm, freeeboard ≥ 9 inches

Freeboard Requirements are Met.

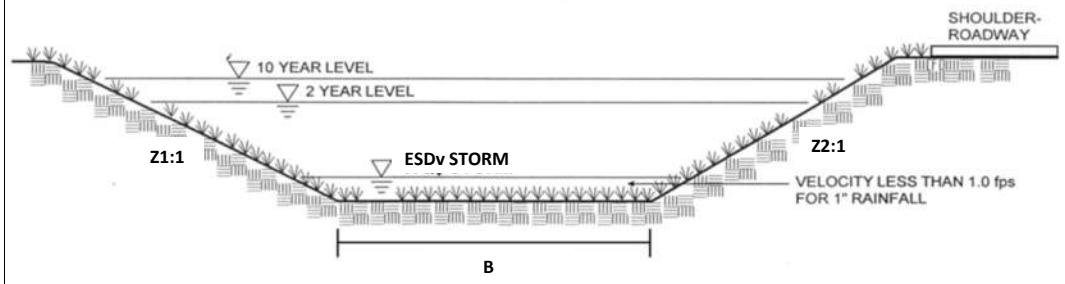
Step 9: Check 1" Stom Event Velocity:

1. The maximum flow velocity for runoff from the ESDv rainfall shall be less than or equal to 1.0 fps (see Appendix D.10 for methodology to compute flowrate). Ref. Vol. I, ch 5, pg 5.109

Project:	NPDES/MS4 Assessment of Controls	Designed By:	
		Checked By:	SBP
County/Gr:	Howard County	Approved By:	
Watershed:		Date:	10/3/2017
SHA Project Number:			
RKK Project Number:		**POI:**	
Design Phase:	Concept	**Facility No:**	**Bio-swale A**
		Location:	

ESDv Rainfall Depth (Pe) =	2.6	in.	= Use Required Contributing Pe
Drainage Area (A) =	0.964	ac.	
Total Impervious Area (I) =	0.309	ac.	
Time-of-Concentration (Tc) =	0.100	hr.	= Tc value from TR-55 Computations
Percent Impervious =	32.0	%	= I/A
Runoff Coefficient (Rv) =	0.338		= 0.05+0.009*(I)
Runoff Volume (Qe) =	0.88	in.	= Pe * Rv (Eq. Ref. Vol. II, Appendix D.10)
Adjusted RCN =	79		= 1000 / [10+5Pe+10Qa-10V(Qa2+1.25QaPe)] (Eq. Ref. Vol. II, Appendix D.10)
Initial Abstract (Ia) =	0.53		= (200/CN)-2
Ia/Pe =	0.20		= If Ia/Pe is less than 0.1 then 0.1 will be used.
Unit Peak Discharge (qu) =	972.3	csm/in.	= Log (q_u) = C_0 + C_1 * Log (Tc) + C_2 * [Log (Tc)]^2 (Figure D.11.1)
ESDv Peak Flow (Qw) =	1.29	cfs.	= (qu csm/in) * (A mi2) * (Qe in)

Typical Swale Cross section



Side Slope (Z1) =	4.000	:1
Side Slope (Z2) =	4.000	:1
Bottom Width (B) =	8	ft.
Slope of Channel (S) =	0.0094	ft/ft

$V = (1.49 * A * R^{2/3} * S^{1/2}) / n$

Flow Depth	Mann Coeff. (n)	Flow Area (A)	Hydraulic Radius (R)	R^(2/3)	A*R^(2/3)	Capacity (Qw)	Qp	Velocity (V)	Wetted Perimeter (WP)
(in.)		(sf.)	(ft.)			cfs	Cfs	fps	ft.
1.42	0.150	1.00	0.11	0.232	0.233	0.224	1.29	0.22	8.98
1.92	0.150	1.38	0.15	0.280	0.387	0.373	1.29	0.27	9.32
2.42	0.150	1.78	0.18	0.323	0.574	0.553	1.29	0.31	9.66

Depth of Flow = d =	1.92	in.	= from table above	
Computed Velocity = V =	0.27	fps	= Qw/A	velocity must be less than or equal to 1 fps -----> OK

Manning Roughness Coefficient (n) = 0.04 @ d > 12 in.* = reference for "n" value: P.1-2-B-6 of SHA Highway Drainage Manual

* n = 1.015 for d < 4" and n = 0.207-0.0145*d for 4" < d < 12" (Grass Channel Paper)

Step 10: Check 10-yr Stom Event Velocity:

2. The maximum flow velocity for runoff from the ten-year design event shall be non erosive. Ref. Vol. I, ch 5, pg 5.109

Revised 6/14/2016

Maximum permissible velocities of flow shall not exceed the values shown on the following table:

Table D.12.1 Permissible Velocities for Channels Lined with Vegetation

Project: NPDES/MS4 Assessment of Controls
County/Gr: Howard County
Watershed:
SHA Project Number:
RKK Project Number:
Design Phase: Concept

Designed By:
Checked By: SBP
Approved By:
Date: 10/3/2017

POI:
Facility No: Bio-swale A
Location:

Channel Slope	Lining	Permissible Velocity[1] (ft/sec)
0-5%	Reed canarygrass Tall fescue Kentucky bluegrass	5
	Grass-legume mixture	4
	Red fescue Redtop Sericea lespedeza Annual lespedeza Small grains	2.5
5-10%	Reed canarygrass Tall fescue Kentucky bluegrass	4
	Grass-legume mixture	3
Greater than 10%	Reed canarygrass Tall fescue Kentucky bluegrass	3

[1] For highly erodible soils, permissible velocities should be decreased 25%. An erodibility factor (K) greater than 0.35 would indicate a highly erodible soil. Erodibility factors (K-factors) for Maryland soils are listed either in the Soil Survey or on the Soils-5 forms available in each Soil Conservation District or local NRCS office.

The permissible velocity = 4.00 *fps*

Maximum permissible velocities are given in Table D.12.1 (Appendix D.12 of MDE Manual). If you are providing soil stabilization you may use Limiting Velocities from P.I-3-A-3 of SHA Highway Drainage Manual.

10-yr Discharge (Q_{10}) = 8.00 *cfs* *from TR-55*

$V = (1.49 * A * R^{2/3} * S^{1/2}) / n$

Flow Depth	Mann Coeff. (n)	Flow Area (A)	Hydraulic Radius (R)	R^(2/3)	A*R^(2/3)	Capacity (Qw)	Q_{10}	Velocity (V)	Wetted Perimeter (WP)
(in.)		(sf.)	(ft.)			cfs	Cfs	fps	ft.
8.4	0.085	7.56	0.55	0.670	5.068	8.594	8.00	1.14	13.77
8.9	0.078	8.13	0.58	0.692	5.632	10.438	8.00	1.28	14.12
9.4	0.071	8.72	0.60	0.714	6.226	12.721	8.00	1.46	14.46

Depth of Flow = d = 8.90 *in.* *= from table above*
Computed Velocity = V = 1.28 *fps* *= Qw/A* *velocity must be less than or equal to permissible velocity fps*
---------> OK

Manning Roughness Coefficient (n) = 0.04 *@ d > 12 in.** *= reference for "n" value: P.1-2-B-6 of SHA Highway Drainage Manual*

** n = 1.015 for d < 4" and n = 0.207-0.0145*d for 4" < d < 12" (Grass Channel Paper)*

Project:	NPDES/MS4 Assessment of Controls	Designed By:	
		Checked By:	SBP
County/Gr:	Howard County	Approved By:	
Watershed:		Date:	10/3/2017
SHA Project Number:			
RKK Project Number:		**POI:**	
Design Phase:	Concept	**Facility No:**	**Bio-swale B**
		Location:	

M-8: Bio-swale Design Calculations (TMDL only)

Step 1: Determine Contributing Area Data:

Input Cell

ESD_v Target (P_E) =	2.6	*in.*	= Target P_E (1.0 to 2.6 inches) ---> will be iterative based on site constraints	
Contributing Area (A) =	109901	*sf.*	---------->	2.52 *ac.*
Contributing Impervious Area (A_i) =	39403	*sf.*	---------->	0.90 *ac.*
Percent Impervious Area ($\%_{IMP}$) =	35.9	% → use	40%	
Volumetric Runoff Coefficient (R_v) =	0.373		= 0.05 + 0.009 * ($\%_{IMP}$) (pg 5-18 of the MDE manual)	
ESDv Required (ESD_v) =	8874	*cf.*	= (P_E * A * R_v) / 12 (pg 5-18 of the MDE manual)	

Step 2: Assume Bio-swale Dimensions:

Bioswale Length (L) =	803	*ft.*		
Bioswale Bottom Width (W) =	8	*ft.*		A_f/A =
Bioswale Surface Area (A_f) =	6424	*sf.*	= Surface Area must be ≥ 2% of the contributing Area ---->	16%
Left Side Slope (S_{S1}) =	0.25	*ft/ft*	= 3:1 or flatter	
Right Side Slope (S_{S2}) =	0.25	*ft/ft*	= 3:1 or flatter	
Bioswale Slope (S_L) =	0.0175	*ft/ft*	= 4% maximum longitudinal slope	

Step 3: Determine Storage Requirements:

Percent Impervious Area ($\%_{IMP}$) =	40.0%		= impervious area divided by total contributing drainage area (A_i/A)
A_f/A_i =	16.3%		= filter bed area divided by impervious area (A_f/A_i)
ESD_v Required (ESD_v) =	8874	*cf.*	= (P_E * A * R_v) / 12
Percent Storage Required Above Surface ($V_{\%-S}$) =	43.2%	*of* ESD_v	= Surface Storage tables based on P_E, $\%_{IMP}$, and A_f/A_i
Min. Surface Storage Required (V_S) =	3834	*cf.*	= $V_{\%-R}$ * ESD_v

Tables to be used with State Highway Administration (SHA) Bioretention Soil Mix (BSM)

Storage Volume (% of ESDv) required above surface for Pe = 2 - 2.6 inches

%Imp	Af/Ai										
	2%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
5%	46%	43%	39%	36%	32%	28%	26%	23%	21%	19%	18%
10%	50%	46%	41%	36%	32%	29%	27%	25%	23%	21%	20%
15%	53%	49%	43%	39%	35%	32%	30%	28%	26%	25%	24%
20%	55%	51%	45%	41%	38%	35%	33%	31%	29%	28%	26%
25%	55%	51%	46%	42%	39%	36%	34%	32%	30%	28%	27%
30%	56%	52%	46%	42%	39%	37%	35%	32%	31%	29%	28%
35%	56%	52%	47%	43%	40%	38%	35%	33%	31%	30%	28%
40%	57%	53%	48%	44%	41%	38%	36%	34%	32%	31%	29%
45%	58%	54%	48%	45%	42%	39%	37%	35%	33%	31%	30%
50%	58%	54%	49%	45%	42%	40%	38%	36%	34%	32%	30%
55%	59%	55%	50%	46%	43%	41%	38%	36%	34%	33%	31%
60%	59%	55%	50%	46%	44%	41%	39%	37%	35%	33%	31%
65%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
70%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
75%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
80%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
85%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
90%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
95%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
100%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%

Revised 6/14/2016

Step 4: Determine Surface Storage Provided by Bio-swale:

Check Dam Top Width (CD_W) =	1.00	*ft.*

Project: NPDES/MS4 Assessment of Controls
County/Gr: Howard County
Watershed:
SHA Project Number:
RKK Project Number:
Design Phase: Concept

Designed By:
Checked By: SBP
Approved By:
Date: 10/3/2017

POI:
Facility No: Bio-swale B
Location:

Check Dam Slope (S_{CD}) =	0.17	ft/ft	= max. slope 6:1 in clear zone and 3:1 outside the clear zone
Check Dam Height (CD_H) =	1.00	ft.	= max. 6" in the clear zone and 12" outside the clear zone
Maximal Length of Storage (L_{max}) =	57.14	ft.	= CD_H / S_L, If less than 50 ft. a minimum of 50 ft is used.
Length of Storage (L_S) =	50.00	ft.	= Length must be ≥ 50 ft and < L_{max}
Check Dam Length (CD_L) =	13.00	ft.	= $2 * CD_H / S_{CD} + CD_W$
Check Dam Spacing (CD_S) =	63.00	ft.	= $L_S + CD_L$
Number of cells (C) =	12.00		= L / CD_S
Minimal Storage Depth (d_{min}) =	0.13	ft.	= $S_L * (L_{max} - L_S)$

Surface Storage Per Cell (V_C) = $CD_H^3 / (6 * S_L * S_{S1}) + CD_H^3 / (6 * S_L * S_{S2}) + CD_H^2 * W / (2 * S_L)$
$- d_{min}^3 / (6 * S_L * S_{S1}) - d_{min}^3 / (6 * S_L * S_{S2}) - d_{min}^2 * W / (2 * S_L)$
= 301.04 cf.

Total Surface Storage Provided (V_T) = 3837.23 cf. = $V_C * C + ((L - CD_S * C) * V_C / CD_S)$

Step 5: Determine Treatment Provided by the Bio-swale:

Min. Surface Storage Required (V_{S-R}) =	3834	cf.	= Surface Storage tables based on P_E, $\%_{IMP}$, and A_f/A_i
Surface Storage Provided (V_{S-P}) =	3837.2	cf.	= total volume from step 3
Percent Surface Storage Provided ($V_{\%-S}$) =	43%		= percent surface storage provided based on a Pe of 2.6 inches

Because the proposed facility is providing more than enough surface storage, iterations will need to be done to determine the larger Pe treated.

			Percent Storage		Actual >
From	P_E	ESD_v	Required	Actual	Required
	in.	cf.	%	%	Y/N
Table	2.60	8874	43.22%	43.24%	Yes
Iteration	2.60	8874	43.22%	43.24%	Yes
Table	0.00	0	0.00%	#DIV/0!	#DIV/0!

The PE treated is based on providing a surface storage volume that is a certain percent of the ESDv, but the ESDv changes depending on the Pe. Therefore, determing the Pe treated is an iterative process. The table shown demonstrates this process. The user should input the highest Pe value possible that still meets the required percent surface storage.

Because the proposed facility is providing a Pe greater than 2.6 in., the Pe credited is 2.6 in. and the ESDv credited is 8874.

Step 6: Determine the Impervious Area Treated by the Bio-swale:

Contributing Impervious Area	P_E treated	Impervious Acre Credit*
ac.	in.	ac.
0.90	2.60	1.27

** Impervious Acre Credit is based on Table 3 (page 12) of the MDE Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated from August 2014.*

Step 7: Determine if Underdrain is Required:

Primary HSG Soil Group under filter media = D — underdrain is not required in A/B soils

Underdrain is Required.

Step 8: Check Freeboard:

Q_{10} =	2	cfs	= 10-yr discharge from TR-55
Weir Length (L) =	6	ft.	
Discharge Coefficient (C) =	3.1		= typically 3.1
Hydraulic Head (H) =	0.23	ft.	$=(Q_{10} / (CL))^{2/3}$
Lowest SHA roadway elevation =	605	ft.	
Facility Control Elevation =	603	ft.	= control elevation where highest 10-yr WSE will occur
Highest WSE of 10-yr storm =	604.2	ft.	= highest 10-yr WSE will typically occur on top of most downstream checkdam
Freeboard =	0.8	ft.	= roadway elevation - WSE of 10-yr storm, freeeboard ≥ 9 inches

Freeboard Requirements are Met.

Step 9: Check 1" Stom Event Velocity:

1. The maximum flow velocity for runoff from the ESDv rainfall shall be less than or equal to 1.0 fps (see Appendix D.10 for methodology to compute flowrate). Ref. Vol. I, ch 5, pg 5.109

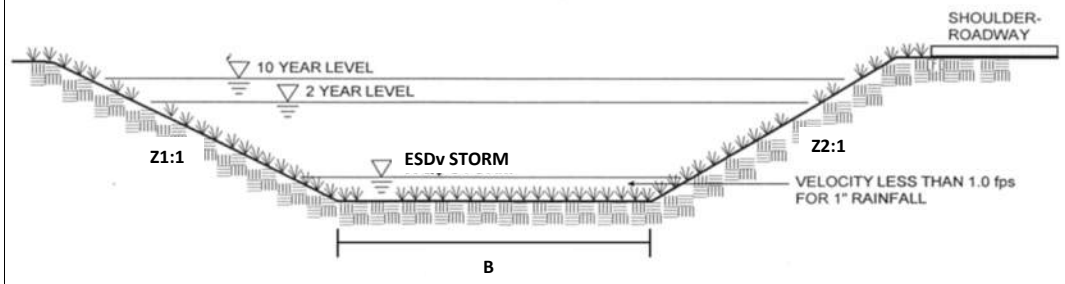
Project: NPDES/MS4 Assessment of Controls
County/Gr: Howard County
Watershed:
SHA Project Number:
RKK Project Number:
Design Phase: Concept

Designed By:
Checked By: SBP
Approved By:
Date: 10/3/2017

POI:
Facility No: Bio-swale B
Location:

ESDv Rainfall Depth (Pe) =	2.6	in.	= Use Required Contributing Pe
Drainage Area (A) =	2.523	ac.	
Total Impervious Area (I) =	0.905	ac.	
Time-of-Concentration (Tc) =	0.100	hr.	= Tc value from TR-55 Computations
Percent Impervious =	35.9	%	= I/A
Runoff Coefficient (Rv) =	0.373		= 0.05+0.009*(I)
Runoff Volume (Qe) =	0.97	in.	= Pe * Rv (Eq. Ref. Vol. II, Appendix D.10)
Adjusted RCN =	80		= 1000 / [10+5Pe+10Qa-10V(Qa2+1.25QaPe)] (Eq. Ref. Vol. II, Appendix D.10)
Initial Abstract (Ia) =	0.50		= (200/CN)-2
Ia/Pe =	0.19		= If Ia/Pe is less than 0.1 then 0.1 will be used.
Unit Peak Discharge (qu) =	976.0	csm/in.	= Log (q_u) = C_0 + C_1 * Log (Tc) + C_2 * [Log (Tc)]^2 (Figure D.11.1)
ESDv Peak Flow (Qw) =	3.73	cfs.	= (qu csm/in) * (A mi2) * (Qe in)

Typical Swale Cross section



Side Slope (Z1) =	4.000	:1
Side Slope (Z2) =	4.000	:1
Bottom Width (B) =	8	ft.
Slope of Channel (S) =	0.0175	ft/ft

$V = (1.49 * A * R^{2/3} * S^{1/2}) / n$

Flow Depth	Mann Coeff. (n)	Flow Area (A)	Hydraulic Radius (R)	R^(2/3)	A*R^(2/3)	Capacity (Qw)	Qp	Velocity (V)	Wetted Perimeter (WP)
(in.)		(sf.)	(ft.)			cfs	Cfs	fps	ft.
1.42	0.150	1.00	0.11	0.232	0.233	0.306	3.73	0.30	8.98
1.92	0.150	1.38	0.15	0.280	0.387	0.509	3.73	0.37	9.32
2.42	0.150	1.78	0.18	0.323	0.574	0.754	3.73	0.42	9.66

Depth of Flow = d =	1.92	in.	= from table above	
Computed Velocity = V =	0.37	fps	= Qw/A	velocity must be less than or equal to 1 fps -----> OK

Manning Roughness Coefficient (n) = 0.04 @ d > 12 in.* = reference for "n" value: P.1-2-B-6 of SHA Highway Drainage Manual

* n = 1.015 for d < 4" and n = 0.207-0.0145*d for 4" < d < 12" (Grass Channel Paper)

Step 10: Check 10-yr Stom Event Velocity:

2. The maximum flow velocity for runoff from the ten-year design event shall be non erosive. Ref. Vol. I, ch 5, pg 5.109

Revised 6/14/2016

Maximum permissible velocities of flow shall not exceed the values shown on the following table:

Table D.12.1 Permissible Velocities for Channels Lined with Vegetation

Project: NPDES/MS4 Assessment of Controls
County/Gr: Howard County
Watershed:
SHA Project Number:
RKK Project Number:
Design Phase: Concept

Designed By:
Checked By: SBP
Approved By:
Date: 10/3/2017

POI:
Facility No: Bio-swale B
Location:

Channel Slope	Lining	Permissible Velocity[1] (ft/sec)
0-5%	Reed canarygrass Tall fescue Kentucky bluegrass	5
	Grass-legume mixture	4
	Red fescue Redtop Sericea lespedeza Annual lespedeza Small grains	2.5
5-10%	Reed canarygrass Tall fescue Kentucky bluegrass	4
	Grass-legume mixture	3
Greater than 10%	Reed canarygrass Tall fescue Kentucky bluegrass	3

[1] For highly erodible soils, permissible velocities should be decreased 25%. An erodibility factor (K) greater than 0.35 would indicate a highly erodible soil. Erodibility factors (K-factors) for Maryland soils are listed either in the Soil Survey or on the Soils-5 forms available in each Soil Conservation District or local NRCS office.

The permissible velocity = 4.00 *fps*

Maximum permissible velocities are given in Table D.12.1 (Appendix D.12 of MDE Manual). If you are providing soil stabilization you may use Limiting Velocities from P.I-3-A-3 of SHA Highway Drainage Manual.

10-yr Discharge (Q_{10}) = 8.00 *cfs* *from TR-55*

$V = (1.49 * A * R^{2/3} * S^{1/2}) / n$

Flow Depth	Mann Coeff. (n)	Flow Area (A)	Hydraulic Radius (R)	R^(2/3)	A*R^(2/3)	Capacity (Qw)	Q_{10}	Velocity (V)	Wetted Perimeter (WP)
(in.)		(sf.)	(ft.)			cfs	Cfs	fps	ft.
8.4	0.085	7.56	0.55	0.670	5.068	11.725	8.00	1.55	13.77
8.9	0.078	8.13	0.58	0.692	5.632	14.241	8.00	1.75	14.12
9.4	0.071	8.72	0.60	0.714	6.226	17.357	8.00	1.99	14.46

Depth of Flow = d = 8.90 *in.* *= from table above*
Computed Velocity = V = 1.75 *fps* *= Qw/A* *velocity must be less than or equal to permissible velocity fps*
---------> OK

Manning Roughness Coefficient (n) = 0.04 *@ d > 12 in.** *= reference for "n" value: P.1-2-B-6 of SHA Highway Drainage Manual*

** n = 1.015 for d < 4" and n = 0.207-0.0145*d for 4" < d < 12" (Grass Channel Paper)*

Project:	NPDES/MS4 Assessment of Controls	Designed By:	
		Checked By:	SBP
County/Gr:	Howard County	Approved By:	
Watershed:		Date:	10/3/2017
SHA Project Number:			
RKK Project Number:		**POI:**	
Design Phase:	Concept	**Facility No:**	**Bio-swale C**
		Location:	

M-8: Bio-swale Design Calculations (TMDL only)

Step 1: Determine Contributing Area Data:

Input Cell

ESD_v Target (P_E) =	2.6	*in.*	= Target P_E (1.0 to 2.6 inches) ---> will be iterative based on site constraints	
Contributing Area (A) =	104829	*sf.*	---------->	2.41 *ac.*
Contributing Impervious Area (A_i) =	43989	*sf.*	---------->	1.01 *ac.*
Percent Impervious Area ($\%_{IMP}$) =	42.0	% → use	45%	
Volumetric Runoff Coefficient (R_v) =	0.428		= 0.05 + 0.009 * ($\%_{IMP}$) (pg 5-18 of the MDE manual)	
ESDv Required (ESD_v) =	9714	*cf.*	= (P_E * A * R_v) / 12 (pg 5-18 of the MDE manual)	

Step 2: Assume Bio-swale Dimensions:

Bioswale Length (L) =	617	*ft.*		
Bioswale Bottom Width (W) =	8	*ft.*		A_f/A =
Bioswale Surface Area (A_f) =	4936	*sf.*	= Surface Area must be ≥ 2% of the contributing Area ---->	11%
Left Side Slope (S_{S1}) =	0.25	*ft/ft*	= 3:1 or flatter	
Right Side Slope (S_{S2}) =	0.25	*ft/ft*	= 3:1 or flatter	
Bioswale Slope (S_L) =	0.0069	*ft/ft*	= 4% maximum longitudinal slope	

Step 3: Determine Storage Requirements:

Percent Impervious Area ($\%_{IMP}$) =	45.0%		= impervious area divided by total contributing drainage area (A_i/A)
A_f/A_i =	11.2%		= filter bed area divided by impervious area (A_f/A_i)
ESD_v Required (ESD_v) =	9714	*cf.*	= (P_E * A * R_v) / 12
Percent Storage Required Above Surface ($V_{\%-S}$) =	47.3%	*of* ESD_v	= Surface Storage tables based on P_E, $\%_{IMP}$, and A_f/A_i
Min. Surface Storage Required (V_S) =	4595	*cf.*	= $V_{\%-R}$ * ESD_v

Tables to be used with State Highway Administration (SHA) Bioretention Soil Mix (BSM)

Storage Volume (% of ESDv) required above surface for Pe = 2 - 2.6 inches

%Imp	Af/Ai										
	2%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
5%	46%	43%	39%	36%	32%	28%	26%	23%	21%	19%	18%
10%	50%	46%	41%	36%	32%	29%	27%	25%	23%	21%	20%
15%	53%	49%	43%	39%	35%	32%	30%	28%	26%	25%	24%
20%	55%	51%	45%	41%	38%	35%	33%	31%	29%	28%	26%
25%	55%	51%	46%	42%	39%	36%	34%	32%	30%	28%	27%
30%	56%	52%	46%	42%	39%	37%	35%	32%	31%	29%	28%
35%	56%	52%	47%	43%	40%	38%	35%	33%	31%	30%	28%
40%	57%	53%	48%	44%	41%	38%	36%	34%	32%	31%	29%
45%	58%	54%	48%	45%	42%	39%	37%	35%	33%	31%	30%
50%	58%	54%	49%	45%	42%	40%	38%	36%	34%	32%	30%
55%	59%	55%	50%	46%	43%	41%	38%	36%	34%	33%	31%
60%	59%	55%	50%	46%	44%	41%	39%	37%	35%	33%	31%
65%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
70%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
75%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
80%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
85%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
90%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
95%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
100%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%

Step 4: Determine Surface Storage Provided by Bio-swale:

Check Dam Top Width (CD_W) =	1.00	*ft.*

Project:	NPDES/MS4 Assessment of Controls	Designed By:	
		Checked By:	SBP
County/Gr:	Howard County	Approved By:	
Watershed:		Date:	10/3/2017
SHA Project Number:			
RKK Project Number:		**POI:**	
Design Phase:	Concept	**Facility No:**	**Bio-swale C**
		Location:	

Check Dam Slope (S_{CD}) =	0.17	ft/ft	= max. slope 6:1 in clear zone and 3:1 outside the clear zone
Check Dam Height (CD_H) =	1.00	ft.	= max. 6" in the clear zone and 12" outside the clear zone
Maximal Length of Storage (L_{max}) =	144.93	ft.	= CD_H / S_L, If less than 50 ft. a minimum of 50 ft is used.
Length of Storage (L_S) =	50.00	ft.	= Length must be ≥ 50 ft and < L_{max}
Check Dam Length (CD_L) =	13.00	ft.	= 2 * CD_H / S_{CD} + CD_W
Check Dam Spacing (CD_S) =	63.00	ft.	= L_S + CD_L
Number of cells (C) =	9.00		= L / CD_S
Minimal Storage Depth (d_{min}) =	0.66	ft.	= S_L * (L_{max} - L_S)

Surface Storage Per Cell (V_C) = CD_H^3 / (6 * S_L* S_{S1}) + CD_H^3 / (6 * S_L* S_{S2}) + CD_H^2 * W / (2 * S_L)
- d_{min}^3 / (6 * S_L* S_{S1}) - d_{min}^3 / (6 * S_L* S_{S2}) - d_{min}^2 * W / (2 * S_L)

= 469.94 cf.

Total Surface Storage Provided (V_T) = 4602.55 cf. = V_C * C + ((L - CD_S * C) * V_C / CD_S)

Step 5: Determine Treatment Provided by the Bio-swale:

Min. Surface Storage Required (V_{S-R}) =	4595	cf.	= Surface Storage tables based on P_E, $\%_{IMP}$, and A_f/A_i
Surface Storage Provided (V_{S-P}) =	4602.6	cf.	= total volume from step 3
Percent Surface Storage Provided ($V_{\%-S}$) =	47%		= percent surface storage provided based on a Pe of 2.6 inches

Because the proposed facility is providing more than enough surface storage, iterations will need to be done to determine the larger Pe treated.

			Percent Storage		*Actual > Required*
From	P_E	ESD_v	Required	Actual	
	in.	cf.	%	%	Y/N
Table	2.60	9714	47.27%	47.38%	Yes
Iteration	2.60	9714	47.27%	47.38%	Yes
Table	0.00	0	0.00%	#DIV/0!	#DIV/0!

The PE treated is based on providing a surface storage volume that is a certain percent of the ESDv, but the ESDv changes depending on the Pe. Therefore, determing the Pe treated is an iterative process. The table shown demonstrates this process. The user should input the highest Pe value possible that still meets the required percent surface storage.

Because the proposed facility is providing a Pe greater than 2.6 in., the Pe credited is 2.6 in. and the ESDv credited is 9714.

Step 6: Determine the Impervious Area Treated by the Bio-swale:

Contributing Impervious Area	P_E treated	Impervious Acre Credit*
ac.	in.	ac.
1.01	2.60	1.41

** Impervious Acre Credit is based on Table 3 (page 12) of the MDE Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated from August 2014.*

Step 7: Determine if Underdrain is Required:

Primary HSG Soil Group under filter media = D — *underdrain is not required in A/B soils*

Underdrain is Required.

Step 8: Check Freeboard:

Q_{10} =	2	cfs	= 10-yr discharge from TR-55
Weir Length (L) =	6	ft.	
Discharge Coefficient (C) =	3.1		= typically 3.1
Hydraulic Head (H) =	0.23	ft.	=(Q_{10} / (CL))$^{2/3}$
Lowest SHA roadway elevation =	605	ft.	
Facility Control Elevation =	603	ft.	= control elevation where highest 10-yr WSE will occur
Highest WSE of 10-yr storm =	604.2	ft.	= highest 10-yr WSE will typically occur on top of most downstream checkdam
Freeboard =	0.8	ft.	= roadway elevation - WSE of 10-yr storm, freeeboard ≥ 9 inches

Freeboard Requirements are Met.

Step 9: Check 1" Stom Event Velocity:

1. The maximum flow velocity for runoff from the ESDv rainfall shall be less than or equal to 1.0 fps (see Appendix D.10 for methodology to compute flowrate). Ref. Vol. I, ch 5, pg 5.109

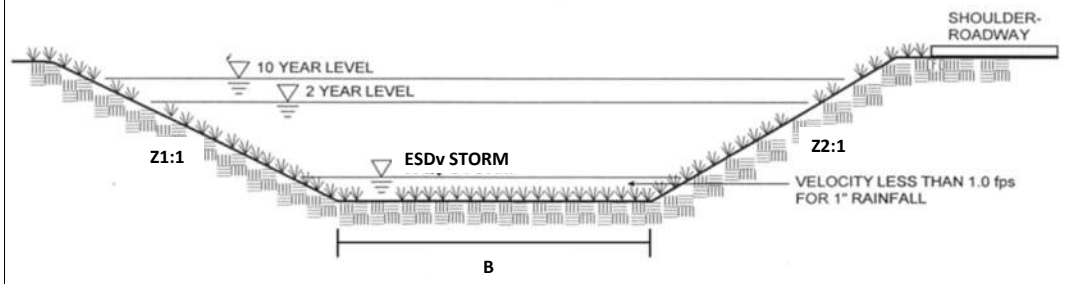
Project: NPDES/MS4 Assessment of Controls
County/Gr: Howard County
Watershed:
SHA Project Number:
RKK Project Number:
Design Phase: Concept

Designed By:
Checked By: SBP
Approved By:
Date: 10/3/2017

POI:
Facility No: Bio-swale C
Location:

ESDv Rainfall Depth (Pe) =	2.6	in.	= Use Required Contributing Pe
Drainage Area (A) =	2.407	ac.	
Total Impervious Area (I) =	1.010	ac.	
Time-of-Concentration (Tc) =	0.100	hr.	= Tc value from TR-55 Computations
Percent Impervious =	42.0	%	= I/A
Runoff Coefficient (Rv) =	0.428		= 0.05+0.009*(I)
Runoff Volume (Qe) =	1.11	in.	= Pe * Rv (Eq. Ref. Vol. II, Appendix D.10)
Adjusted RCN =	83		= 1000 / [10+5Pe+10Qa-10V(Qa2+1.25QaPe)] (Eq. Ref. Vol. II, Appendix D.10)
Initial Abstract (Ia) =	0.41		= (200/CN)-2
Ia/Pe =	0.16		= If Ia/Pe is less than 0.1 then 0.1 will be used.
Unit Peak Discharge (qu) =	991.0	csm/in.	= Log (q_u) = C_0 + C_1 * Log (Tc) + C_2 * [Log (Tc)]^2 (Figure D.11.1)
ESDv Peak Flow (Qw) =	4.14	cfs.	= (qu csm/in) * (A mi2) * (Qe in)

Typical Swale Cross section



Side Slope (Z1) =	4.000	:1
Side Slope (Z2) =	4.000	:1
Bottom Width (B) =	8	ft.
Slope of Channel (S) =	0.0069	ft/ft

$V = (1.49 * A * R^{2/3} * S^{1/2}) / n$

Flow Depth	Mann Coeff. (n)	Flow Area (A)	Hydraulic Radius (R)	R^(2/3)	A*R^(2/3)	Capacity (Qw)	Qp	Velocity (V)	Wetted Perimeter (WP)
(in.)		(sf.)	(ft.)			cfs	Cfs	fps	ft.
1.42	0.150	1.00	0.11	0.232	0.233	0.192	4.14	0.19	8.98
1.92	0.150	1.38	0.15	0.280	0.387	0.320	4.14	0.23	9.32
2.42	0.150	1.78	0.18	0.323	0.574	0.474	4.14	0.27	9.66

Depth of Flow = d =	1.92	in.	= from table above	
Computed Velocity = V =	0.23	fps	= Qw/A	velocity must be less than or equal to 1 fps -----> OK

Manning Roughness Coefficient (n) = 0.04 @ d > 12 in.* = reference for "n" value: P.1-2-B-6 of SHA Highway Drainage Manual

* n = 1.015 for d < 4" and n = 0.207-0.0145*d for 4" < d < 12" (Grass Channel Paper)

Step 10: Check 10-yr Stom Event Velocity:

2. The maximum flow velocity for runoff from the ten-year design event shall be non erosive. Ref. Vol. I, ch 5, pg 5.109

Revised 6/14/2016

Maximum permissible velocities of flow shall not exceed the values shown on the following table:

Table D.12.1 Permissible Velocities for Channels Lined with Vegetation

Project: NPDES/MS4 Assessment of Controls
County/Gr: Howard County
Watershed:
SHA Project Number:
RKK Project Number:
Design Phase: Concept

Designed By:
Checked By: SBP
Approved By:
Date: 10/3/2017

POI:
Facility No: Bio-swale C
Location:

Channel Slope	Lining	Permissible Velocity[1] (ft/sec)
0-5%	Reed canarygrass Tall fescue Kentucky bluegrass	5
	Grass-legume mixture	4
	Red fescue Redtop Sericea lespedeza Annual lespedeza Small grains	2.5
5-10%	Reed canarygrass Tall fescue Kentucky bluegrass	4
	Grass-legume mixture	3
Greater than 10%	Reed canarygrass Tall fescue Kentucky bluegrass	3

[1] For highly erodible soils, permissible velocities should be decreased 25%. An erodibility factor (K) greater than 0.35 would indicate a highly erodible soil. Erodibility factors (K-factors) for Maryland soils are listed either in the Soil Survey or on the Soils-5 forms available in each Soil Conservation District or local NRCS office.

The permissible velocity = 4.00 *fps*

Maximum permissible velocities are given in Table D.12.1 (Appendix D.12 of MDE Manual). If you are providing soil stabilization you may use Limiting Velocities from P.I-3-A-3 of SHA Highway Drainage Manual.

10-yr Discharge (Q_{10}) = 8.00 *cfs* *from TR-55*

$V = (1.49 * A * R^{2/3} * S^{1/2}) / n$

Flow Depth	Mann Coeff. (n)	Flow Area (A)	Hydraulic Radius (R)	R^(2/3)	A*R^(2/3)	Capacity (Qw)	Q_{10}	Velocity (V)	Wetted Perimeter (WP)
(in.)		(sf.)	(ft.)			cfs	Cfs	fps	ft.
8.4	0.085	7.56	0.55	0.670	5.068	7.363	8.00	0.97	13.77
8.9	0.078	8.13	0.58	0.692	5.632	8.943	8.00	1.10	14.12
9.4	0.071	8.72	0.60	0.714	6.226	10.899	8.00	1.25	14.46

Depth of Flow = d = 8.90 *in.* *= from table above*
Computed Velocity = V = 1.10 *fps* *= Qw/A* *velocity must be less than or equal to permissible velocity fps*
---------> OK

Manning Roughness Coefficient (n) = 0.04 *@ d > 12 in.** *= reference for "n" value: P.1-2-B-6 of SHA Highway Drainage Manual*

** n = 1.015 for d < 4" and n = 0.207-0.0145*d for 4" < d < 12" (Grass Channel Paper)*

Project:		Designed By:	
County:	Howard County	Checked By:	SBP
Watershed:		Approved By:	
SHA Project Number:		Date:	
PRD Project Number:			
Design Phase:	Concept	**POI:**	
		Facility No:	**Grass Swale A**
		Location:	

Grass Swale with Check Dams Design Calculations

Step 1: Determine Contributing Area Data:

Input Cell

Contributing Rainfall Target (P_E) =	1.6	in.	= Target Pe for the Contributing Area	
HSG A =	0	sf.	= HSG A within Contributing Area	
HSG B =	0	sf.	= HSG B within Contributing Area	
HSG C =	0	sf.	= HSG C within Contributing Area	
HSG D =	123184	sf.	= HSG D within Contributing Area	
Contributing Area (A) =	123184	sf.		
Contributing Impervious Area (A_i) =	41,939	sf.		
Percent Impervious Area ($\%_{IMP}$) =	34.0	% → use	35%	Used to calculate only "Contributing Rainfall Target (Pe)"
Volumetric Runoff Coefficient (R_v) =	0.356		= 0.05 + 0.009 * ($\%_{IMP}$)	
ESDv Required (ESDv) =	5854	cf.	= (P_E * A * R_v) / 12	

Step 2: Determine Grass Swale Dimensions:

Grass Swale Length (L) =	1180	ft.		
Grass Swale Bottom Width (W) =	8	ft.		
Grass Swale Surface Area (A_f) =	9440	sf.	= Surface Area must be ≥ 2% of the contributing Area ---->	8%
Left Side Slope (S_{S1}) =	0.25	ft/ft	= 3:1 or flatter	
Right Side Slope (S_{S2}) =	0.25	ft/ft	= 3:1 or flatter	
Grass Swale Slope (S_L) =	0.0056	ft/ft	= 4% maximum longitudinal slope	
A_f/A_i =	22.5	%		

Step 3: Determine Treatment Provided by the Grass Swale:

Rainfall Treated (Pe) =	0.77	in.	= 10" * (Af / A) (Equation 5.3)
ESDv Provided (ESDv) =	2817	cf.	= (P_E * A * R_v) / 12

The Pe credited is 0.77 in. and the ESDv credited is 2817 cf.

Step 4: Determine the Impervious Area Treated by the Grass Swale:

Contributing Impervious Area	P_E treated	Impervious Area Treated
ac.	in.	ac.
0.96	0.77	0.74

Step 5: Determine Storage Provided by Grass Swale with Check Dams

Check Dam Top Width (CD_W) =	1.00	ft.	
Check Dam Slope (S_{CD}) =	0.17	ft/ft	
Check Dam Height (CD_H) =	1	ft.	
Maximal Length of Storage (L_{max}) =	178.57	ft.	= CD_H / S_L, If less than 50 ft. a minimum of 50 ft is used.
Length of Storage (L_S) =	50	ft.	= Length must be ≥ 50 ft
Check Dam Length (CD_L) =	13.00	ft.	= 2 * CD_H / S_{CD} + CD_W
Check Dam Spacing (CD_S) =	63.00	ft.	= L_S + CD_L
Number of full length facilities (F) =	18.00		= L / CD_S
Minimal Storage Depth (d_{min}) =	0.72	ft.	= S_L * (L_{max} - L_S)

Surface Storage Per Facility (V_F) = $CD_H^3 / (6 * S_L * S_{S1}) + CD_H^3 / (6 * S_L * S_{S2}) + CD_H^2 * W / (2 * S_L) - d_{min}^3 / (6 * S_L * S_{S1}) - d_{min}^3 / (6 * S_L * S_{S2}) - d_{min}^2 * W / (2 * S_L)$

= 493.23 cf.

Total Surface Storage Provided (V_T) = 9238.57 cf. = V_F * F + ((L - CD_S * F) * V_F / CD_S)

Max volume towards RCN=	9513	cf.	= (P_E * A * Rv) / 12
where P_E =	2.60	in.	Max P_E = 2.6
Actual credited volume towards RCN=	9239	cf.	if V_t <Max volume, then output V_t

Project:		Designed By:	
County:	Howard County	Checked By:	SBP
Watershed:		Approved By:	
SHA Project Number:		Date:	
PRD Project Number:			
Design Phase:	Concept	**POI:**	
		Facility No:	**Grass Swale A**
		Location:	

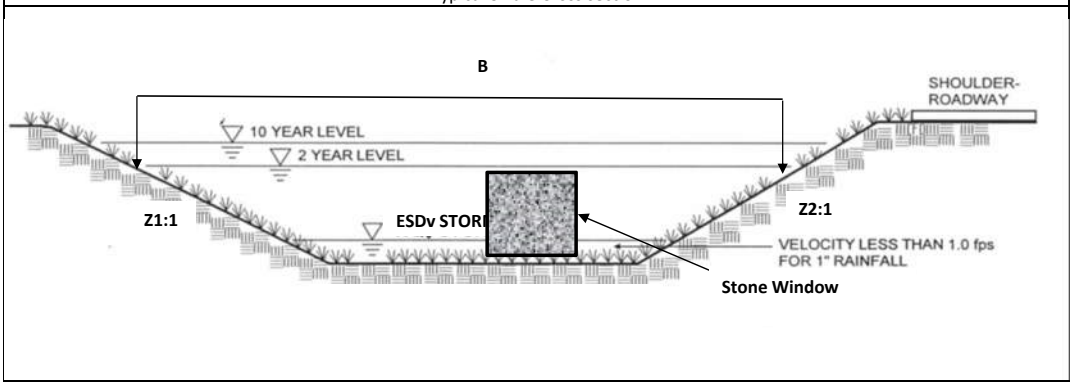
Swale Check: Method for Computing Peak Discharge for ESDv

Drainage Area Data

ESDv Rainfall Depth (Pe) =	1.6	in.	= Use Required Contributing Pe
Drainage Area (A) =	0.961	ac.	= Total Drainage Area to Swale
Total Impervious Area (I) =	0.530	ac.	= Total Impervious Area to Swale
Time-of-Concentration (Tc) =	0.100	hr.	= Tc value from TR-55 Computations
Percent Impervious =	34.0	%	= I/A
Runoff Coefficient (Rv) =	0.356		= 0.05+0.009*(I)
Runoff Volume (Qe) =	0.57	in.	= Pe * Rv (Eq. Ref. Vol. II, Appendix D.10)
Adjusted RCN =	86		= 1000 / [10+5Pe+10Qa-10√(Qa2+1.25QaPe)] (Eq. Ref. Vol. II, Appendix D.10)
Initial Abstract (Ia) =	0.33		= (200/CN)-2
Ia/Pe =	0.21		= If Ia/Pe is less than 0.1 then 0.1 will be used.
Unit Peak Discharge (qu) =	972.3	csm/in.	= Log (q_u) = C_0 + C_i * Log (Tc) + C_2 * [Log (Tc)]^2 (Figure D.11.1)
ESDv Peak Flow (Qw) =	0.83	cfs.	= (qu csm/in) * (A mi2) * (Qe in)

Swale Dimensions

Typical Swale Cross section



Side Slope (Z1) =	4	:1	
Side Slope (Z2) =	4	:1	
Weir Crest (B) =	16	ft.	= (Z_1*CD_H) + (Z_2*CD_H) + W
Slope of Channel (S) =	0.0056	ft/ft	

Criteria for the Swale velocity *Ref. Vol. I, ch 5, pg 5.109*

1. *The maximum flow velocity for runoff from the ESDv rainfall shall be less than or equal to 1.0 fps (see Appendix D.10 for methodology to compute flowrate).*
2. *The maximum flow velocity for runoff from the ten-year design event shall be non erosive.*

Solve Mannings Equation

$$V = (1.49 * A * R^{2/3} * S^{1/2}) / n$$

Flow Depth	Mann Coeff. (n)	Flow Area (A)	Hydraulic Radius (R)	R^(2/3)	A*R^(2/3)	Capacity (Qw)	Qp	Velocity (V)	Wetted Perimeter (WP)
(in.)		(sf.)	(ft.)			cfs	Cfs	fps	ft.
3.84	0.150	5.53	0.30	0.445	2.460	1.828	0.83	0.33	18.64
3.94	0.150	5.68	0.30	0.452	2.569	1.910	0.83	0.34	18.71
4.04	0.150	5.84	0.31	0.459	2.681	1.993	0.83	0.34	18.78

Computed Velocity = V = 0.34 *fps* *= Qw/A* *velocity must be less than or equal to 1 fps*

Project:		Designed By:	
County:	Howard County	Checked By:	
Watershed:		Approved By:	
SHA Project Number:		Date:	
PRD Project Number:			
Design Phase:	Concept	**POI:**	
		Facility No:	**Grass Swale B**
		Location:	

Grass Swale with Check Dams Design Calculations

Step 1: Determine Contributing Area Data:

Input Cell

Contributing Rainfall Target (P_E) =	1.6	in.	= Target Pe for the Contributing Area	
HSG A =	0	sf.	= HSG A within Contributing Area	
HSG B =	0	sf.	= HSG B within Contributing Area	
HSG C =	0	sf.	= HSG C within Contributing Area	
HSG D =	33667	sf.	= HSG D within Contributing Area	
Contributing Area (A) =	33667	sf.		
Contributing Impervious Area (A_i) =	10,727	sf.		
Percent Impervious Area ($\%_{IMP}$) =	31.9	% → use	35%	Used to calculate only "Contributing Rainfall Target (Pe)"
Volumetric Runoff Coefficient (R_v) =	0.337		= 0.05 + 0.009 * ($\%_{IMP}$)	
ESDv Required (ESDv) =	1512	cf.	= (P_E * A * R_v) / 12	

Step 2: Determine Grass Swale Dimensions:

Grass Swale Length (L) =	320	ft.		
Grass Swale Bottom Width (W) =	8	ft.		
Grass Swale Surface Area (A_f) =	2560	sf.	= Surface Area must be ≥ 2% of the contributing Area ---->	8%
Left Side Slope (S_{S1}) =	0.25	ft/ft	= 3:1 or flatter	
Right Side Slope (S_{S2}) =	0.25	ft/ft	= 3:1 or flatter	
Grass Swale Slope (S_L) =	0.0096	ft/ft	= 4% maximum longitudinal slope	
A_f/A_i =	23.9	%		

Step 3: Determine Treatment Provided by the Grass Swale:

Rainfall Treated (Pe) =	0.76	in.	= 10" * (Af / A) (Equation 5.3)
ESDv Provided (ESDv) =	718	cf.	= (P_E * A * R_v) / 12

The Pe credited is 0.76 in. and the ESDv credited is 718 cf.

Step 4: Determine the Impervious Area Treated by the Grass Swale:

Contributing Impervious Area	P_E treated	Impervious Area Treated
ac.	in.	ac.
0.25	0.76	0.19

Step 5: Determine Storage Provided by Grass Swale with Check Dams

Check Dam Top Width (CD_W) =	1.00	ft.	
Check Dam Slope (S_{CD}) =	0.17	ft/ft	
Check Dam Height (CD_H) =	1	ft.	
Maximal Length of Storage (L_{max}) =	104.17	ft.	= CD_H / S_L, If less than 50 ft. a minimum of 50 ft is used.
Length of Storage (L_S) =	50	ft.	= Length must be ≥ 50 ft
Check Dam Length (CD_L) =	13.00	ft.	= 2 * CD_H / S_{CD} + CD_W
Check Dam Spacing (CD_S) =	63.00	ft.	= L_S + CD_L
Number of full length facilities (F) =	5.00		= L / CD_S
Minimal Storage Depth (d_{min}) =	0.52	ft.	= S_L * (L_{max} - L_S)

Surface Storage Per Facility (V_F) = $CD_H^3 / (6 * S_L * S_{S1}) + CD_H^3 / (6 * S_L * S_{S2}) + CD_H^2 * W / (2 * S_L)$
$- d_{min}^3 / (6 * S_L * S_{S1}) - d_{min}^3 / (6 * S_L * S_{S2}) - d_{min}^2 * W / (2 * S_L)$

=	423.36	cf.	
Total Surface Storage Provided (V_T) =	2150.48	cf.	= V_F * F + ((L - CD_S * F) * V_F / CD_S)

Max volume towards RCN=	2456	cf.	= (P_E * A * Rv) / 12
where P_E =	2.60	in.	Max P_E = 2.6

Actual credited volume towards RCN=	2150	cf.	if V_t <Max volume, then output V_t

Project:		*Designed By:*	
County:	*Howard County*	*Checked By:*	
Watershed:		*Approved By:*	
SHA Project Number:		*Date:*	
PRD Project Number:			
Design Phase:	*Concept*	***POI:***	
		Facility No:	***Grass Swale B***
		Location:	

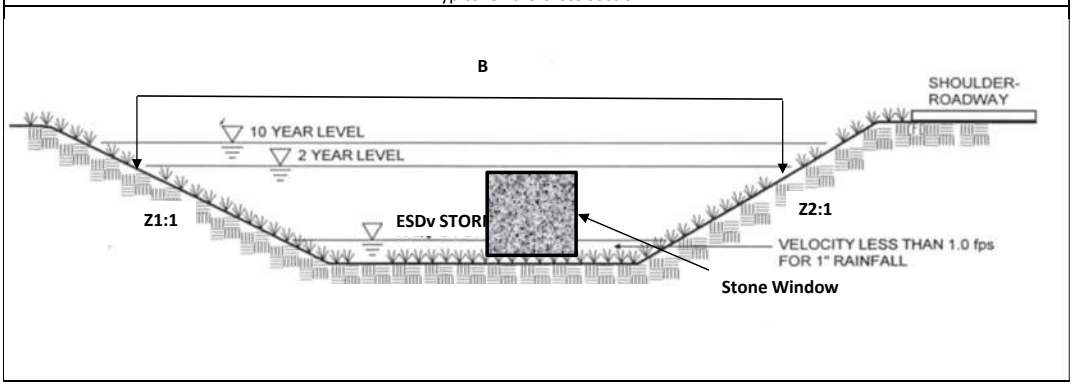
Swale Check: Method for Computing Peak Discharge for ESDv

Drainage Area Data

ESDv Rainfall Depth (Pe) =	1.6	*in.*	*= Use Required Contributing Pe*
Drainage Area (A) =	0.961	*ac.*	*= Total Drainage Area to Swale*
Total Impervious Area (I) =	0.530	*ac.*	*= Total Impervious Area to Swale*
Time-of-Concentration (Tc) =	0.100	*hr.*	*= Tc value from TR-55 Computations*
Percent Impervious =	31.9	*%*	*= I/A*
Runoff Coefficient (Rv) =	0.337		*= 0.05+0.009*(I)*
Runoff Volume (Qe) =	0.54	*in.*	*= Pe * Rv (Eq. Ref. Vol. II, Appendix D.10)*
Adjusted RCN =	86		*= 1000 / [10+5Pe+10Qa-10√(Qa2+1.25QaPe)] (Eq. Ref. Vol. II, Appendix D.10)*
Initial Abstract (Ia) =	0.33		*= (200/CN)-2*
Ia/Pe =	0.21		*= If Ia/Pe is less than 0.1 then 0.1 will be used.*
Unit Peak Discharge (qu) =	972.3	*csm/in.*	*= Log (q_u) = C_0 + C_i * Log (Tc) + C_2 * [Log (Tc)]^2 (Figure D.11.1)*
ESDv Peak Flow (Qw) =	0.79	*cfs.*	*= (qu csm/in) * (A mi2) * (Qe in)*

Swale Dimensions

Typical Swale Cross section



Side Slope (Z1) =	4	*:1*	
Side Slope (Z2) =	4	*:1*	
Weir Crest (B) =	16	*ft.*	= (Z_1*CD_H) + (Z_2*CD_H) + W
Slope of Channel (S) =	0.0096	*ft/ft*	

Criteria for the Swale velocity *Ref. Vol. I, ch 5, pg 5.109*

1. *The maximum flow velocity for runoff from the ESDv rainfall shall be less than or equal to 1.0 fps (see Appendix D.10 for methodology to compute flowrate).*
2. *The maximum flow velocity for runoff from the ten-year design event shall be non erosive.*

Solve Mannings Equation

$$V = (1.49 * A * R^{2/3} * S^{1/2}) / n$$

Flow Depth	Mann Coeff. (n)	Flow Area (A)	Hydraulic Radius (R)	R^(2/3)	A*R^(2/3)	Capacity (Qw)	Qp	Velocity (V)	Wetted Perimeter (WP)
(in.)		(sf.)	(ft.)			cfs	Cfs	fps	ft.
3.84	0.150	5.53	0.30	0.445	2.460	2.394	0.79	0.43	18.64
3.94	0.150	5.68	0.30	0.452	2.569	2.501	0.79	0.44	18.71
4.04	0.150	5.84	0.31	0.459	2.681	2.609	0.79	0.45	18.78

Computed Velocity = V = 0.44 *fps* *= Qw/A* *velocity must be less than or equal to 1 fps*

Project:	NPDES/MS4 Assessment of Controls	Designed By:	
		Checked By:	SBP
County/Gr:	Howard County	Approved By:	
Watershed:		Date:	10/3/2017
SHA Project Number:			
RKK Project Number:		**POI:**	
Design Phase:	Concept	**Facility No:**	**HO BioSwale A**
		Location:	

M-8: Bio-swale Design Calculations (TMDL only)

Step 1: Determine Contributing Area Data:

Input Cell

ESD_v Target (P_E) =	1.8	*in.*	= Target P_E (1.0 to 2.6 inches) ---> will be iterative based on site constraints	
Contributing Area (A) =	28631	*sf.*	---------->	0.66 *ac.*
Contributing Impervious Area (A_i) =	16493	*sf.*	---------->	0.38 *ac.*
Percent Impervious Area ($\%_{IMP}$) =	57.6	% → use	60%	
Volumetric Runoff Coefficient (R_v) =	0.568		= 0.05 + 0.009 * ($\%_{IMP}$) (pg 5-18 of the MDE manual)	
ESDv Required (ESD_v) =	2401	*cf.*	= (P_E * A * R_v) / 12 (pg 5-18 of the MDE manual)	

Step 2: Assume Bio-swale Dimensions:

Bioswale Length (L) =	450	*ft.*		
Bioswale Bottom Width (W) =	8	*ft.*		A_f/A =
Bioswale Surface Area (A_f) =	3600	*sf.*	= Surface Area must be ≥ 2% of the contributing Area ---->	22%
Left Side Slope (S_{S1}) =	0.25	*ft/ft*	= 3:1 or flatter	
Right Side Slope (S_{S2}) =	0.25	*ft/ft*	= 3:1 or flatter	
Bioswale Slope (S_L) =	0.0385	*ft/ft*	= 4% maximum longitudinal slope	

Step 3: Determine Storage Requirements:

Percent Impervious Area ($\%_{IMP}$) =	60.0%		= impervious area divided by total contributing drainage area (A_i/A)
A_f/A_i =	21.8%		= filter bed area divided by impervious area (A_f/A_i)
ESD_v Required (ESD_v) =	2401	*cf.*	= (P_E * A * R_v) / 12
Percent Storage Required Above Surface ($V_{\%-S}$) =	41.3%	*of* ESD_v	= Surface Storage tables based on P_E, $\%_{IMP}$, and A_f/A_i
Min. Surface Storage Required (V_S) =	992	*cf.*	= $V_{\%-R}$ * ESD_v

Tables to be used with State Highway Administration (SHA) Bioretention Soil Mix (BSM)

Storage Volume (% of ESDv) required above surface for Pe = 1.8 inches

%Imp	Af/Ai										
	2%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
5%	45%	43%	39%	34%	30%	27%	24%	22%	20%	18%	17%
10%	49%	46%	40%	35%	31%	28%	25%	23%	22%	20%	19%
15%	52%	48%	42%	37%	34%	31%	29%	27%	25%	24%	22%
20%	55%	50%	44%	40%	37%	34%	32%	30%	28%	26%	25%
25%	55%	50%	45%	41%	37%	35%	32%	30%	28%	27%	25%
30%	56%	51%	45%	41%	38%	36%	33%	31%	29%	28%	26%
35%	56%	51%	46%	42%	39%	36%	34%	32%	30%	28%	27%
40%	57%	52%	47%	43%	40%	37%	35%	33%	31%	29%	27%
45%	57%	53%	47%	44%	41%	38%	36%	33%	32%	30%	28%
50%	58%	54%	48%	44%	41%	39%	36%	34%	32%	30%	29%
55%	58%	54%	49%	45%	42%	39%	37%	35%	33%	31%	29%
60%	59%	55%	49%	45%	42%	40%	37%	35%	33%	31%	30%
65%	59%	55%	49%	45%	42%	40%	37%	35%	33%	31%	30%
70%	59%	55%	49%	45%	42%	40%	37%	35%	33%	31%	30%
75%	59%	55%	49%	45%	42%	40%	37%	35%	33%	31%	30%
80%	59%	55%	49%	45%	42%	40%	37%	35%	33%	31%	30%
85%	59%	55%	49%	45%	42%	40%	37%	35%	33%	31%	30%
90%	59%	55%	49%	45%	42%	40%	37%	35%	33%	31%	30%
95%	59%	55%	49%	45%	42%	40%	37%	35%	33%	31%	30%
100%	59%	55%	49%	45%	42%	40%	37%	35%	33%	31%	30%

Revised 6/14/2016

Step 4: Determine Surface Storage Provided by Bio-swale:

Check Dam Top Width (CD_W) =	1.00	*ft.*

Project: NPDES/MS4 Assessment of Controls
County/Gr: Howard County
Watershed:
SHA Project Number:
RKK Project Number:
Design Phase: Concept

Designed By:
Checked By: SBP
Approved By:
Date: 10/3/2017

POI:
Facility No: HO BioSwale A
Location:

Check Dam Slope (S_{CD}) =	0.17	ft/ft	= max. slope 6:1 in clear zone and 3:1 outside the clear zone
Check Dam Height (CD_H) =	1.00	ft.	= max. 6" in the clear zone and 12" outside the clear zone
Maximal Length of Storage (L_{max}) =	50.00	ft.	= CD_H / S_L, If less than 50 ft. a minimum of 50 ft is used.
Length of Storage (L_S) =	50.00	ft.	= Length must be ≥ 50 ft and < L_{max}
Check Dam Length (CD_L) =	13.00	ft.	= 2 * CD_H / S_{CD} + CD_W
Check Dam Spacing (CD_S) =	63.00	ft.	= L_S + CD_L
Number of cells (C) =	7.00		= L / CD_S
Minimal Storage Depth (d_{min}) =	0.00	ft.	= S_L * (L_{max} - L_S)

Surface Storage Per Cell (V_C) = CD_H^3 / (6 * S_L* S_{S1}) + CD_H^3 / (6 * S_L* S_{S2}) + CD_H^2 * W / (2 * S_L)
- d_{min}^3 / (6 * S_L* S_{S1}) - d_{min}^3 / (6 * S_L* S_{S2}) - d_{min}^2 * W / (2 * S_L)
= 138.53 cf.

Total Surface Storage Provided (V_T) = 989.52 cf. = V_C * C + ((L - CD_S * C) * V_C / CD_S)

Step 5: Determine Treatment Provided by the Bio-swale:

Min. Surface Storage Required (V_{S-R}) =	992	cf.	= Surface Storage tables based on P_E, $\%_{IMP}$, and A_f/A_i
Surface Storage Provided (V_{S-P}) =	989.5	cf.	= total volume from step 3
Percent Surface Storage Provided ($V_{\%-S}$) =	41%		= percent surface storage provided based on a Pe of 1.8 inches

Because the proposed facility does not provide enough surface storage to treat the target Pe, iterations will need to be done to determine the reduced Pe

			Percent Storage		Actual >
From	P_E	ESD_v	Required	Actual	Required
	in.	cf.	%	%	Y/N
Table	1.70	2306	40.90%	42.92%	Yes
Iteration	1.77	2401	41.16%	41.21%	Yes
Table	1.80	2441	41.27%	40.53%	No

The PE treated is based on providing a surface storage volume that is a certain percent of the ESDv, but the ESDv changes depending on the Pe. Therefore, determing the Pe treated is an iterative process. The table shown demonstrates this process. The user should input the highest Pe value possible that still meets the required percent surface storage.

The Pe credited is 1.77 in. and the ESDv credited is 2401 cf.

Step 6: Determine the Impervious Area Treated by the Bio-swale:

Contributing Impervious Area	P_E treated	Impervious Acre Credit*
ac.	in.	ac.
0.38	1.77	0.45

** Impervious Acre Credit is based on Table 3 (page 12) of the MDE Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated from August 2014.*

Step 7: Determine if Underdrain is Required:

Primary HSG Soil Group under filter media = D — underdrain is not required in A/B soils

Underdrain is Required.

Step 8: Check Freeboard:

Q_{10} =	2	cfs	= 10-yr discharge from TR-55
Weir Length (L) =	6	ft.	
Discharge Coefficient (C) =	3.1		= typically 3.1
Hydraulic Head (H) =	0.23	ft.	=(Q_{10} / (CL))$^{2/3}$
Lowest SHA roadway elevation =	605	ft.	
Facility Control Elevation =	603	ft.	= control elevation where highest 10-yr WSE will occur
Highest WSE of 10-yr storm =	604.2	ft.	= highest 10-yr WSE will typically occur on top of most downstream checkdam
Freeboard =	0.8	ft.	= roadway elevation - WSE of 10-yr storm, freeeboard ≥ 9 inches

Freeboard Requirements are Met.

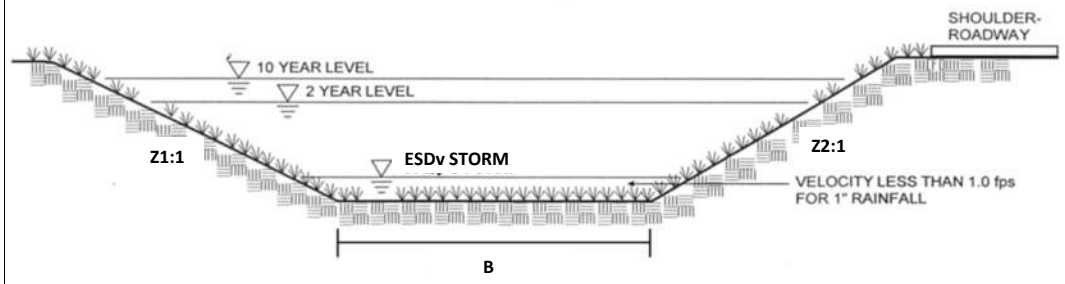
Step 9: Check 1" Stom Event Velocity:

1. The maximum flow velocity for runoff from the ESDv rainfall shall be less than or equal to 1.0 fps (see Appendix D.10 for methodology to compute flowrate). Ref. Vol. I, ch 5, pg 5.109

Project:	NPDES/MS4 Assessment of Controls	Designed By:	
		Checked By:	SBP
County/Gr:	Howard County	Approved By:	
Watershed:		Date:	10/3/2017
SHA Project Number:			
RKK Project Number:		POI:	
Design Phase:	Concept	Facility No:	HO BioSwale A
		Location:	

ESDv Rainfall Depth (Pe) =	1.8	in.	= Use Required Contributing Pe
Drainage Area (A) =	0.657	ac.	
Total Impervious Area (I) =	0.379	ac.	
Time-of-Concentration (Tc) =	0.100	hr.	= Tc value from TR-55 Computations
Percent Impervious =	57.6	%	= I/A
Runoff Coefficient (Rv) =	0.568		= 0.05+0.009*(I)
Runoff Volume (Qe) =	1.01	in.	= Pe * Rv (Eq. Ref. Vol. II, Appendix D.10)
Adjusted RCN =	92		= 1000 / [10+5Pe+10Qa-10V(Qa2+1.25QaPe)] (Eq. Ref. Vol. II, Appendix D.10)
Initial Abstract (Ia) =	0.17		= (200/CN)-2
Ia/Pe =	0.10		= If Ia/Pe is less than 0.1 then 0.1 will be used.
Unit Peak Discharge (qu) =	1010.0	csm/in.	= Log (q_u) = C_0 + C_1 * Log (Tc) + C_2 * [Log (Tc)]^2 (Figure D.11.1)
ESDv Peak Flow (Qw) =	1.04	cfs.	= (qu csm/in) * (A mi2) * (Qe in)

Typical Swale Cross section



Side Slope (Z1) =	4.000	:1
Side Slope (Z2) =	4.000	:1
Bottom Width (B) =	8	ft.
Slope of Channel (S) =	0.0385	ft/ft

$V = (1.49 * A * R^{2/3} * S^{1/2}) / n$

Flow Depth	Mann Coeff. (n)	Flow Area (A)	Hydraulic Radius (R)	R^(2/3)	A*R^(2/3)	Capacity (Qw)	Qp	Velocity (V)	Wetted Perimeter (WP)
(in.)		(sf.)	(ft.)			cfs	Cfs	fps	ft.
1.42	0.150	1.00	0.11	0.232	0.233	0.453	1.04	0.45	8.98
1.92	0.150	1.38	0.15	0.280	0.387	0.755	1.04	0.55	9.32
2.42	0.150	1.78	0.18	0.323	0.574	1.119	1.04	0.63	9.66

Depth of Flow = d =	1.92	in.	= from table above	
Computed Velocity = V =	0.55	fps	= Qw/A	velocity must be less than or equal to 1 fps -----> OK

Manning Roughness Coefficient (n) = 0.04 @ d > 12 in.* = reference for "n" value: P.1-2-B-6 of SHA Highway Drainage Manual

* n = 1.015 for d < 4" and n = 0.207-0.0145*d for 4" < d < 12" (Grass Channel Paper)

Step 10: Check 10-yr Stom Event Velocity:

2. The maximum flow velocity for runoff from the ten-year design event shall be non erosive. Ref. Vol. I, ch 5, pg 5.109

Revised 6/14/2016

Maximum permissible velocities of flow shall not exceed the values shown on the following table:

Table D.12.1 Permissible Velocities for Channels Lined with Vegetation

Project: NPDES/MS4 Assessment of Controls
County/Gr: Howard County
Watershed:
SHA Project Number:
RKK Project Number:
Design Phase: Concept

Designed By:
Checked By: SBP
Approved By:
Date: 10/3/2017

POI:
Facility No: HO BioSwale A
Location:

Channel Slope	Lining	Permissible Velocity[1] (ft/sec)
0-5%	Reed canarygrass Tall fescue Kentucky bluegrass	5
	Grass-legume mixture	4
	Red fescue Redtop Sericea lespedeza Annual lespedeza Small grains	2.5
5-10%	Reed canarygrass Tall fescue Kentucky bluegrass	4
	Grass-legume mixture	3
Greater than 10%	Reed canarygrass Tall fescue Kentucky bluegrass	3

[1] For highly erodible soils, permissible velocities should be decreased 25%. An erodibility factor (K) greater than 0.35 would indicate a highly erodible soil. Erodibility factors (K-factors) for Maryland soils are listed either in the Soil Survey or on the Soils-5 forms available in each Soil Conservation District or local NRCS office.

The permissible velocity = 4.00 *fps*

Maximum permissible velocities are given in Table D.12.1 (Appendix D.12 of MDE Manual). If you are providing soil stabilization you may use Limiting Velocities from P.I-3-A-3 of SHA Highway Drainage Manual.

10-yr Discharge (Q_{10}) = 8.00 *cfs* *from TR-55*

$V = (1.49 * A * R^{2/3} * S^{1/2}) / n$

Flow Depth	Mann Coeff. (n)	Flow Area (A)	Hydraulic Radius (R)	R^(2/3)	A*R^(2/3)	Capacity (Qw)	Q_{10}	Velocity (V)	Wetted Perimeter (WP)
(in.)		(sf.)	(ft.)			cfs	Cfs	fps	ft.
8.4	0.085	7.56	0.55	0.670	5.068	17.392	8.00	2.30	13.77
8.9	0.078	8.13	0.58	0.692	5.632	21.124	8.00	2.60	14.12
9.4	0.071	8.72	0.60	0.714	6.226	25.744	8.00	2.95	14.46

Depth of Flow = d = 8.90 *in.* *= from table above*
Computed Velocity = V = 2.60 *fps* *= Qw/A* *velocity must be less than or equal to permissible velocity fps*
---------> OK

Manning Roughness Coefficient (n) = 0.04 *@ d > 12 in.** *= reference for "n" value: P.1-2-B-6 of SHA Highway Drainage Manual*

** n = 1.015 for d < 4" and n = 0.207-0.0145*d for 4" < d < 12" (Grass Channel Paper)*

Project:	NPDES/MS4 Assessment of Controls	Designed By:	
		Checked By:	SBP
County/Gr:	Howard County	Approved By:	
Watershed:		Date:	10/3/2017
SHA Project Number:			
RKK Project Number:		**POI:**	
Design Phase:	Concept	**Facility No:**	**HO Bioswale B**
		Location:	

M-8: Bio-swale Design Calculations (TMDL only)

Step 1: Determine Contributing Area Data:

Input Cell

ESD_v Target (P_E) =	1.9	*in.*	= Target P_E (1.0 to 2.6 inches) ---> will be iterative based on site constraints	
Contributing Area (A) =	20707	*sf.*	---------->	0.48 *ac.*
Contributing Impervious Area (A_i) =	13056	*sf.*	---------->	0.30 *ac.*
Percent Impervious Area ($\%_{IMP}$) =	63.1	% → use	65%	
Volumetric Runoff Coefficient (R_v) =	0.617		= 0.05 + 0.009 * ($\%_{IMP}$) (pg 5-18 of the MDE manual)	
ESDv Required (ESD_v) =	2024	*cf.*	= (P_E * A * R_v) / 12 (pg 5-18 of the MDE manual)	

Step 2: Assume Bio-swale Dimensions:

Bioswale Length (L) =	160	*ft.*		
Bioswale Bottom Width (W) =	8	*ft.*		A_f/A =
Bioswale Surface Area (A_f) =	1280	*sf.*	= Surface Area must be ≥ 2% of the contributing Area ---->	10%
Left Side Slope (S_{S1}) =	0.25	*ft/ft*	= 3:1 or flatter	
Right Side Slope (S_{S2}) =	0.25	*ft/ft*	= 3:1 or flatter	
Bioswale Slope (S_L) =	0.011	*ft/ft*	= 4% maximum longitudinal slope	

Step 3: Determine Storage Requirements:

Percent Impervious Area ($\%_{IMP}$) =	65.0%		= impervious area divided by total contributing drainage area (A_i/A)
A_f/A_i =	9.8%		= filter bed area divided by impervious area (A_f/A_i)
ESD_v Required (ESD_v) =	2024	*cf.*	= (P_E * A * R_v) / 12
Percent Storage Required Above Surface ($V_{\%-S}$) =	50.2%	*of* ESD_v	= Surface Storage tables based on P_E, $\%_{IMP}$, and A_f/A_i
Min. Surface Storage Required (V_S) =	1016	*cf.*	= $V_{\%-R}$ * ESD_v

Tables to be used with State Highway Administration (SHA) Bioretention Soil Mix (BSM)

Storage Volume (% of ESDv) required above surface for Pe = 1.9 inches

%Imp	Af/Ai										
	2%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
5%	45%	43%	39%	35%	31%	28%	25%	22%	20%	19%	17%
10%	49%	46%	40%	35%	31%	28%	26%	24%	22%	21%	20%
15%	53%	49%	43%	38%	34%	32%	29%	27%	26%	24%	23%
20%	55%	51%	45%	41%	37%	34%	32%	30%	28%	27%	26%
25%	55%	51%	45%	41%	38%	35%	33%	31%	29%	28%	26%
30%	56%	51%	46%	42%	39%	36%	34%	32%	30%	28%	27%
35%	56%	52%	47%	43%	40%	37%	35%	33%	31%	29%	28%
40%	57%	53%	47%	43%	40%	38%	36%	33%	32%	30%	28%
45%	57%	53%	48%	44%	41%	38%	36%	34%	32%	31%	29%
50%	58%	54%	49%	45%	42%	39%	37%	35%	33%	31%	30%
55%	59%	55%	49%	45%	43%	40%	38%	36%	34%	32%	30%
60%	59%	55%	50%	46%	43%	40%	38%	36%	34%	32%	31%
65%	59%	55%	50%	46%	43%	40%	38%	36%	34%	32%	31%
70%	59%	55%	50%	46%	43%	40%	38%	36%	34%	32%	31%
75%	59%	55%	50%	46%	43%	40%	38%	36%	34%	32%	31%
80%	59%	55%	50%	46%	43%	40%	38%	36%	34%	32%	31%
85%	59%	55%	50%	46%	43%	40%	38%	36%	34%	32%	31%
90%	59%	55%	50%	46%	43%	40%	38%	36%	34%	32%	31%
95%	59%	55%	50%	46%	43%	40%	38%	36%	34%	32%	31%
100%	59%	55%	50%	46%	43%	40%	38%	36%	34%	32%	31%

Revised 6/14/2016

Step 4: Determine Surface Storage Provided by Bio-swale:

Check Dam Top Width (CD_W) =	1.00	*ft.*

Project: NPDES/MS4 Assessment of Controls
County/Gr: Howard County
Watershed:
SHA Project Number:
RKK Project Number:
Design Phase: Concept

Designed By:
Checked By: SBP
Approved By:
Date: 10/3/2017

POI:
Facility No: HO Bioswale B
Location:

Check Dam Slope (S_{CD}) =	0.17	ft/ft	= max. slope 6:1 in clear zone and 3:1 outside the clear zone
Check Dam Height (CD_H) =	1.00	ft.	= max. 6" in the clear zone and 12" outside the clear zone
Maximal Length of Storage (L_{max}) =	90.91	ft.	= CD_H / S_L, If less than 50 ft. a minimum of 50 ft is used.
Length of Storage (L_S) =	50.00	ft.	= Length must be ≥ 50 ft and < L_{max}
Check Dam Length (CD_L) =	13.00	ft.	= 2 * CD_H / S_{CD} + CD_W
Check Dam Spacing (CD_S) =	63.00	ft.	= L_S + CD_L
Number of cells (C) =	2.00		= L / CD_S
Minimal Storage Depth (d_{min}) =	0.45	ft.	= S_L * (L_{max} - L_S)

Surface Storage Per Cell (V_C) = CD_H^3 / (6 * S_L* S_{S1}) + CD_H^3 / (6 * S_L* S_{S2}) + CD_H^2 * W / (2 * S_L)
- d_{min}^3 / (6 * S_L* S_{S1}) - d_{min}^3 / (6 * S_L* S_{S2}) - d_{min}^2 * W / (2 * S_L)
= 400.17 cf.

Total Surface Storage Provided (V_T) = 1016.34 cf. = V_C * C + ((L - CD_S * C) * V_C / CD_S)

Step 5: Determine Treatment Provided by the Bio-swale:

Min. Surface Storage Required (V_{S-R}) =	1016	cf.	= Surface Storage tables based on P_E, $\%_{IMP}$, and A_f/A_i
Surface Storage Provided (V_{S-P}) =	1016.3	cf.	= total volume from step 3
Percent Surface Storage Provided ($V_{\%-S}$) =	50%		= percent surface storage provided based on a Pe of 1.9 inches

Because the proposed facility is providing more than enough surface storage, iterations will need to be done to determine the larger Pe treated.

			Percent Storage		Actual >
From	P_E	ESD_v	Required	Actual	Required
	in.	cf.	%	%	Y/N
Table	1.90	2024	50.20%	50.20%	Yes
Iteration	1.90	2024	50.20%	50.21%	Yes
Table	2.00	2131	50.20%	47.69%	No

The PE treated is based on providing a surface storage volume that is a certain percent of the ESDv, but the ESDv changes depending on the Pe. Therefore, determing the Pe treated is an iterative process. The table shown demonstrates this process. The user should input the highest Pe value possible that still meets the required percent surface storage.

The Pe credited is 1.9 in. and the ESDv credited is 2024 cf.

Step 6: Determine the Impervious Area Treated by the Bio-swale:

Contributing Impervious Area	P_E treated	Impervious Acre Credit*
ac.	in.	ac.
0.30	1.90	0.37

** Impervious Acre Credit is based on Table 3 (page 12) of the MDE Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated from August 2014.*

Step 7: Determine if Underdrain is Required:

Primary HSG Soil Group under filter media = D — underdrain is not required in A/B soils

Underdrain is Required.

Step 8: Check Freeboard:

Q_{10} =	2	cfs	= 10-yr discharge from TR-55
Weir Length (L) =	6	ft.	
Discharge Coefficient (C) =	3.1		= typically 3.1
Hydraulic Head (H) =	0.23	ft.	=(Q_{10} / (CL))$^{2/3}$
Lowest SHA roadway elevation =	605	ft.	
Facility Control Elevation =	603	ft.	= control elevation where highest 10-yr WSE will occur
Highest WSE of 10-yr storm =	604.2	ft.	= highest 10-yr WSE will typically occur on top of most downstream checkdam
Freeboard =	0.8	ft.	= roadway elevation - WSE of 10-yr storm, freeeboard ≥ 9 inches

Freeboard Requirements are Met.

Step 9: Check 1" Stom Event Velocity:

1. The maximum flow velocity for runoff from the ESDv rainfall shall be less than or equal to 1.0 fps (see Appendix D.10 for methodology to compute flowrate). Ref. Vol. I, ch 5, pg 5.109

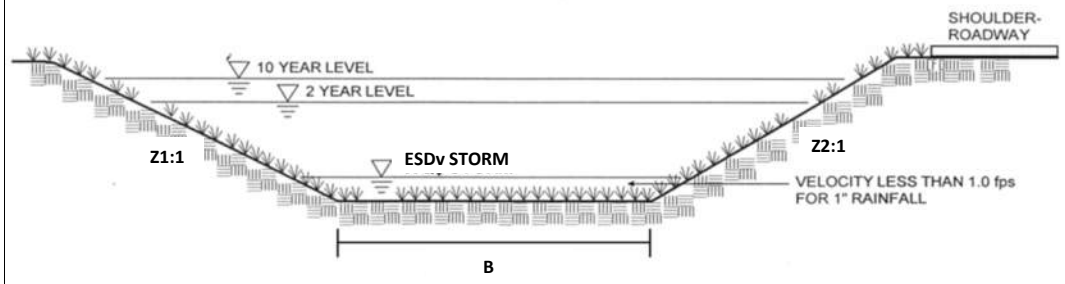
Project: NPDES/MS4 Assessment of Controls
County/Gr: Howard County
Watershed:
SHA Project Number:
RKK Project Number:
Design Phase: Concept

Designed By:
Checked By: SBP
Approved By:
Date: 10/3/2017

POI:
Facility No: HO Bioswale B
Location:

ESDv Rainfall Depth (Pe) =	1.9	in.	= Use Required Contributing Pe
Drainage Area (A) =	0.475	ac.	
Total Impervious Area (I) =	0.300	ac.	
Time-of-Concentration (Tc) =	0.100	hr.	= Tc value from TR-55 Computations
Percent Impervious =	63.1	%	= I/A
Runoff Coefficient (Rv) =	0.617		= 0.05+0.009*(I)
Runoff Volume (Qe) =	1.17	in.	= Pe * Rv (Eq. Ref. Vol. II, Appendix D.10)
Adjusted RCN =	92		= 1000 / [10+5Pe+10Qa-10V(Qa2+1.25QaPe)] (Eq. Ref. Vol. II, Appendix D.10)
Initial Abstract (Ia) =	0.17		= (200/CN)-2
Ia/Pe =	0.10		= If Ia/Pe is less than 0.1 then 0.1 will be used.
Unit Peak Discharge (qu) =	1010.0	csm/in.	= Log (q_u) = C_0 + C_1 * Log (Tc) + C_2 * [Log (Tc)]^2 (Figure D.11.1)
ESDv Peak Flow (Qw) =	0.88	cfs.	= (qu csm/in) * (A mi2) * (Qe in)

Typical Swale Cross section



Side Slope (Z1) =	4.000	:1
Side Slope (Z2) =	4.000	:1
Bottom Width (B) =	8	ft.
Slope of Channel (S) =	0.011	ft/ft

$V = (1.49 * A * R^{2/3} * S^{1/2}) / n$

Flow Depth	Mann Coeff. (n)	Flow Area (A)	Hydraulic Radius (R)	R^(2/3)	A*R^(2/3)	Capacity (Qw)	Qp	Velocity (V)	Wetted Perimeter (WP)
(in.)		(sf.)	(ft.)			cfs	Cfs	fps	ft.
1.42	0.150	1.00	0.11	0.232	0.233	0.242	0.88	0.24	8.98
1.92	0.150	1.38	0.15	0.280	0.387	0.404	0.88	0.29	9.32
2.42	0.150	1.78	0.18	0.323	0.574	0.598	0.88	0.34	9.66

Depth of Flow = d =	1.92	in.	= from table above	
Computed Velocity = V =	0.29	fps	= Qw/A	velocity must be less than or equal to 1 fps -----> OK

Manning Roughness Coefficient (n) = 0.04 @ d > 12 in.* = reference for "n" value: P.1-2-B-6 of SHA Highway Drainage Manual

* n = 1.015 for d < 4" and n = 0.207-0.0145*d for 4" < d < 12" (Grass Channel Paper)

Step 10: Check 10-yr Stom Event Velocity:

2. The maximum flow velocity for runoff from the ten-year design event shall be non erosive. Ref. Vol. I, ch 5, pg 5.109

Revised 6/14/2016

Maximum permissible velocities of flow shall not exceed the values shown on the following table:

Table D.12.1 Permissible Velocities for Channels Lined with Vegetation

Project: NPDES/MS4 Assessment of Controls
County/Gr: Howard County
Watershed:
SHA Project Number:
RKK Project Number:
Design Phase: Concept

Designed By:
Checked By: SBP
Approved By:
Date: 10/3/2017

POI:
Facility No: HO Bioswale B
Location:

Channel Slope	Lining	Permissible Velocity[1] (ft/sec)
0-5%	Reed canarygrass Tall fescue Kentucky bluegrass	5
	Grass-legume mixture	4
	Red fescue Redtop Sericea lespedeza Annual lespedeza Small grains	2.5
5-10%	Reed canarygrass Tall fescue Kentucky bluegrass	4
	Grass-legume mixture	3
Greater than 10%	Reed canarygrass Tall fescue Kentucky bluegrass	3

[1] For highly erodible soils, permissible velocities should be decreased 25%. An erodibility factor (K) greater than 0.35 would indicate a highly erodible soil. Erodibility factors (K-factors) for Maryland soils are listed either in the Soil Survey or on the Soils-5 forms available in each Soil Conservation District or local NRCS office.

The permissible velocity = 4.00 *fps*

Maximum permissible velocities are given in Table D.12.1 (Appendix D.12 of MDE Manual). If you are providing soil stabilization you may use Limiting Velocities from P.I-3-A-3 of SHA Highway Drainage Manual.

10-yr Discharge (Q_{10}) = 8.00 *cfs* *from TR-55*

$V = (1.49 * A * R^{2/3} * S^{1/2}) / n$

Flow Depth	Mann Coeff. (n)	Flow Area (A)	Hydraulic Radius (R)	R^(2/3)	A*R^(2/3)	Capacity (Qw)	Q_{10}	Velocity (V)	Wetted Perimeter (WP)
(in.)		(sf.)	(ft.)			cfs	Cfs	fps	ft.
8.4	0.085	7.56	0.55	0.670	5.068	9.296	8.00	1.23	13.77
8.9	0.078	8.13	0.58	0.692	5.632	11.291	8.00	1.39	14.12
9.4	0.071	8.72	0.60	0.714	6.226	13.761	8.00	1.58	14.46

Depth of Flow = d = 8.90 *in.* *= from table above*
Computed Velocity = V = 1.39 *fps* *= Qw/A* *velocity must be less than or equal to permissible velocity fps*
---------> OK

Manning Roughness Coefficient (n) = 0.04 *@ d > 12 in.** *= reference for "n" value: P.1-2-B-6 of SHA Highway Drainage Manual*

** n = 1.015 for d < 4" and n = 0.207-0.0145*d for 4" < d < 12" (Grass Channel Paper)*

Project: NPDES/MS4 Assessment of Controls
County/Gr: Howard County
Watershed:
SHA Project Number:
RKK Project Number:
Design Phase: Concept

Designed By:
Checked By: SBP
Approved By:
Date: 10/3/2017

POI:
Facility No: HO Micro-bioretention
Location:

F-6: Bioretention Design Calculations (TMDL only)

Step 1: Determine Contributing Area Data:

Input Cell

ESD_v Target (P_E) =	2.6	*in.*	= Target P_E (1.0 to 2.6 inches) ---> will be iterative based on site constraints	
Contributing Area (A) =	45667	*sf.*	---------->	1.05 *ac.*
Contributing Impervious Area (A_i) =	24393	*sf.*	---------->	0.56 *ac.*
Percent Impervious Area ($\%_{IMP}$) =	53.4	% → use	55%	
Volumetric Runoff Coefficient (R_v) =	0.531		= 0.05 + 0.009 * ($\%_{IMP}$) (pg 5-18 of the MDE manual)	
$ESDv$ Required (ESD_v) =	5251	*cf.*	= (P_E * A * R_v) / 12 (pg 5-18 of the MDE manual)	

Step 2: Determine Bioretention Dimensions:

Filter bed depth (d_f)=	2.0	*ft.*	
Coefficient of Permeability (k)=	2.0	*ft/day*	
Average height above filter bed (h_f)=	0.5	*ft.*	= average ponding depth, maximum 12" for ESD_v
Filter bed draindown time (t_f)=	2.0	*days*	
Filter Bed Area Required =	404	*sf.*	= (WQ_v) (d_f) / [(k) (h_f + d_f) (t_f)] (pg 3.40 of MDE Manual)
Side Slope =	0.25	*ft/ft*	= 3:1 or flatter
Filter Bed Area Provided (A_f) =	1,914.68	*sf.*	

Facility footprint is adequate.

Step 3: Determine Storage Requirements:

Percent Impervious Area ($\%_{IMP}$) =	55.0%		= impervious area divided by total contributing drainage area (A_i/A)
A_f/A_i =	7.8%		= filter bed area divided by impervious area (A_f/A_i)
ESD_v Required (ESD_v) =	5251	*cf.*	= (P_E * A * R_v) / 12
Percent Storage Required Above Surface ($V_{\%-S}$) =	52.2%	*of* ESD_v	= Surface Storage tables based on P_E, $\%_{IMP}$, and A_f/A_i
Min. Surface Storage Required (V_S)=	2741	*cf.*	= $V_{\%-R}$ * ESD_v

Tables to be used with State Highway Administration (SHA) Bioretention Soil Mix (BSM)

Storage Volume (% of ESDv) required above surface for Pe = 2 - 2.6 inches

%Imp	Af/Ai 2%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
5%	46%	43%	39%	36%	32%	28%	26%	23%	21%	19%	18%
10%	50%	46%	41%	36%	32%	29%	27%	25%	23%	21%	20%
15%	53%	49%	43%	39%	35%	32%	30%	28%	26%	25%	24%
20%	55%	51%	45%	41%	38%	35%	33%	31%	29%	28%	26%
25%	55%	51%	46%	42%	39%	36%	34%	32%	30%	28%	27%
30%	56%	52%	46%	42%	39%	37%	35%	32%	31%	29%	28%
35%	56%	52%	47%	43%	40%	38%	35%	33%	31%	30%	28%
40%	57%	53%	48%	44%	41%	38%	36%	34%	32%	31%	29%
45%	58%	54%	48%	45%	42%	39%	37%	35%	33%	31%	30%
50%	58%	54%	49%	45%	42%	40%	38%	36%	34%	32%	30%
55%	59%	55%	50%	46%	43%	41%	38%	36%	34%	33%	31%
60%	59%	55%	50%	46%	44%	41%	39%	37%	35%	33%	31%
65%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
70%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
75%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
80%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
85%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
90%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
95%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
100%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%

Step 4: Determine Surface Storage Provided by Bioretention:

Project:	NPDES/MS4 Assessment of Controls	Designed By:	
		Checked By:	SBP
County/Gr:	Howard County	Approved By:	
Watershed:		Date:	10/3/2017
SHA Project Number:			
RKK Project Number:		**POI:**	
Design Phase:	Concept	**Facility No:**	**HO Micro-bioretention**
		Location:	

Stage Storage Table

Elevation [ft.]	Area [ft²]	Area [acre]	Change in Elevation [ft]	Average Area [acre]	Incremental Volume [acre·ft]	Cumulative Volume [acre·ft]	Cumulative Volume [ft³]
475.00	1,914.68	0.0440				0.0000	0.00
475.50	2888.88	0.0663	0.5	0.0551	0.0276	0.0276	1,200.89
476.00	3,971.78	0.0912	0.5	0.0787	0.0394	0.0669	2,916.06

Step 5: Determine Treatment Provided by the Bioretention:

Min. Surface Storage Required (V_S)=	2741	*cf.*	*= Surface Storage tables based on P_E, $\%_{IMP}$, and A_f/A_i*
Surface Storage Provided (V_S)=	2916	*cf.*	*= total volume from stage storage table*
Percent Surface Storage Provided ($V_{\%-S}$)=	56%		*= percent surface storage provided based on a Pe of 2.6 inches*

Because the proposed facility is providing more than enough surface storage, iterations will need to be done to determine the larger Pe treated.

			Percent Storage		*Actual > Required*
From	P_E	ESD_v	Required	Actual	
	in.	cf.	%	%	Y/N
Table	2.60	5251	52.15%	55.53%	Yes
Iteration	2.60	5251	52.15%	55.53%	Yes
Table	0.00	0	0.00%	#DIV/0!	#DIV/0!

The PE treated is based on providing a surface storage volume that is a certain percent of the ESDv, but the ESDv changes depending on the Pe. Therefore, determing the Pe treated is an iterative process. The table shown demonstrates this process. The user should input the highest Pe value possible that still meets the required percent surface storage.

Because the proposed facility is providing a Pe greater than 2.6 in., the Pe credited is 2.6 in. and the ESDv credited is 5251.

Step 6: Determine the Impervious Area Treated by the Bioretention:

Contributing Impervious Area	P_E treated	Impervious Acre Credit*
ac.	in.	ac.
0.56	2.60	0.78

** Impervious Acre Credit is based on Table 3 (page 12) of the MDE Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated from August 2014.*

Step 7: Determine if Underdrain is Required:

Primary HSG Soil Group under filter media =	D		*underdrain is not required in A/B soils*

Underdrain is Required.

Step 8: Check Freeboard:

Q_{10} =	2	*cfs*	*= 10-yr discharge from TR-55*
Weir Length (L) =	6	*ft.*	
Discharge Coefficient (C) =	3.1		*= typically 3.1*
Hydraulic Head (H) =	0.23	*ft.*	*$=(Q_{10} / (CL))^{2/3}$*
Lowest SHA roadway elevation =	605	*ft.*	
Facility Control Elevation =	603	*ft.*	*= control elevation where highest 10-yr WSE will occur (typically outfall weir)*
Highest WSE of 10-yr storm =	604.2	*ft.*	*= highest 10-yr WSE will typically occur on top outfall weir*
Freeboard =	0.80	*ft.*	*= roadway elevation - WSE of 10-yr storm, freeeboard ≥ 9 inches*

Freeboard Requirements are Met.

Summary of Facility Drainage Areas and RCN

	Impervious (s	Lawn Good Condition (sc	Total Sq ft	Total (acres)	Weighted RCN	
Grass Swale A	41939	81246	123185	2.83	86.13	10609686
Grass Swale B	10727	22940	33667	0.77	89.27	3005604.7
Dry Swale A	13456	28553	42008	0.96	85.77	3602862.3
Dry Swale B	39403	70499	109901	2.52	86.45	9501344.5
Dry Swale C	43989	60840	104829	2.41	87.55	9178137.4
Bioretention	77597	115838	193435	4.44	86.51	16734610
MicroBioretention	24393	21274	45667	1.05	89.61	4092436.4
BioSwale A	16493	12137	28631	0.66	90.37	2587337.2
BioSwale B	13056	7651	20707	0.48	90.87	1881555.7
Total	**281053**	**420977**	**702030**	**16.12**		**61193574**

87.1666 Collective Weighted RCN

Project:	I-270 ICM	Designed By:	JAC
County:	Montgomery	Checked By:	MBS
Watershed:	02-14-02	Approved By:	
SHA Project Number:		Date:	Sep-17
PRD Project Number:			
Design Phase	Concept		

ESD Facility Routing Calculations

Step 1: Calculate Storage in BSM Media:

Input Cell

Total Length of Facilities (L) =	735.0	ft.	
Weighted Average Width of Facilities (w) =	8.83	ft.	
Depth of Facilities (d) =	2	ft.	
Porosity (n) =	40	%	
Storage in BSM Media =	5191	cf.	= L*w*d*n

Step 2: Determine Dimensions of Hypothetical Pond:

Total Surface Storage Provided (V_T) =	29675	cf.	= from ESD Facility calculations step 3
Hypothetical Pond Length (L) =	353.27	ft.	= Total Surface Storage / (Hypothetical Pond Width * Hypothetical Pond Depth)
Hypothetical Pond Width (W) =	84.00	sf.	= Total Weir Length
Hypothetical Pond Depth (D) =	1.00	ft/ft	= Check dam height
Side Slope (S_S) =	0.33	ft/ft	= assume 3:1 above 1' depth

Step 3: Determine Surface Storage Provided by Hypothetical Pond: w1

Stage Storage Table

Elevation [ft.]	Area [ft²]	Area [acre]	Change in Elevation [ft]	Average Area [acre]	Incremental Volume [acre·ft]	Cumulative Volume [acre·ft]	Cumulative Volume [ft³]
0.00	29675	0.6812				0.1192	5,190.57
1.00	29675	0.6812	1.00	0.6812	0.6812	0.8004	34,865.27
1.20	30201	0.6933	0.20	0.6873	0.1375	0.9378	40,852.83
1.40	30730	0.7055	0.20	0.6994	0.1399	1.0777	46,945.90
1.60	31262	0.7177	0.20	0.7116	0.1423	1.2200	53,145.07
1.80	31797	0.7299	0.20	0.7238	0.1448	1.3648	59,450.91
2.00	32334	0.7423	0.20	0.7361	0.1472	1.5120	65,864.00

Project:	I-270 ICM	Designed By:	JAC
County:	Montgomery	Checked By:	MBS
Watershed:	02-14-02	Approved By:	
SHA Project Number:		Date:	Sep-17
PRD Project Number:			
Design Phase	Concept		

Step 4: Determine Discharge Data for Hypothetical Pond:

Bottom of Swale =	0.00	ft.
Weir Length =	84.00	ft.
Weir Elevation =	1.00	ft.

Stage Storage Dischage Table

Elevation [ft.]	Head [ft.]	Discharge [cfs.]	Cumulative Volume [acre-ft]
0.00			0.1192
1.00	0.00	0.000	0.8004
1.20	0.20	24.794	0.9378
1.40	0.40	70.127	1.0777
1.60	0.60	128.831	1.2200
1.80	0.80	198.348	1.3648
2.00	1.00	277.200	1.5120

$Q = 3.3 * \text{Weir Length} * \text{Head}^{1.5}$

Existing Conditions

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WinTR-20: version 3.10                  0         0                   0
I70/Marriotsville Detailed Existing Conditions

SUB-AREA:
          Existing  OUTLET              1.9259    75.56     4.027     Y
          Facility  OUTLET              0.0252    86.39     0.1       Y



STORM ANALYSIS:
          2-yr                          3.19      TYPE II   2
          10-yr                         4.91      TYPE II   2




RAINFALL DISTRIBUTION:
          Rain  1             0.10000
                    0.0       0.00310   0.00620   0.00930   0.01240
                    0.01550   0.01850   0.02160   0.02470   0.02780
                    0.03090   0.03400   0.03710   0.04020   0.04330
                    0.04640   0.04940   0.05250   0.05560   0.05870
                    0.06180   0.06490   0.06800   0.07110   0.07420
                    0.07730   0.08030   0.08340   0.08650   0.08960
                    0.09270   0.09810   0.10350   0.10890   0.11440
                    0.11980   0.12520   0.13060   0.13600   0.14140
                    0.14680   0.15220   0.15770   0.16310   0.16850
                    0.17390   0.17820   0.18260   0.18690   0.19130
                    0.19560   0.20560   0.21550   0.22550   0.23540
                    0.24530   0.26550   0.28560   0.31780   0.36890
                    0.50000   0.63110   0.68220   0.71440   0.73450
                    0.75470   0.76460   0.77450   0.78450   0.79440
                    0.80440   0.80870   0.81310   0.81740   0.82180
                    0.82610   0.83150   0.83690   0.84230   0.84780
                    0.85320   0.85860   0.86400   0.86940   0.87480
                    0.88020   0.88560   0.89110   0.89650   0.90190
                    0.90730   0.91040   0.91350   0.91660   0.91970
                    0.92270   0.92580   0.92890   0.93200   0.93510
                    0.93820   0.94130   0.94440   0.94750   0.95060
                    0.95360   0.95670   0.95980   0.96290   0.96600
                    0.96910   0.97220   0.97530   0.97840   0.98150
                    0.98450   0.98760   0.99070   0.99380   0.99690
                    1.00000



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VERIFICATION:
          PROCESSING                Y




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I70/Marriotsville Detailed Existing Conditions

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STORM 2-yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Existing	1.926		1.119		14.55	247.4	128.46
Facility	0.025		1.821		11.93	46.1	1828.89
OUTLET	1.951		1.128		14.55	248.8	127.54

STORM 10-yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Existing	1.926		2.424		14.59	566.7	294.25
Facility	0.025		3.379		11.93	83.5	3312.56
OUTLET	1.951		2.436		14.58	569.1	291.70

Area or Reach Identifier	Drainage Area (sq mi)	Peak Flow by Storm 2-yr (cfs)	10-yr (cfs)	(cfs)	(cfs)	(cfs)
Existing	1.926	247.4	566.7			
Facility	0.025	46.1	83.5			
OUTLET	1.951	248.8	569.1			

Proposed Conditions (No treatment)

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I70/Marriotsville Proposed Condtions

SUB-AREA:
          Proposed  OUTLET              1.9518    75.661    4.027     Y



STORM ANALYSIS:
          2-yr                          3.19      TYPE II   2
          10-yr                         4.91      TYPE II   2




RAINFALL DISTRIBUTION:
          Rain  1             0.10000
                    0.0       0.00310   0.00620   0.00930   0.01240
                    0.01550   0.01850   0.02160   0.02470   0.02780
                    0.03090   0.03400   0.03710   0.04020   0.04330
                    0.04640   0.04940   0.05250   0.05560   0.05870
                    0.06180   0.06490   0.06800   0.07110   0.07420
                    0.07730   0.08030   0.08340   0.08650   0.08960
                    0.09270   0.09810   0.10350   0.10890   0.11440
                    0.11980   0.12520   0.13060   0.13600   0.14140
                    0.14680   0.15220   0.15770   0.16310   0.16850
                    0.17390   0.17820   0.18260   0.18690   0.19130
                    0.19560   0.20560   0.21550   0.22550   0.23540
                    0.24530   0.26550   0.28560   0.31780   0.36890
                    0.50000   0.63110   0.68220   0.71440   0.73450
                    0.75470   0.76460   0.77450   0.78450   0.79440
                    0.80440   0.80870   0.81310   0.81740   0.82180
                    0.82610   0.83150   0.83690   0.84230   0.84780
                    0.85320   0.85860   0.86400   0.86940   0.87480
                    0.88020   0.88560   0.89110   0.89650   0.90190
                    0.90730   0.91040   0.91350   0.91660   0.91970
                    0.92270   0.92580   0.92890   0.93200   0.93510
                    0.93820   0.94130   0.94440   0.94750   0.95060
                    0.95360   0.95670   0.95980   0.96290   0.96600
                    0.96910   0.97220   0.97530   0.97840   0.98150
                    0.98450   0.98760   0.99070   0.99380   0.99690
                    1.00000



GLOBAL OUTPUT:
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VERIFICATION:
          PROCESSING                Y




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I70/Marriotsville Proposed Condtions

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STORM 2-yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Proposed	1.952		1.125		14.52	252.0	129.11
OUTLET	1.952		1.125		14.52	252.0	129.11

STORM 10-yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Proposed	1.952		2.432		14.56	576.5	295.39
OUTLET	1.952		2.432		14.56	576.5	295.39

I70/Marriotsville Proposed Condtions

Area or Reach Identifier	Drainage Area (sq mi)	Peak Flow by Storm 2-yr (cfs)	10-yr (cfs)	(cfs)	(cfs)	(cfs)
Proposed	1.952	252.0	576.5			
OUTLET	1.952	252.0	576.5			

Proposed Conditions (with ESD Facilities)

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WinTR-20: version 3.10                  0         0                   0
I70/Marriotsville Proposed Routed Condtions

SUB-AREA:
          POND      Weir                .0252     87.17     0.1
          Proposed  OUTLET              1.9259    75.56     4.027


STREAM REACH:
          Weir      OUTLET              Pond


STORM ANALYSIS:
          2-yr                          3.19      TYPE II   2
          10-yr                         4.91      TYPE II   2



STRUCTURE RATING:
          Pond      1.
                    1.        0.        .8004
                    1.2       24.794    .9378
                    1.4       70.127    1.0777
                    1.6       128.831   1.2200
                    1.8       198.348   1.3648
                    2.        277.2     1.5120


RAINFALL DISTRIBUTION:
          Rain  1             0.10000
                    0.0       0.00310   0.00620   0.00930   0.01240
                    0.01550   0.01850   0.02160   0.02470   0.02780
                    0.03090   0.03400   0.03710   0.04020   0.04330
                    0.04640   0.04940   0.05250   0.05560   0.05870
                    0.06180   0.06490   0.06800   0.07110   0.07420
                    0.07730   0.08030   0.08340   0.08650   0.08960
                    0.09270   0.09810   0.10350   0.10890   0.11440
                    0.11980   0.12520   0.13060   0.13600   0.14140
                    0.14680   0.15220   0.15770   0.16310   0.16850
                    0.17390   0.17820   0.18260   0.18690   0.19130
                    0.19560   0.20560   0.21550   0.22550   0.23540
                    0.24530   0.26550   0.28560   0.31780   0.36890
                    0.50000   0.63110   0.68220   0.71440   0.73450
                    0.75470   0.76460   0.77450   0.78450   0.79440
                    0.80440   0.80870   0.81310   0.81740   0.82180
                    0.82610   0.83150   0.83690   0.84230   0.84780
                    0.85320   0.85860   0.86400   0.86940   0.87480
                    0.88020   0.88560   0.89110   0.89650   0.90190
                    0.90730   0.91040   0.91350   0.91660   0.91970
                    0.92270   0.92580   0.92890   0.93200   0.93510
                    0.93820   0.94130   0.94440   0.94750   0.95060
                    0.95360   0.95670   0.95980   0.96290   0.96600
                    0.96910   0.97220   0.97530   0.97840   0.98150
                    0.98450   0.98760   0.99070   0.99380   0.99690
                    1.00000


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VERIFICATION:
          PROCESSING                Y


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I70/Marriotsville Proposed Routed Condtions

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Area or Reach Identifier	Drainage Area (sq mi)	Peak Flow by Storm 2-yr (cfs)	10-yr (cfs)	(cfs)	(cfs)	(cfs)
POND	0.025	47.6	85.0			
Proposed	1.926	247.4	566.7			
Weir	0.025	47.6	85.0			
DOWNSTREAM		44.2	80.5			
OUTLET	1.951	248.9	569.2			

Appendix F

Howard County Data and Planning

F.2 – Marriottsville Road Improvement Plans

MARYLAND DEPARTMENT OF TRANSPORTATION™

STATE HIGHWAY ADMINISTRATION

Marriottsville Road Improvements, Phase III

STORMWATER MANAGEMENT AND EROSION & SEDIMENT CONTROL REPORT

Howard County Project No: J-4205
Howard County, Maryland

PREPARED FOR:

Howard County Department of Public Works
George Howard Building
3430 Court House Drive
Ellicott City, MD 21043

PREPARED BY:

STV 100 Years

7125 Ambassador Road
Suite 200
Baltimore, MD 21244

May 2017

Professional Certification. I hereby certify that these documents were prepared or approved by me, and that I am a duly licensed professional engineer under the laws of the State of Maryland, License No: 40784 Expiration Date: 11-08-2017

Table of Contents

I. INTRODUCTION 1

II. METHODOLOGY 1

III. STORMWATER MANAGEMENT ANALYSIS 4

A. POI 1 4

i. Description 4

ii. ESD Requirements 4

iii. ESD Provided 4

iv. Quantity Management 5

v. Downstream Impacts 5

B. POI 2 5

i. Description 5

ii. ESD Requirements 5

iii. ESD Provided 5

iv. Quantity Management 6

v. Downstream Impacts 6

C. POI 3 6

i. Description 6

ii. ESD Requirements 6

iii. ESD Provided 6

iv. Quantity Management 7

v. Downstream Impacts 7

D. LOI 4 7

i. Description 7

ii. ESD Requirements 7

iii. ESD Provided 7

iv. Quantity Management 8

v. Downstream Impacts 8

E. POI 5 8

i. Description 8

ii. ESD Requirements 8

iii. ESD Provided 8

iv. Quantity Management 9
v. Downstream Impacts 9
F. POI 6 9
i. Description 9
ii. ESD Requirements 10
iii. ESD Provided 10
iv. Quantity Management 10
v. Downstream Impacts 10
G. POI 7 11
i. Description 11
ii. ESD Requirements 11
iii. ESD Provided 11
iv. Quantity Management 11
v. Downstream Impacts 12
H. POI 8 12
i. Description 12
ii. ESD Requirements 12
iii. ESD Provided 12
iv. Quantity Management 12
v. Downstream Impacts 13
I. POI 9 13
i. Description 13
ii. ESD Requirements 13
iii. ESD Provided 13
iv. Quantity Management 13
v. Downstream Impacts 14
J. POI 10 14
i. Description 14
ii. ESD Requirements 14
iii. ESD Provided 14
iv. Quantity Management 14
v. Downstream Impacts 15

K. LOI 11 15
i. Description 15
ii. ESD Requirements 15
iii. ESD Provided 15
iv. Quantity Management 15
v. Downstream Impacts 16
L. LOI 12 16
i. Description 16
ii. ESD Requirements 16
iii. ESD Provided 16
iv. Quantity Management 16
v. Downstream Impacts 16
G. Summary of POIs 17
IV. EROSION AND SEDIMENT CONTROL ANALYSIS 18
V. EXISTING CULVERT ANALYSIS 19
A. Existing 14'x6' Box Culvert 19
B. Existing Double 8'x7' Box Culvert 19
VI. CONCLUSIONS 20
VII. REFERENCES 20
VIII. APPENDIX A – TR-55 Output i
IX. APPENDIX B – Soil Survey ii
X. APPENDIX C – Stream Designation Information iii
XI. APPENDIX D – ESD Computations iv
XII. APPENDIX E – Water Quality Maps v
XIII. APPENDIX F – Site Resource/Existing Drainage Area Map vi
XIV. APPENDIX G – Proposed Drainage Area Map vii
XV. APPENDIX H – Outfall Photos viii
XVI. APPENDIX I – Outfall Discharge Computations ix
XVII. APPENDIX J – Storm Drain Computations x
XVIII. APPENDIX K – Existing Culvert Analyses xi

I. INTRODUCTION

This project is located in Marriottsville in Howard County along Marriottsville Road at the overpass of I-70 and extending to the next intersection north and south of the bridge (see Figure 1.1 for location map). The primary purpose of the project is to provide widening to the bridge and the approach roadways in order to accommodate four travel lanes and two bike lanes (one bike lane on each side).

Under existing conditions, Marriottsville Road is an undivided two lane roadway along the bridge. The approaches widen to accommodate ramps from I-70 and turning lanes at the intersections north and south of the bridge. Except for on the bridge, the roadway is open section with roadside ditches or steep slopes that lead to the Little Patuxent River. In proposed conditions, the bridge will be widened to accommodate the four travel lanes (including one turning lane) and the two bike lanes. Additionally, entrance Ramp 4 and Ramp 5 to I-70 will be widened to accommodate increased traffic flows. Improvements to the intersection will result in an increase in impervious area throughout the corridor project.

The project corridor is surrounded by residential development, commercial, and forested areas containing the Little Patuxent River. In addition to the forested areas, the site is bordered by a 100-year floodplain to the east. There is also a wetland and wetland buffer located at approximately 123+50, LT in which the project improvements will impact. A Joint Permit Application (JPA) will be required due to these impacts to the wetland.

There is an existing grass channel BMP located along the west side of Marriottsville south of the bridge. As a result of the widening, this facility will be removed and bioswales will be used adjacent to the new edge of shoulder along the roadway. Additionally, two bioswales are proposed along the west side of Marriottsville north of the bridge and one bioswale is proposed in the gore area to the east of the Marriottsville Road south of the bridge. A micro-bioretention is proposed in the gore area north of the bridge along the east side of Marriottsville Road. The east side of the Marriottsville road is characterized by steep slopes and heavily vegetated and forested areas. As such, no facilities are proposed here in order to minimize the extent and type of impacts to natural resources around the project site. Underground detention facilities are proposed, where feasible, at locations where peak discharges from the proposed improvements exceed the existing conditions peak rates. The ESD requirements were implemented to the Maximum Extent Practicable (MEP) within the project limits.

II. METHODOLOGY

Using GIS topographic data, aerial imagery, and detailed field survey, 1” = 40’ scale water quality maps (see **Appendix E**) of the project area were created. A field visit was conducted to verify the topography, confirm the drainage patterns and land use and investigate the condition of drainage structures.

<u>Environmental Site Design Requirements</u>

Environmental Site Design (ESD) requirements were calculated using methods detailed in Chapter 5 of the *Maryland Stormwater Design Manual, May 2009*. The criteria for sizing ESD practices are based on capturing and retaining enough rainfall so that the runoff leaving the site for the 1-year storm event is reduced to a level equivalent to a wooded site in good condition as determined using United States

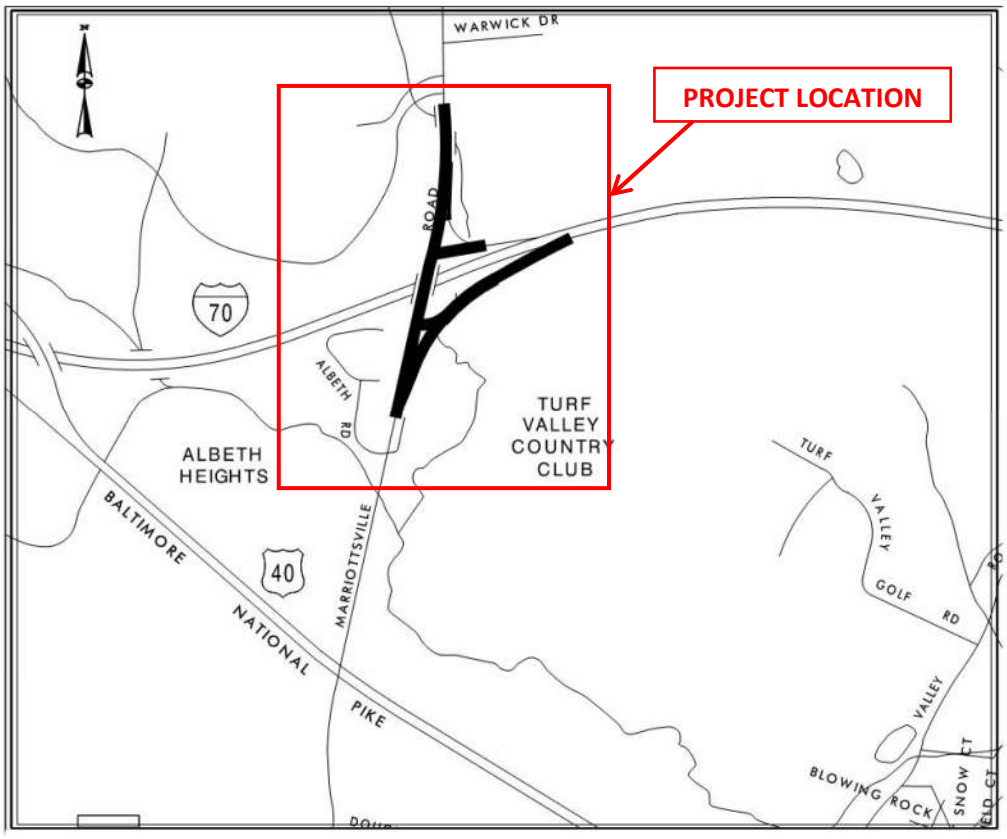
Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) methods. Also, the *Howard County Design Manual, Volume 1 – Storm Drainage* (henceforth referred to as "County Manual") was used in determining ESD requirements.

Per the *Howard County Code, Title 18, Subtitle 9*, projects with an existing impervious area that exceeds 40% are classified as Redevelopment and are subject to the requirements set forth in Section 18.910, while any project with an existing impervious area that is equal to or less than 40% must meet the new development requirements. In order to calculate the percentage of existing impervious area and determine the project classification, the area bounded by the limit-of-work (LOW) was delineated, as shown in **Appendix E**, and existing impervious area determined to calculate a percentage. POI's were then delineated and, per the *County Manual*, the impervious area requiring treatment (IART) and required ESD volume (ESDv) were computed based for each POI. If a POI was determined to be "Redevelopment" but also contained an increase in impervious are, the existing impervious area was calculated based on "Redevelopment" requirements, but the increase in impervious area was calculated per "New Development" requirements. This scenario is denoted at the POI level as being "Combination".

The LOW was used to determine that the classification for the project is Redevelopment. POI's with an increase in impervious area are denoted as "Combination" in which the increase in impervious area is treated as new development. In order to determine the ESD requirements for the project, the proposed conditions were analyzed within the LOD for each POI (please refer to **Appendix E** for Water Quality Maps). The proposed condition values were then used to compute the required ESD volume (ESD_V) for each POI and the impervious area requiring treatment (IART) was tabulated for each POI.

Quantitative Management Requirements

Quantitative management of the 2-year and 10-year storm events (Qp_2, Qp_{10}) is required for projects located in Howard County. Existing and proposed discharges were computed per POI and then analyzed to determine if Qp_2 and Qp_{10} requirements were satisfied. A TR-55 analysis has been completed in order to determine the existing and proposed runoff for the project site at all the POI locations and is presented in **Appendix A** of this report.



Scale: 1” = 2000’

Figure 1.1 – Location Map

III. STORMWATER MANAGEMENT ANALYSIS

The predominant land use surrounding the project is forested areas and residential development. The project is located within Hydrologic Soil Group (HSG) 'A', 'B', 'C', and 'D' (please refer to **Appendix B** for Soil Survey Report and **Appendix F** for Site Resource Mapping). The project site lies within the Patuxent River watershed (02-13-11). The entire project drains to the Little Patuxent River and an Unnamed Tributary to the Little Patuxent River which are designated as Use Class IV-P (please refer to **Appendix C** for Stream Designation Information).

The LOW was used to determine project classification and the results are as follows:

Project	Area within LOW (ac)	Existing Imp Area (ac)	% Existing Imp.	Classification Based on LOW
Marriottsville Phase 3	9.39	5.05	53%	Redevelopment

Table II.A.1 – Project Classification

A. POI 1

i. Description

Under existing conditions, runoff drains from just south of the bridge around STA 113+80 from the crown of Marriottsville Road to the west shoulder to a roadside channel. The channel conveys runoff south along the roadway to a culvert entrance where the POI is located. Runoff drains to an Unnamed Tributary to the Little Patuxent River. In proposed conditions, runoff is similarly conveyed to the POI; however, due to the widening, the existing channel will be removed and two new 8' flat bottom bioswales will be used to convey runoff to the POI along the new edge of shoulder of Marriottsville Road. The two bioswale limits were determined in order to restrict the runoff to each bioswale from exceeding the maximum allowable drainage area to these types of facilities. A storm drain trunkline is proposed to be constructed in the roadway shoulder parallel to the bioswale in order to bypass runoff from the BS-1-2 to the POI from getting into BS-1-1. Drainage patterns are not altered in proposed conditions.

ii. ESD Requirements

ESD requirements for POI 1 are summarized in **Table III.A.1**. As there is a net increase to impervious area within the POI, it is subject to Redevelopment-Combination ESD requirements.

iii. ESD Provided

The required ESD is provided by a proposed Chapter 5 Bioswale along the west side of Marriottsville Road. Furthermore, with the full ESDv and IART achieved in the Bioswale (see **Appendix D**), Cp_v and Re_v are also satisfied for this POI. The Bioswale type facility was chosen because an existing roadside ditch conveys runoff and limited additional property impacts would occur to implement the facility (SWM borings will be provided in future submittals). **Table III.A.1** summarizes the ESD provided within POI 1.

POI Designation by LOW	Total LOD Area (ac)	Existing Imp Area (ac)	Proposed Imp Area (ac)	Target PE (in)	Required ESDv (cf)	Provided ESDv (cf)	IART (ac)	IAT (ac)
Combination	1.63	0.05	0.82	1.0/2.0	5359	6795	0.795	1.06

Table III.A.1 – Summary of ESD_V Required & Provided at POI 1

iv. Quantity Management

The proposed conditions were analyzed using a reduced runoff curve number (RRCN) for the area treated by the bioswale. Based on the results of the peak discharges utilizing the RRCN, $Qp_{2,10,100}$ management is not required because the use of the RRCN for proposed conditions results in a reduction in the peak flows from existing to proposed conditions. **Table III.A.2** provides a summary of peak discharges for POI 1.

Peak Discharge Summary POI 1			
	2-YR	**10-YR**	**100-YR**
Existing Conditions	13.85	30.51	68.33
Proposed Conditions*	13.07	29.50	67.07

Table III.A.2 – Summary of Peak Discharges at POI 1

***Note: Since ESDv was provided for a Pe≥1, a reduced RCN per the MDE manual was used to determine peak flows.**

v. Downstream Impacts

From a field investigation, the existing outfall appears to be stable and in good condition. (Please refer to **Appendix H** for Site Outfall Photos).

B. POI 2

i. Description

Similar to POI 1, runoff from Marriottsville Road drains from about STA 110+50 from the crown of the roadway to a roadside V-ditch along the east side. The ditch then conveys runoff south along Marriottsville to a inlet at the adjacent to the intersection of Marriottsville Road and Resort Road where the POI is located. In proposed conditions, runoff is similarly conveyed through a roadside V-ditch; however, the ditch centerline will be shifted from STA 101+50 to STA 105+50 to accommodate the ramp widening. Drainage patterns are not altered and runoff eventually drains to an Unnamed Tributary to the Little Patuxent River.

ii. ESD Requirements

ESD requirements for POI 2 are summarized in **Table III.B.1**. As there is a net increase to impervious area within the POI, it is subject to Redevelopment-Combination ESD requirements.

iii. ESD Provided

Due to site topography, right-of-way constraints, and limited available areas, no ESD facilities were provide in this POI. **Table III.B.1** summarizes the ESD provided within POI 2.

POI Designation by LOW	Total LOD Area (ac)	Existing Imp Area (ac)	Proposed Imp Area (ac)	Target PE (in)	Required ESDv (cf)	Provided ESDv (cf)	IART (ac)	IAT (ac)
Combination	0.87	0.27	0.37	1.0/2.0	951	0	0.235	0.00

Table III.B.1 – Summary of ESD_V Required & Provided at POI 2

Since no ESD facilities were able to be implemented, the POI has a remaining Re_v of 24 cf. Since the proposed discharge of the 1-year storm does not exceed the existing discharge (see Appendix D), no Cpv is required for this POI. Additionally, since ESDv was unable to be provided in this POI, facilities in other POI's for this project have been sized to over provide quality treatment. As such, the ESDv for the total project has been provided and therefore, Cpv and Rev are satisfied for the entire project.

iv. Quantity Management

$Qp_{2,10,100}$ management is not required because the drainage area remains unchanged in proposed conditions and there is no increase in peak flows for any of the storm events. **Table III.B.2** provides a summary of peak discharges for POI 2.

Peak Discharge Summary POI 2			
	2-YR	**10-YR**	**100-YR**
Existing Conditions	5.85	11.80	24.70
Proposed Conditions	5.85	11.80	24.70

Table III.B.2 – Summary of Peak Discharges at POI 2

v. Downstream Impacts

From a field investigation, the existing inlet appears to be stable and in good condition. (Please refer to **Appendix H** for Site Outfall Photos).

C. POI 3

i. Description

Runoff drains east from Marriottsville Road to the gore areas south of the bridge. Along the east side of Marriottsville Road from STA 112+50 to STA 111+20, runoff is collected in a ditch to an inlet that combines with runoff from the other median in the POI to a common outfall east of Marriottsville Road where the outfall is located. Runoff from a portion of Ramp 5 is also collected and discharged here. In proposed drainage conditions, runoff is similarly conveyed except for one of the inlets being relocated south due to roadway impacts. Also, a Chapter 5 Bioswale facility is proposed where the median ditch is located from STA 112+50 to STA 111+20 in order to treat ESDv requirements. Drainage patterns are not altered and runoff eventually drains to the Little Patuxent River.

ii. ESD Requirements

ESD requirements for POI 3 are summarized in **Table III.C.1**. As there is a net increase to impervious area within the POI, it is subject to Redevelopment-Combination ESD requirements.

iii. ESD Provided

The required ESD is provided by a proposed Chapter 5 Bioswale along the east side of Marriottsville Road in the gore area between the ramp and Marriottsville Road from STA 112+50 to STA 111+20.

Furthermore, with the full ESDv and IART achieved in the Bioswale (see **Appendix D**), Cpv and Rev are also satisfied for this POI. The Bioswale type facility was chosen because an existing roadside ditch conveys runoff and limited additional property impacts would occur to implement the facility (SWM borings will be provided in future submittals). **Table III.C.1** summarizes the ESD provided within POI 3.

POI Designation by LOW	Total LOD Area (ac)	Existing Imp Area (ac)	Proposed Imp Area (ac)	Target PE (in)	Required ESDv (cf)	Provided ESDv (cf)	IART (ac)	IAT (ac)
Combination	0.33	0.09	0.12	1.00/2.00	294	515	0.075	0.14

Table III.C.1 – Summary of ESD_V Required & Provided at POI 3

iv. Quantity Management

The proposed conditions were analyzed using a reduced runoff curve number (RRCN) for the area treated by the bioswale. Based on the results of the peak discharges utilizing the RRCN, $Qp_{2,10,100}$ management is not required because the use of the RRCN for proposed conditions results in a reduction in the peak flows from existing to proposed conditions. **Table III.C.2** provides a summary of peak discharges for POI 3.

Peak Discharge Summary POI 3			
	2-YR	**10-YR**	**100-YR**
Existing Conditions	1.38	2.53	4.93
Proposed Conditions*	1.20	2.35	4.83

Table III.C.2 – Summary of Peak Discharges at POI 3

***Note: Since ESDv was provided for Pe≥1, a reduced RCN per the MDE manual was used to determine peak flows.**

v. Downstream Impacts

From a field investigation, the existing outfall appears to be stable and in good condition. (Please refer to **Appendix H** for Site Outfall Photos).

D. LOI 4

i. Description

Under proposed conditions runoff drains southeast across Ramp 5 as sheet flow and exits the site along the fill slope as sheet flow at the LOI from STA 1008+00 to STA 1019+25. In proposed conditions, runoff is similarly conveyed across Ramp 5 to the LOI. Drainage patterns are not altered and runoff eventually drains to the Little Patuxent River.

ii. ESD Requirements

ESD requirements for LOI 4 are summarized in **Table III.D.1**. As there is no change in impervious area within the LOI, it is subject to Redevelopment ESD requirements.

iii. ESD Provided

Due to site constraints and limited available areas, no ESD facilities were provided in this LOI. **Table III.D.1** summarizes the ESD provided within LOI 4.

LOI Designation by LOW	Total Area (ac)	Existing Imp Area (ac)	Proposed Imp Area (ac)	Target PE (in)	Required ESDv (cf)	Provided ESDv (cf)	IART (ac)	IAT (ac)
Redevelopment	**0.69**	0.35	0.35	1.0	603	0	0.185	0.00

Table III.D.1 – Summary of ESD_V Required & Provided at LOI 4

Additionally, since ESDv was unable to be provided in this POI, facilities in other POI's for this project have been sized to over provide quality treatment. As such, the ESDv for the total project has been provided and therefore, Cpv and Rev are satisfied for the entire project.

iv. Quantity Management

$Qp_{2,10,100}$ management is not required because the drainage area remains unchanged in proposed conditions and there is no increase in peak flows for any of the storm events. **Table III.D.2** provides a summary of peak discharges for LOI 4.

Peak Discharge Summary LOI 4			
	2-YR	**10-YR**	**100-YR**
Existing Conditions	4.12	9.14	20.59
Proposed Conditions	4.12	9.14	20.59

Table III.D.2 – Summary of Peak Discharges at LOI 4

v. Downstream Impacts

From a field investigation, the existing outfall appears to be stable and in good condition. (Please refer to **Appendix H** for Site Outfall Photos).

E. POI 5

i. Description

Runoff from the bridge to just south of Marriottsville road drains west from the crown to the shoulder where runoff drains down the fill slope of the bridge to a ditch along I-70 where the POI is located. In proposed conditions, runoff from Marriottsville Road will be collected in an inlet along the proposed curb and conveyed to the ditch along I-70. An underground detention will be utilized to reduce peak flows. Runoff eventually drains to the Little Patuxent River.

ii. ESD Requirements

ESD requirements for POI 5 are summarized in **Table III.E.1**. As there is a net increase to impervious area within the POI, it is subject to Redevelopment-Combination ESD requirements.

iii. ESD Provided

Due to site constraints and limited available areas, no ESD facilities were provided in this POI. **Table III.E.1** summarizes the ESD provided within POI 5.

POI Designation by LOW	Total Area (ac)	Existing Imp Area (ac)	Proposed Imp Area (ac)	Target PE (in)	Required ESDv (cf)	Provided ESDv (cf)	IART (ac)	IAT (ac)
Combination	0.20	0.01	0.11	1.0/ 2.0	699	0	0.105	0.00

Table III.E.1 – Summary of ESD_V Required & Provided at POI 5

Since no ESD facilities were able to be implemented, the POI has a remaining Re_v = 24 cf and Cpv = 555 cf (See Appendix D). The Cpv requirement will be managed in the underground detention facility as noted in the following Quantity Management section. Additionally, since ESDv was unable to be provided in this POI, facilities in other POI's for this project have been sized to over provide quality treatment. As such, the ESDv for the total project has been provided and therefore, Cpv and Rev are satisfied for the entire project.

iv. Quantity Management

$Qp_{2,10,100}$ management is required because of a small increase in the peak flows for all storm events. A proposed underground detention facility with approximate dimension of 20'x20' with 2.5' of storage depth will be utilized to manage the peak flows so there is not an increase at the POI between existing and proposed conditions. **Table III.E.2** provides a summary of peak discharges and **Table III.E.3** provides a summary of the quantity requirements for POI 5 (See appendix D for calculations).

Peak Discharge Summary POI 5			
	2-YR	10-YR	100-YR
Existing Conditions	0.66	1.40	3.06
Proposed Conditions	1.06	1.86	3.49

Table III.E.2 – Summary of Peak Discharges at POI 5

Quantity Requirements Summary POI 5		
	2-YR	10-YR
Qp Volume (cf)	677	1049

Table III.E.3 – Summary of Quantity Requirements at POI 5

v. Downstream Impacts

From a field investigation, the existing outfall appears to be stable and in good condition. (Please refer to **Appendix H** for Site Outfall Photos).

F. POI 6

i. Description

Runoff from the bridge to just south Marriottsville Road drains east from the crown to an inlet along the shoulder. Runoff outfalls along the fill slope to a ditch along I-70 which conveys runoff to an inlet where the POI is located. In proposed conditions, the existing inlet will be relocated to the new proposed curb and a new outfall pipe will be installed. An underground detention will be utilized to reduce peak flows. Runoff eventually drains to the Little Patuxent River.

ii. ESD Requirements

ESD requirements for POI 6 are summarized in **Table III.F.1**. As there is a net increase to impervious area within the POI, it is subject to Redevelopment-Combination ESD requirements.

iii. ESD Provided

Due to site constraints and limited available areas, no ESD facilities were provided in this POI. **Table III.F.1** summarizes the ESD provided within POI 6.

POI Designation by LOW	Total Area (ac)	Existing Imp Area (ac)	Proposed Imp Area (ac)	Target PE (in)	Required ESDv (cf)	Provided ESDv (cf)	IART (ac)	IAT (ac)
Combination	0.84	0.05	0.21	1.0/2.0	1152	0	0.185	0.00

Table III.F.1 – Summary of ESD_V Required & Provided at POI 6

Since no ESD facilities were able to be implemented, the POI has a remaining Re_v = 39 cf and Cpv = 1329 cf (See Appendix D). The Cpv requirement will be managed in the underground detention facility as noted in the following Quantity Management section. Additionally, since ESDv was unable to be provided in this POI, facilities in other POI's for this project have been sized to over provide quality treatment. As such, the ESDv for the total project has been provided and therefore, Cpv and Rev are satisfied for the entire project.

iv. Quantity Management

$Qp_{2,10,100}$ management is required because of a small increase in the peak flows for all storm events. A proposed underground detention facility with approximate dimension of 25'x25' with 4' of storage depth will be utilized to manage the peak flows so there is not an increase at the POI between existing and proposed conditions. Please note that a decrease is listed for the 100-year storm which is the result in the slight decrease in drainage area for the proposed conditions due to how TR-55 calculates peak discharges for larger storm events. **Table III.F.2** provides a summary of peak discharges and **Table III.F.3** provides a summary of the quantity requirements for POI 6 (See appendix D for calculations).

Peak Discharge Summary POI 6			
	2-YR	10-YR	100-YR
Existing Conditions	5.95	10.74	20.66
Proposed Conditions	6.08	10.82	20.55

Table III.F.2 – Summary of Peak Discharges at POI 6

Quantity Requirements Summary POI 6		
	2-YR	10-YR
Qp Volume (cf)	1663	2939

Table III.F.3 – Summary of Quantity Requirements at POI 5

v. Downstream Impacts

From a field investigation, the existing outfall appears to be stable and in good condition. (Please refer to **Appendix H** for Site Outfall Photos).

G. POI 7

i. Description

Runoff from the bridge to just north of Marriottsville road drains west from the crown to the shoulder where runoff drains down the fill slope of the bridge to a ditch along I-70 where the POI is located. In proposed conditions, runoff from Marriottsville Road will be collected in an inlet along the proposed curb and conveyed to the ditch along I-70. An underground detention will be utilized to reduce peak flows. Runoff eventually drains to the Little Patuxent River.

ii. ESD Requirements

ESD requirements for POI 7 are summarized in **Table III.G.1**. As there is a net increase to impervious area within the POI, it is subject to Redevelopment-Combination ESD requirements.

iii. ESD Provided

Due to site constraints and limited available areas, no ESD facilities were provided in this POI. **Table III.G.1** summarizes the ESD provided within POI 7.

POI Designation by LOW	Total LOD Area (ac)	Existing Imp Area (ac)	Proposed Imp Area (ac)	Target PE (in)	Required ESDv (cf)	Provided ESDv (cf)	IART (ac)	IAT (ac)
Combination	0.10	0.01	0.07	1.0/2.0	424	0	0.065	0.00

Table III.G.1 – Summary of ESD_V Required & Provided at POI 7

Since no ESD facilities were able to be implemented, the POI has a remaining Re_v = 14 cf and Cpv = 478 cf (See Appendix D). The Cpv requirement will be managed in the underground detention facility as noted in the following Quantity Management section. Additionally, since ESDv was unable to be provided in this POI, facilities in other POI's for this project have been sized to over provide quality treatment. As such, the ESDv for the total project has been provided and therefore, Cpv and Rev are satisfied for the entire project.

iv. Quantity Management

$Qp_{2,10,100}$ management is required because of a small increase in the peak flows for all storm events. A proposed underground detention facility with approximate dimension of 20'x20' with 2' of storage depth will be utilized to manage the peak flows so there is not an increase at the POI between existing and proposed conditions. **Table III.G.2** provides a summary of peak discharges and **Table III.G.3** provides a summary of the quantity requirements for POI 7 (See appendix D for calculations).

Peak Discharge Summary POI 7			
	2-YR	10-YR	100-YR
Existing Conditions	0.52	0.99	1.99
Proposed Conditions	0.81	1.38	2.54

Table III.G.2 – Summary of Peak Discharges at POI 7

Quantity Requirements Summary POI 6		
	2-YR	10-YR
Qp Volume (cf)	519	851

Table III.F.3 – Summary of Quantity Requirements at POI 7

v. Downstream Impacts

From a field investigation, the existing outfall appears to be stable and in good condition. (Please refer to **Appendix H** for Site Outfall Photos).

H. POI 8

i. Description

Runoff from the bridge to just north of Marriottsville Road drains east from the crown to an inlet along the shoulder. Runoff outfalls along the fill slope to a ditch along I-70 where the POI is located. In proposed conditions, the existing inlet will be relocated to the new proposed curb and a new outfall pipe will be installed. Drainage patterns are not altered in proposed conditions. Runoff eventually drains to the Little Patuxent River.

ii. ESD Requirements

ESD requirements for POI 8 are summarized in **Table III.H.1**. As there is a net increase to impervious area within the POI, it is subject to Redevelopment-Combination ESD requirements.

iii. ESD Provided

Due to site constraints and limited available areas, no ESD facilities were provided in this POI. **Table III.H.1** summarizes the ESD provided within POI 8.

POI Designation by LOW	Total LOD Area (ac)	Existing Imp Area (ac)	Proposed Imp Area (ac)	Target PE (in)	Required ESDv (cf)	Provided ESDv (cf)	IART (ac)	IAT (ac)
Combination	0.17	0.03	0.05	1.0/2.0	167	0	0.035	0.00

Table III.H.1 – Summary of ESD_V Required & Provided at POI 8

Since no ESD facilities were able to be implemented, the POI has a remaining Re_v of 5 cf. Since the proposed discharge of the 1-year storm does not exceed the existing discharge (see Appendix D), no Cpv is required for this POI. Additionally, since ESDv was unable to be provided in this POI, facilities in other POI's for this project have been sized to over provide quality treatment. As such, the ESDv for the total project has been provided and therefore, Cpv and Rev are satisfied for the entire project.

iv. Quantity Management

$Qp_{2,10,100}$ management is not required because the drainage area remains unchanged in proposed conditions and there is no increase in peak flows for any of the storm events. **Table III.H.2** provides a summary of peak discharges for POI 8.

Peak Discharge Summary POI 8			
	2-YR	10-YR	100-YR
Existing Conditions	5.43	10.14	20.01
Proposed Conditions	5.43	10.14	20.01

Table III.H.2 – Summary of Peak Discharges at POI 8

v. Downstream Impacts

With a decrease in peak flows for the 10-year and 100-year storm even, no negative impacts are expected to the downstream reaches of POI 8. (Please refer to **Appendix H** for Site Outfall Photos).

I. POI 9

i. Description

Runoff drains from a portion of Marriottsville Road and Ramp 7 to an inlet located in the median area between Ramp 7 and Ramp 2. Runoff is then conveyed through a culvert to an outfall northeast of Ramp 2 at the bottom of the fill slope. In proposed conditions, a microbioretention is proposed where the existing median inlet is and runoff patterns will not change. The discharge from the microbiorention will utilize the existing storm drain so as to not impact environmental areas northeast of the Ramp 7 in order to install a new storm drain pipe. Runoff eventually drains to the Little Patuxent River.

ii. ESD Requirements

ESD requirements for POI 9 are summarized in **Table III.I.1**.

iii. ESD Provided

The required ESD is provided by a proposed Chapter 5 Microbioretention facility along the east side of Marriottsville Road in the gore area between the roadway and the ramp from STA 119+00 to STA 119+75. Furthermore, with the full ESDv and IART achieved in the Microbioretention (see **Appendix D**), Cpv and Rev are also satisfied for this POI. The Microbioretention type facility was chosen because runoff leads to an inlet in a median with a grate elevation that is already several feet below the edge of shoulder which is ideal for this type of facility. Minimal grading and excavation would be required outside of what's needed for the filter bed. **Table III.I.1** summarizes the ESD provided within POI 9.

POI Designation by LOW	Total LOD Area (ac)	Existing Imp Area (ac)	Proposed Imp Area (ac)	Target PE (in)	Required ESDv (cf)	Provided ESDv (cf)	IART (ac)	IAT (ac)
Combination	0.67	0.14	0.18	1.00/2.00	412	2586	0.11	0.29

Table III.I.1 – Summary of ESD_V Required & Provided at POI 9

iv. Quantity Management

$Qp_{2,10,100}$ management is not required because the drainage area remains unchanged in proposed conditions and there is no increase in peak flows for any of the storm events. **Table III.H.2** provides a summary of peak discharges for POI 9.

Peak Discharge Summary POI 9			
	2-YR	10-YR	100-YR
Existing Conditions	3.78	7.05	13.92
Proposed Conditions	3.71	6.92	13.66

Table III.I.2 – Summary of Peak Discharges at POI 9

v. Downstream Impacts

From a field investigation, the existing outfall appears to be stable and in good condition. (Please refer to **Appendix H** for Site Outfall Photos).

J. POI 10

i. Description

Runoff from the west side of Marriottsville Road is conveyed in a ditch along the western roadway shoulder to an existing 24" culvert that outfalls on the east side of Marriottsville at the fill slope where the POI is located. Also, the east side of Marriottsville Road drains down the fill slope to this POI point. In proposed conditions, two 8' flat bottom bioswales will be utilized to convey runoff from the west side of the roadway to the existing culvert. Drainage patterns will not be alter and runoff eventually drains to the Little Patuxent River.

ii. ESD Requirements

ESD requirements for POI 10 are summarized in **Table III.J.1**. As there is a net increase to impervious area within the POI, it is subject to Redevelopment-Combination ESD requirements.

iii. ESD Provided

The required ESD is provided by a two proposed Chapter 5 Bioswale facilities along the west side of Marriottsville Road from STA 117+00 to STA 122+50 and STA 125+25 to STA 123+75. Furthermore, with the full ESDv and IART achieved in the Bioswales (see **Appendix D**), Cpv and Rev are also satisfied for this POI. The Bioswale type facility was chosen because of it's linear nature and ability to convey runoff similar to ad ditch in order to mimic existing drainage patterns. **Table III.J.1** summarizes the ESD provided within POI 10.

POI Designation by LOW	Total Area (ac)	Existing Imp Area (ac)	Proposed Imp Area (ac)	Target PE (in)	Required ESDv (cf)	Provided ESDv (cf)	IART (ac)	IAT (ac)
Combination	1.61	0.41	0.79	1.0/2.0	3018	3975	0.585	0.90

Table III.J.1 – Summary of ESD_V Required & Provided at POI 10

iv. Quantity Management

The proposed conditions were analyzed using a reduced runoff curve number (RRCN) for the area treated by the bioswales. Based on the results of the peak discharges utilizing the RRCN, $Qp_{2,10,100}$ management is not required because the use of the RRCN for proposed conditions results in a reduction in the peak flows from existing to proposed conditions. **Table III.J.2** provides a summary of peak discharges for POI 10.

Peak Discharge Summary POI 10			
	2-YR	**10-YR**	**100-YR**
Existing Conditions	5.97	11.02	21.59
Proposed Conditions*	5.11	10.12	20.89

Table III.J.2 – Summary of Peak Discharges at POI 10

***Note: Since ESDv was provided for Pe≥1, a reduced RCN per the MDE manual was used to determine peak flows.**

v. Downstream Impacts

From a field investigation, the existing outfall appears to be stable and in good condition. (Please refer to **Appendix H** for Site Outfall Photos).

K. LOI 11

i. Description

Runoff from the eastern shoulder of Marriottsville Road from STA 125+50 to STA 128+86 is conveyed down a fill slope as sheet flow to an LOI where runoff leaves the right-of-way. In proposed conditions, runoff is similarly conveyed down the fill slope to the LOI. As such, drainage patterns are not altered in proposed conditions. Runoff eventually drains to the Little Patuxent River.

ii. ESD Requirements

ESD requirements for LOI 11 are summarized in **Table III.K.1**.

iii. ESD Provided

Due to the nature of the improvements in this LOI, ESD is not required. **Table III.K.1** summarizes the ESD provided within LOI 11.

LOI Designation by LOW	Total Area (ac)	Existing Imp Area (ac)	Proposed Imp Area (ac)	Target PE (in)	Required ESDv (cf)	Provided ESDv (cf)	IART (ac)	IAT (ac)
Redevelopment	0.09	0.00	0.00	1.0	0	0	0.00	0.00

Table III.K.1 – Summary of ESD_V Required & Provided at LOI 11

iv. Quantity Management

$Qp_{2,10,100}$ management is not required because the drainage area remains unchanged in proposed conditions and there is no increase in peak flows for any of the storm events. **Table III.K.2** provides a summary of peak discharges for LOI 11.

Peak Discharge Summary LOI 11			
	2-YR	**10-YR**	**100-YR**
Existing Conditions	0.59	1.07	2.06
Proposed Conditions	0.59	1.07	2.06

Table III.K.2 – Summary of Peak Discharges at LOI 11

v. Downstream Impacts

From a field investigation, the existing outfall appears to be stable and in good condition. (Please refer to **Appendix H** for Site Outfall Photos).

L. LOI 12

i. Description

Runoff from Marriottsville Road from STA 125+50 to STA 128+86 is conveyed to the west side of the roadway down a fill slope as sheet flow to an LOI where runoff leaves the right-of-way. In proposed conditions, runoff is similarly conveyed down the fill slope to the LOI. As such, drainage patterns are not altered in proposed conditions. Runoff eventually drains to the Little Patuxent River.

ii. ESD Requirements

ESD requirements for LOI 12 are summarized in **Table III.L.1**.

iii. ESD Provided

Due to site constraints and limited available areas, no ESD facilities were provided in this POI. **Table III.L.1** summarizes the ESD provided within LOI 12.

LOI Designation by LOW	Total Area (ac)	Existing Imp Area (ac)	Proposed Imp Area (ac)	Target PE (in)	Required ESDv (cf)	Provided ESDv (cf)	IART (ac)	IAT (ac)
Redevelopment	0.14	0.05	0.05	1.0	86	0	0.025	0.00

Table III.L.1 – Summary of ESD_V Required & Provided at LOI 12

Additionally, since ESDv was unable to be provided in this POI, facilities in other POI's for this project have been sized to over provide quality treatment. As such, the ESDv for the total project has been provided and therefore, Cpv and Rev are satisfied for the entire project.

iv. Quantity Management

$Qp_{2,10,100}$ management is not required because the drainage area remains unchanged in proposed conditions and there is no increase in peak flows for any of the storm events. **Table III.L.2** provides a summary of peak discharges for LOI 12.

Peak Discharge Summary POI 12			
	2-YR	**10-YR**	**100-YR**
Existing Conditions	2.03	3.17	5.51
Proposed Conditions	2.03	3.17	5.51

Table III.L.2 – Summary of Peak Discharges at POI 12

v. Downstream Impacts

From a field investigation, the existing outfall appears to be stable and in good condition. (Please refer to **Appendix H** for Site Outfall Photos).

G. Summary of POIs

The water quality SWM requirements for all Points of Investigation (POI) due to the proposed improvements will be addressed by providing ESD to the MEP and 2.39 acres of treated impervious area within the Little Patuxent River Watershed. Since the total ESDv required for the project is satisfied, as shown in Table III.M.2, Cpv and Rev are also satisfied throughout the entire project.

STUDY POINT	NEW DEVELOPMENT (Acres)	RECONSTRUCTED IMPERVIOUS (Acres)	IMPERVIOUS REMOVED (Acres)	IMPERVIOUS AREA REQUIRING TREATMENT (Acres)	IMPERVIOUS AREA TREATED (Acres)
POI 1	0.77	0.05	0.00	0.795	1.06
POI 2	0.10	0.27	0.00	0.235	0.00
POI 3	0.03	0.09	0.00	0.075	0.14
LOI 4	0.00	0.35	0.00	0.175	0.00
POI 5	0.10	0.01	0.00	0.105	0.00
POI 6	0.16	0.05	0.00	0.185	0.00
POI 7	0.06	0.01	0.00	0.065	0.00
POI 8	0.02	0.03	0.00	0.035	0.00
POI 9	0.04	0.14	0.00	0.11	0.29
POI 10	0.41	0.41	0.03	0.585	0.90
LOI 11	0.00	0.00	0.00	0.00	0.00
LOI 12	0.00	0.05	0.00	0.025	0.00
TOTAL	***1.69***	***1.46***	***0.03***	***2.39***	***2.39***

Table III.M.1 – Summary of IART Required & Provided for Entire Project

STUDY POINT	ESDv REQUIRED (cf)	ESDv PROVIDED (cf)
POI 1	5359	6795
POI 2	951	0
POI 3	294	515
LOI 4	603	0
POI 5	699	0
POI 6	1152	0
POI 7	424	0
POI 8	167	0
POI 9	412	2586
POI 10	3018	3975
LOI 11	0	0
LOI 12	86	0
TOTAL	***13166***	***13872***

Table III.M.2 – Summary of ESDv Required & Provided for Entire Project

The 2, 10, and 100 year flows were computed using USDA-NRCS-Win TR-55 and are summarized in the following table. Three underground detention facilities will be provided to manage the increase in peak flows at 3 of the POI's while the remaining POI's will not have an increase in peak flows due to the improvements. The TR-55 output is included in **Appendix A** of this report.

STUDY POINT	EXISTING CONDITION (cfs)			PROPOSED CONDITION (cfs)		
	Q2	Q10	Q100	Q2	Q10	Q100
POI 1	13.85	30.51	68.33	13.07	29.50	67.07
POI 2	5.85	11.80	24.70	5.85	11.80	24.70
POI 3	1.38	2.53	4.93	1.20	2.35	4.83
LOI 4	4.12	9.14	20.59	4.12	9.14	20.59
POI 5	0.66	1.40	3.06	1.06	1.86	3.49
POI 6	5.95	10.74	20.66	6.08	10.82	20.55
POI 7	0.52	0.99	1.99	0.81	1.38	2.54
POI 8	5.43	10.14	20.01	5.43	10.14	20.01
POI 9	3.78	7.05	13.92	3.71	6.92	13.66
POI 10	5.97	11.02	21.59	5.11	10.12	20.89
LOI 11	0.59	1.07	2.06	0.59	1.07	2.06
LOI 12	2.03	3.17	5.51	2.03	3.17	5.51

Table III.M.3 – Summary of Existing and Proposed Peak Discharges for Entire Project

IV. EROSION AND SEDIMENT CONTROL ANALYSIS

The proposed improvements result in a disturbance of over 5,000 square feet of earth; therefore, a formal approval for the Erosion and Sediment Control (ESC) will be required. ESC plans depicting only the limit of disturbance are included with the project plans. ESC measures will include a combination of same-day stabilization and perimeter controls in order to prevent sediment deposits from leaving the project site. Furthermore, temporary stone outlet structures, temporary gabion outlet structures, inlet protection, diversion fences, and earth dikes are also utilized. It should be noted that within the project limits, there are several areas of disturbance that fall outside of the County right-of-way and occur within privately owned parcels. These areas will be handled through entry agreements to be established with the current owner(s) of the aforementioned parcels. It is anticipated that only temporary construction easements will be needed as the private property impacts are limited to grading needed to tie back into existing grades.

The project corridor lies just outside the 100-year floodplain from the Little Patuxent River. There is also one area where wetlands and wetland buffers will be impacted due to grading. The project does not contain any waterways, steam buffers, forest buffers, or critical areas. Existing site resource mapping is provided (See **Appendix F**) to highlight areas of environmental concern, site soil characteristics, steep slopes, existing drainage areas, existing impervious areas, existing drainage facilities, and the location of points of discharge leaving the project site.

V. EXISTING CULVERT ANALYSIS

Within the project limits, there are two existing box culverts. The first is a 14'x6' Box Culvert located at STA 100+00 and the other is a double 8'x7' Box Culvert located at STA 128+00.

A. Existing 14'x6' Box Culvert

The improvements result in an increase of 0.77 acres of impervious area to the entrance to this culvert. As such, a TR-20 analysis was run for existing and proposed conditions with two sub-areas, one for offsite area which in there is no change in land use or drainage patterns between existing and proposed, and one for onsite for the area where the improvements are taking place. Due to the overall size of the area draining to the culvert and the on-site area being directly adjacent to the culvert entrance, the time to peak from the on-site area was much shorter than the remaining offsite area draining to the culvert, resulting in no increase in the total peak flow for the routed hydrograph between existing and proposed conditions.

Marriottsville Road is currently classified as an "Intermediate Arterial" roadway; therefore, the culvert is required to pass the 100-year design storm. HY-8 was used to check the headwater on the culvert using the peak flows for the 100-year storm. The resulting calculations show that the headwater overtops the edge of shoulder of the roadway. Available as-built data did not provide information on what design storm the culvert was originally designed to meet and appears that this roadway could have previously been classified as a Major Collector and only required to pass the 50-year storm at the time of construction of the culvert.

Although the improvements do not result in any adverse impacts to the culvert, the culvert no longer meets the county requirements and it is recommended that the culvert be up-graded in the near future to meet current design standards. See **Appendix K** for calculations.

B. Existing Double 8'x7' Box Culvert

The improvements draining to this culvert result in no change to existing land use or drainage patterns and the area will be returned to its existing condition. As such, a TR-20 analysis was run for the existing conditions to the entrance of the culvert.

As previously stated, Marriottsville Road is classified as an "Intermediate Arterial" and subject to the 100-year design storm. HY-8 was used to check the headwater on the culvert using these peak flows. The resulting calculations show that the headwater overtops the edge of the shoulder of the roadway. Available as-built data did not provide information on what design storm the culvert was originally designed to meet and it appears that this roadway could have previously been classified as a Major Collector and only required to pass the 50-year storm at the time of construction of the culvert.

Although the improvements do not result in any adverse impacts to the culvert, the culvert no longer meets the county requirements and it is recommended that the culvert be up-graded in the near future to meet current design standards. See **Appendix K** for calculations

VI. CONCLUSIONS

Based on the analysis provided herein, the following conclusions are presented:

- The proposed improvements will result in a net increase in impervious area of 1.69 acres.
- ESD is provided to the maximum extent practical.
- ESDv is not met on a POI by POI basis; however, the total ESD for the project is met within the facilities provided in POI's 1, 3, 9, and 10; therefore, Cpv and Rev are satisfied for this project.
- A JPA is required due to the impacts to a wetland located at approximately STA 123+50, LT.
- The total IART of 2.39 is satisfied by the water quality facilities in POI's 1, 3, 9, and 10.

VII. REFERENCES

1. *Maryland Stormwater Management Design Manual, May 2009*.
2. *Howard County Code, Title 18, Subtitle 9*
3. *Web Soil Survey for Howard County, Maryland,* United States Department of Agriculture, Natural Resources Conservation Service, Version 7, February 2, 2007.

VIII. APPENDIX A – TR-55 Output

WinTR-55 Current Data Description

--- Identification Data ---

User: MSK
Project: Marriottsville Rd Phase 3
SubTitle: Existing Conditions
State: Maryland
County: Howard NOAA-C
Filename: \\stvgroup.stvinc.com\V3\BAMD\vol3\PROJECTS\4014362\4014362_0003\50_Discipline Information\63_E

Date: 5/8/2017
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
POI 1	Ex. POI 1	Outlet	11.47	76	.2

Total area: 11.47 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

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MSK Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

==========

MSK Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)	10-Yr (cfs)	50-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
POI 1	13.85	30.51	54.98	68.33
REACHES				
OUTLET	13.85	30.51	54.98	68.33

==========

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs)	(hr)	10-Yr (cfs)	(hr)	50-Yr (cfs)	(hr)	100-Yr (cfs)	(hr)
SUBAREAS								
POI 1	13.85	12.18	30.51	12.17	54.98	12.17	68.33	12.17
REACHES								
OUTLET	13.85		30.51		54.98		68.33	

==========

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
POI 1	11.47	0.200	76	Outlet	Ex. POI 1

Total Area: 11.47 (ac)

==========

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
POI 1							
SHEET	100	0.0540	0.150				0.110
SHALLOW	1040	0.0400	0.050				0.090
						Time of Concentration	.2

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
POI 1	Open space; grass cover > 75%	(good)	B	.11	61
	Open space; grass cover > 75%	(good)	D	.84	80
	Paved parking lots, roofs, driveways		B	.72	98
	Paved parking lots, roofs, driveways		C	.51	98
	Paved parking lots, roofs, driveways		D	.57	98
	Residential districts (1/2 acre)		B	2.11	70
	Residential districts (1/2 acre)		C	2.56	80
	Residential districts (1/2 acre)		D	.01	85
	Woods	(good)	B	1.91	55
	Woods	(good)	C	.65	70
	Woods	(good)	D	1.48	77
	Total Area / Weighted Curve Number			11.47	76

WinTR-55 Current Data Description

--- Identification Data ---

User: MSK
Project: Marriottsville Rd Phase 3
SubTitle: Existing Conditions
State: Maryland
County: Howard NOAA-C
Filename: \\stvgroup.stvinc.com\V3\BAMD\vol3\PROJECTS\4014362\4014362_0003\50_Discipline Information\63_E

Date: 5/8/2017
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
POI 2	Ex. POI 2	Outlet	3.58	80	.16

Total area: 3.58 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

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MSK Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

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MSK Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)	10-Yr (cfs)	50-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
POI 2	5.85	11.80	20.18	24.70
REACHES				
OUTLET	5.85	11.80	20.18	24.70

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MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	50-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
POI 2	5.85 12.15	11.80 12.15	20.18 12.15	24.70 12.14
REACHES				
OUTLET	5.85	11.80	20.18	24.70

==========

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
POI 2	3.58	0.160	80	Outlet	Ex. POI 2

Total Area: 3.58 (ac)

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MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
POI 2							
SHEET	100	0.0500	0.150				0.113
SHALLOW	40	0.2200	0.050				0.001
CHANNEL	745	0.0370	0.030	1.37	4.28	4.499	0.046
					Time of Concentration		.16

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
POI 2	Open space; grass cover > 75%	(good)	B	.94	61
	Open space; grass cover > 75%	(good)	D	.21	80
	Paved parking lots, roofs, driveways		B	.08	98
	Paved parking lots, roofs, driveways		D	.79	98
	Commercial & business		B	1.06	92
	Woods	(good)	B	.47	55
	Woods	(good)	D	.03	77
	Total Area / Weighted Curve Number			3.58	80

WinTR-55 Current Data Description

--- Identification Data ---

User: MSK
Project: Marriottsville Rd Phase 3
SubTitle: Existing Conditions
State: Maryland
County: Howard NOAA-C
Filename: \\stvgroup.stvinc.com\V3\BAMD\vol3\PROJECTS\4014362\4014362_0003\50_Discipline Information\63_E

Date: 5/8/2017
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
POI 3	Ex. POI 3	Outlet	0.59	85	0.1

Total area: .59 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

==========

MSK Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

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MSK Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)	10-Yr (cfs)	50-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
POI 3	1.38	2.53	4.10	4.93
REACHES				
OUTLET	1.38	2.53	4.10	4.93

==========

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs)	(hr)	10-Yr (cfs)	(hr)	50-Yr (cfs)	(hr)	100-Yr (cfs)	(hr)
SUBAREAS								
POI 3	1.38	12.12	2.53	12.12	4.10	12.12	4.93	12.12
REACHES								
OUTLET	1.38		2.53		4.10		4.93	

==========

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
POI 3	.59	0.100	85	Outlet	Ex. POI 3

Total Area: .59 (ac)

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MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
POI 3							
SHEET	100	0.0460	0.011				0.014
SHALLOW	100	0.5000	0.050				0.002
						Time of Concentration	0.1

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
POI 3	Open space; grass cover > 75%	(good)	D	.25	80
	Paved parking lots, roofs, driveways		D	.25	98
	Woods	(good)	B	.05	55
	Woods	(good)	D	.04	77
	Total Area / Weighted Curve Number			.59	85

WinTR-55 Current Data Description

--- Identification Data ---

User: MSK
Project: Marriottsville Rd Phase 3
SubTitle: Existing Conditions
State: Maryland
County: Howard NOAA-C
Filename: \\stvgroup.stvinc.com\V3\BAMD\vol3\PROJECTS\4014362\4014362_0003\50_Discipline Information\63_E

Date: 4/20/2017
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
POI 4	Ex. POI 4	Outlet	2.86	75	0.1

Total area: 2.86 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

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MSK Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

==========

MSK Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)	10-Yr (cfs)	50-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
POI 4	4.12	9.14	16.52	20.59
REACHES				
OUTLET	4.12	9.14	16.52	20.59

==========

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs)	(hr)	10-Yr (cfs)	(hr)	50-Yr (cfs)	(hr)	100-Yr (cfs)	(hr)
SUBAREAS								
POI 4	4.12	12.12	9.14	12.13	16.52	12.12	20.59	12.12
REACHES								
OUTLET	4.12		9.14		16.52		20.59	

==========

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
POI 4	2.86	0.100	75	Outlet	Ex. POI 4

Total Area: 2.86 (ac)

==========

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
POI 4							
SHEET	100	0.0460	0.011				0.014
SHALLOW	100	0.5000	0.050				0.002
						Time of Concentration	0.1

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
POI 4	Open space; grass cover > 75%	(good)	D	.15	80
	Paved parking lots, roofs, driveways		D	.67	98
	Woods	(good)	A	.42	30
	Woods	(good)	B	.04	55
	Woods	(good)	D	1.58	77
	Total Area / Weighted Curve Number			2.86	75

WinTR-55 Current Data Description

--- Identification Data ---

User: MSK
Project: Marriottsville Rd Phase 3
SubTitle: Existing Conditions
State: Maryland
County: Howard NOAA-C
Filename: \\stvgroup.stvinc.com\V3\BAMD\vol3\PROJECTS\4014362\4014362_0003\50_Discipline Information\63_E

Date: 5/8/2017
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
POI 5	Ex. POI 5	Outlet	0.41	77	0.1

Total area: .41 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

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MSK Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

==========

MSK Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)	10-Yr (cfs)	50-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
POI 5	0.66	1.40	2.47	3.06
REACHES				
OUTLET	0.66	1.40	2.47	3.06

==========

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs)	(hr)	10-Yr (cfs)	(hr)	50-Yr (cfs)	(hr)	100-Yr (cfs)	(hr)
SUBAREAS								
POI 5	0.66	12.13	1.40	12.12	2.47	12.12	3.06	12.12
REACHES								
OUTLET	0.66		1.40		2.47		3.06	

==========

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
POI 5	.41	0.100	77	Outlet	Ex. POI 5

Total Area: .41 (ac)

==========

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
POI 5							
SHEET	100	0.2000	0.150				0.065
SHALLOW	25	0.2500	0.050				0.001
						Time of Concentration	0.1

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
POI 5	Open space; grass cover > 75%	(good)	D	.13	80
	Paved parking lots, roofs, driveways		D	.07	98
	Woods	(good)	B	.08	55
	Woods	(good)	D	.13	77
	Total Area / Weighted Curve Number			.41	77

WinTR-55 Current Data Description

--- Identification Data ---

User: MSK
Project: Marriottsville Rd Phase 3
SubTitle: Existing Conditions
State: Maryland
County: Howard NOAA-C
Filename: \\stvgroup.stvinc.com\V3\BAMD\vol3\PROJECTS\4014362\4014362_0003\50_Discipline Information\63_E

Date: 5/8/2017
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
POI 6	Ex. POI 6	Outlet	2.44	86	0.1

Total area: 2.44 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

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MSK Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

==========

MSK Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)	10-Yr (cfs)	50-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
POI 6	5.95	10.74	17.20	20.66
REACHES				
OUTLET	5.95	10.74	17.20	20.66

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MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs)	(hr)	10-Yr (cfs)	(hr)	50-Yr (cfs)	(hr)	100-Yr (cfs)	(hr)
SUBAREAS								
POI 6	5.95	12.12	10.74	12.12	17.20	12.12	20.66	12.12
REACHES								
OUTLET	5.95		10.74		17.20		20.66	

==========

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
POI 6	2.44	0.100	86	Outlet	Ex. POI 6

Total Area: 2.44 (ac)

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MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
POI 6							
SHEET	100	0.0200	0.011				0.020
CHANNEL	750	0.0220	0.030	1.42	4.91	3.205	0.065
						Time of Concentration	0.1

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
POI 6	Open space; grass cover > 75%	(good)	D	1.01	80
	Paved parking lots, roofs, driveways		D	.94	98
	Woods	(good)	D	.49	77
	Total Area / Weighted Curve Number			2.44	86

WinTR-55 Current Data Description

--- Identification Data ---

User: MSK
Project: Marriottsville Rd Phase 3
SubTitle: Existing Conditions
State: Maryland
County: Howard NOAA-C
Filename: \\stvgroup.stvinc.com\V3\BAMD\vol3\PROJECTS\4014362\4014362_0003\50_Discipline Information\63_E

Date: 4/20/2017
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
POI 7	Ex. POI 7	Outlet	0.24	83	0.1

Total area: .24 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

==========

MSK Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

==========

MSK Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)	10-Yr (cfs)	50-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
POI 7	0.52	0.99	1.64	1.99
REACHES				
OUTLET	0.52	0.99	1.64	1.99

==========

MSK Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs)	(hr)	10-Yr (cfs)	(hr)	50-Yr (cfs)	(hr)	100-Yr (cfs)	(hr)
SUBAREAS								
POI 7	0.52	12.12	0.99	12.12	1.64	12.12	1.99	12.12
REACHES								
OUTLET	0.52		0.99		1.64		1.99	

==========

MSK Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
POI 7	.24	0.100	83	Outlet	Ex. POI 7

Total Area: .24 (ac)

==========

MSK Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
POI 7							
SHEET	100	0.2500	0.150				0.060
						Time of Concentration	0.1

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
POI 7	Open space; grass cover > 75%	(good)	D	.07	80
	Paved parking lots, roofs, driveways		D	.06	98
	Woods	(good)	D	.11	77
	Total Area / Weighted Curve Number			.24	83

WinTR-55 Current Data Description

--- Identification Data ---

User: MSK
Project: Marriottsville Rd Phase 3
SubTitle: Existing Conditions
State: Maryland
County: Howard NOAA-C
Filename: \\stvgroup.stvinc.com\V3\BAMD\vol3\PROJECTS\4014362\4014362_0003\50_Discipline Information\63_E

Date: 5/8/2017
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
POI 8	Ex. POI 8	Outlet	2.42	84	0.100

Total area: 2.42 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

==========

MSK Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

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MSK Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)	10-Yr (cfs)	50-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
POI 8	5.43	10.14	16.60	20.01
REACHES				
OUTLET	5.43	10.14	16.60	20.01

==========

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs)	(hr)	10-Yr (cfs)	(hr)	50-Yr (cfs)	(hr)	100-Yr (cfs)	(hr)
SUBAREAS								
POI 8	5.43	12.12	10.14	12.12	16.60	12.12	20.01	12.12
REACHES								
OUTLET	5.43		10.14		16.60		20.01	

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MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
POI 8	2.42	0.100	84	Outlet	Ex. POI 8

Total Area: 2.42 (ac)

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MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
POI 8							
SHEET	25	0.2500	0.150				0.020
CHANNEL	790					3.500	0.063
					Time of Concentration		0.100

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
POI 8	Open space; grass cover > 75%	(good)	D	.72	80
	Paved parking lots, roofs, driveways		D	.67	98
	Woods	(good)	D	1.03	77
	Total Area / Weighted Curve Number			2.42	84

WinTR-55 Current Data Description

--- Identification Data ---

User: MSK
Project: Marriottsville Rd Phase 3
SubTitle: Existing Conditions
State: Maryland
County: Howard NOAA-C
Filename: \\stvgroup.stvinc.com\V3\BAMD\vol3\PROJECTS\4014362\4014362_0003\50_Discipline Information\63_E

Date: 4/20/2017
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
POI 9	Ex. POI 9	Outlet	1.68	84	0.1

Total area: 1.68 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

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MSK Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

==========

MSK Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)	10-Yr (cfs)	50-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
POI 9	3.78	7.05	11.55	13.92
REACHES				
OUTLET	3.78	7.05	11.55	13.92

==========

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs)	(hr)	10-Yr (cfs)	(hr)	50-Yr (cfs)	(hr)	100-Yr (cfs)	(hr)
SUBAREAS								
POI 9	3.78	12.12	7.05	12.12	11.55	12.12	13.92	12.12
REACHES								
OUTLET	3.78		7.05		11.55		13.92	

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MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
POI 9	1.68	0.100	84	Outlet	Ex. POI 9

Total Area: 1.68 (ac)

==========

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
POI 9							
SHEET	100	0.0360	0.011				0.016
SHALLOW	88	0.0360	0.050				0.008
CHANNEL	175					3.000	0.016
					Time of Concentration		0.1

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
POI 9	Open space; grass cover > 75%	(good)	D	.54	80
	Paved parking lots, roofs, driveways		D	.45	98
	Woods	(good)	D	.69	77
	Total Area / Weighted Curve Number			1.68	84

WinTR-55 Current Data Description

--- Identification Data ---

User: MSK
Project: Marriottsville Rd Phase 3
SubTitle: Existing Conditions
State: Maryland
County: Howard NOAA-C
Filename: \\stvgroup.stvinc.com\V3\BAMD\vol3\PROJECTS\4014362\4014362_0003\50_Discipline Information\63_E

Date: 5/8/2017
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
POI 10	Ex. POI 10	Outlet	2.94	85	.164

Total area: 2.94 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

==========

MSK Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

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MSK Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)	10-Yr (cfs)	50-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
POI 10	5.97	11.02	17.93	21.59
REACHES				
OUTLET	5.97	11.02	17.93	21.59

==========

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs)	(hr)	10-Yr (cfs)	(hr)	50-Yr (cfs)	(hr)	100-Yr (cfs)	(hr)
SUBAREAS								
POI 10	5.97	12.16	11.02	12.15	17.93	12.15	21.59	12.15
REACHES								
OUTLET	5.97		11.02		17.93		21.59	

==========

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
POI 10	2.94	0.164	85	Outlet	Ex. POI 10

Total Area: 2.94 (ac)

==========

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
POI 10							
SHEET	100	0.0500	0.150				0.113
SHALLOW	240	0.0500	0.050				0.018
CHANNEL	530					4.500	0.033
					Time of Concentration		.164

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
POI 10	Open space; grass cover > 75%	(good)	C	.08	74
	Open space; grass cover > 75%	(good)	D	1.23	80
	Paved parking lots, roofs, driveways		D	.99	98
	Woods	(good)	C	.12	70
	Woods	(good)	D	.52	77
	Total Area / Weighted Curve Number			2.94	85

WinTR-55 Current Data Description

--- Identification Data ---

User: MSK
Project: Marriottsville Rd Phase 3
SubTitle: Existing Conditions
State: Maryland
County: Howard NOAA-C
Filename: \\stvgroup.stvinc.com\V3\BAMD\vol3\PROJECTS\4014362\4014362_0003\50_Discipline Information\63_E

Date: 5/8/2017
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
POI 11	Ex. POI 11	Outlet	0.24	86	0.1

Total area: .24 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

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MSK Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

==========

MSK Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)	10-Yr (cfs)	50-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
POI 11	0.59	1.07	1.72	2.06
REACHES				
OUTLET	0.59	1.07	1.72	2.06

==========

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs)	(hr)	10-Yr (cfs)	(hr)	50-Yr (cfs)	(hr)	100-Yr (cfs)	(hr)
SUBAREAS								
POI 11	0.59	12.12	1.07	12.12	1.72	12.12	2.06	12.12
REACHES								
OUTLET	0.59		1.07		1.72		2.06	

==========

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
POI 11	.24	0.100	86	Outlet	Ex. POI 11

Total Area: .24 (ac)

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MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
POI 11							
SHEET	100	0.0300	0.011				0.017
						Time of Concentration	0.1

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
POI 11	Open space; grass cover > 75%	(good)	D	.04	80
	Paved parking lots, roofs, driveways		D	.1	98
	Woods	(good)	D	.1	77
	Total Area / Weighted Curve Number			.24	86

WinTR-55 Current Data Description

--- Identification Data ---

User: MSK
Project: Marriottsville Rd Phase 3
SubTitle: Existing Conditions
State: Maryland
County: Howard NOAA-C
Filename: \\stvgroup.stvinc.com\V3\BAMD\vol3\PROJECTS\4014362\4014362_0003\50_Discipline Information\63_E

Date: 5/8/2017
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
POI 12	Ex. POI 12	Outlet	0.6	97	0.1

Total area: .60 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

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MSK Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

==========

MSK Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)	10-Yr (cfs)	50-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
POI 12	2.03	3.17	4.70	5.51
REACHES				
OUTLET	2.03	3.17	4.70	5.51

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MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	50-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS				
POI 12	2.03 12.12	3.17 12.12	4.70 12.12	5.51 12.11
REACHES				
OUTLET	2.03	3.17	4.70	5.51

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MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
POI 12	.60	0.100	97	Outlet	Ex. POI 12

Total Area: .60 (ac)

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MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
POI 12							
SHEET	100	0.0300	0.011				0.017
						Time of Concentration	0.1

MSK

Marriottsville Rd Phase 3
Existing Conditions
Howard NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
POI 12	Open space; grass cover > 75% (good)	D	.04	80
	Paved parking lots, roofs, driveways	D	.56	98
	Total Area / Weighted Curve Number		.6	97

WinTR-55 Current Data Description

--- Identification Data ---

User: MSK
Project: Marriottsville Rd Phase 3
SubTitle: Proposed Conditions
State: Maryland
County: Howard NOAA-C
Filename: \\stvgroup.stvinc.com\V3\BAMD\vol3\PROJECTS\4014362\4014362_0003\50_Discipline Information\63_E

Date: 5/8/2017
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
POI 1	Pr. POI 1	Outlet	11.47	75	0.200

Total area: 11.47 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

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MSK Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

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MSK Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)	10-Yr (cfs)	50-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
POI 1	13.07	29.50	53.74	67.07
REACHES				
OUTLET	13.07	29.50	53.74	67.07

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs)	(hr)	10-Yr (cfs)	(hr)	50-Yr (cfs)	(hr)	100-Yr (cfs)	(hr)
SUBAREAS								
POI 1	13.07	12.18	29.50	12.18	53.74	12.17	67.07	12.17
REACHES								
OUTLET	13.07		29.50		53.74		67.07	

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
POI 1	11.47	0.200	75	Outlet	Pr. POI 1

Total Area: 11.47 (ac)

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MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
POI 1							
SHEET	100	0.0540	0.150				0.110
SHALLOW	1040	0.0400	0.050				0.090
						Time of Concentration	0.200

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
POI 1	Open space; grass cover > 75%	(good)	B	.11	61
	Open space; grass cover > 75%	(good)	D	.13	80
	Paved parking lots, roofs, driveways		B	.72	98
	Paved parking lots, roofs, driveways		C	.51	98
	Paved parking lots, roofs, driveways		D	.28	98
	Residential districts (1/2 acre)		B	2.11	70
	Residential districts (1/2 acre)		C	2.56	80
	Residential districts (1/2 acre)		D	.01	85
	User defined urban (Click button or		B	.28	55
	User defined urban (Click button or		D	1.32	77
	Woods	(good)	B	1.64	55
	Woods	(good)	C	.65	70
	Woods	(good)	D	1.15	77
	Total Area / Weighted Curve Number			11.47	75

WinTR-55 Current Data Description

--- Identification Data ---

User: MSK
Project: Marriottsville Rd Phase 3
SubTitle: Proposed Conditions
State: Maryland
County: Howard NOAA-C
Filename: \\stvgroup.stvinc.com\V3\BAMD\vol3\PROJECTS\4014362\4014362_0003\50_Discipline Information\63_E

Date: 5/8/2017
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
POI 2	Pr. POI 2	Outlet	3.58	80	.16

Total area: 3.58 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

==========

MSK Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

==========

MSK Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)	10-Yr (cfs)	50-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
POI 2	5.85	11.80	20.18	24.70
REACHES				
OUTLET	5.85	11.80	20.18	24.70

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs)	(hr)	10-Yr (cfs)	(hr)	50-Yr (cfs)	(hr)	100-Yr (cfs)	(hr)
SUBAREAS								
POI 2	5.85	12.15	11.80	12.15	20.18	12.15	24.70	12.14
REACHES								
OUTLET	5.85		11.80		20.18		24.70	

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
POI 2	3.58	0.160	80	Outlet	Pr. POI 2

Total Area: 3.58 (ac)

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
POI 2							
SHEET	100	0.0500	0.150				0.113
SHALLOW	40	0.2200	0.050				0.001
CHANNEL	745	0.0370	0.030	1.37	4.28	4.499	0.046
					Time of Concentration		.16

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
POI 2	Open space; grass cover > 75%	(good)	B	.86	61
	Open space; grass cover > 75%	(good)	D	.21	80
	Paved parking lots, roofs, driveways		B	.16	98
	Paved parking lots, roofs, driveways		D	.8	98
	Commercial & business		B	1.05	92
	Woods	(good)	B	.47	55
	Woods	(good)	D	.03	77
	Total Area / Weighted Curve Number			3.58	80

WinTR-55 Current Data Description

--- Identification Data ---

User: MSK
Project: Marriottsville Rd Phase 3
SubTitle: Proposed Conditions
State: Maryland
County: Howard NOAA-C
Filename: \\stvgroup.stvinc.com\V3\BAMD\vol3\PROJECTS\4014362\4014362_0003\50_Discipline Information\63_E

Date: 5/8/2017
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
POI 3	Pr. POI 3	Outlet	0.61	81	0.1

Total area: .61 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

==========

MSK Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

==========

MSK Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)	10-Yr (cfs)	50-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
POI 3	1.20	2.35	3.97	4.83
REACHES				
OUTLET	1.20	2.35	3.97	4.83

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs)	(hr)	10-Yr (cfs)	(hr)	50-Yr (cfs)	(hr)	100-Yr (cfs)	(hr)
SUBAREAS								
POI 3	1.20	12.12	2.35	12.12	3.97	12.12	4.83	12.12
REACHES								
OUTLET	1.20		2.35		3.97		4.83	

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
POI 3	.61	0.100	81	Outlet	Pr. POI 3

Total Area: .61 (ac)

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MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
POI 3							
SHEET	100	0.0460	0.011				0.014
SHALLOW	100	0.5000	0.050				0.002
						Time of Concentration	0.1

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
POI 3	Open space; grass cover > 75%	(good)	D	.03	80
	Paved parking lots, roofs, driveways		D	.16	98
	User defined urban (Click button or		D	.33	77
	Woods	(good)	B	.05	55
	Woods	(good)	D	.04	77
	Total Area / Weighted Curve Number			.61	81

WinTR-55 Current Data Description

--- Identification Data ---

User: MSK
Project: Marriottsville Rd Phase 3
SubTitle: Proposed Conditions
State: Maryland
County: Howard NOAA-C
Filename: \\stvgroup.stvinc.com\V3\BAMD\vol3\PROJECTS\4014362\4014362_0003\50_Discipline Information\63_E

Date: 4/20/2017
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
POI 4	Pr. POI 4	Outlet	2.86	75	0.1

Total area: 2.86 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

==========

MSK Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

==========

MSK Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)	10-Yr (cfs)	50-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
POI 4	4.12	9.14	16.52	20.59
REACHES				
OUTLET	4.12	9.14	16.52	20.59

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs)	(hr)	10-Yr (cfs)	(hr)	50-Yr (cfs)	(hr)	100-Yr (cfs)	(hr)
SUBAREAS								
POI 4	4.12	12.12	9.14	12.13	16.52	12.12	20.59	12.12
REACHES								
OUTLET	4.12		9.14		16.52		20.59	

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
POI 4	2.86	0.100	75	Outlet	Pr. POI 4

Total Area: 2.86 (ac)

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
POI 4							
SHEET	100	0.0460	0.011				0.014
SHALLOW	100	0.5000	0.050				0.002
						Time of Concentration	0.1

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
POI 4	Open space; grass cover > 75%	(good)	D	.13	80
	Paved parking lots, roofs, driveways		D	.69	98
	Woods	(good)	A	.42	30
	Woods	(good)	B	.04	55
	Woods	(good)	D	1.58	77
	Total Area / Weighted Curve Number			2.86	75

WinTR-55 Current Data Description

--- Identification Data ---

User: MSK
Project: Marriottsville Rd Phase 3
SubTitle: Proposed Conditions
State: Maryland
County: Howard NOAA-C
Filename: \\stvgroup.stvinc.com\V3\BAMD\vol3\PROJECTS\4014362\4014362_0003\50_Discipline Information\63_E

Date: 4/20/2017
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
POI 5	Pr. POI 5	Outlet	0.4	88	0.1

Total area: .40 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

==========

MSK Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

==========

MSK Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)	10-Yr (cfs)	50-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
POI 5	1.06	1.86	2.92	3.49
REACHES				
OUTLET	1.06	1.86	2.92	3.49

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs)	(hr)	10-Yr (cfs)	(hr)	50-Yr (cfs)	(hr)	100-Yr (cfs)	(hr)
SUBAREAS								
POI 5	1.06	12.12	1.86	12.12	2.92	12.12	3.49	12.12
REACHES								
OUTLET	1.06		1.86		2.92		3.49	

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
POI 5	.40	0.100	88	Outlet	Pr. POI 5

Total Area: .40 (ac)

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
POI 5							
SHEET	100	0.0500	0.011				0.014
SHALLOW	25	0.2500	0.050				0.001
						Time of Concentration	0.1

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
POI 5	Open space; grass cover > 75%	(good)	D	.01	80
	Paved parking lots, roofs, driveways		D	.26	98
	Woods	(good)	B	.05	55
	Woods	(good)	D	.08	77
	Total Area / Weighted Curve Number			.4	88

WinTR-55 Current Data Description

--- Identification Data ---

User: MSK
Project: Marriottsville Rd Phase 3
SubTitle: Proposed Conditions
State: Maryland
County: Howard NOAA-C
Filename: \\stvgroup.stvinc.com\V3\BAMD\vol3\PROJECTS\4014362\4014362_0003\50_Discipline Information\63_E

Date: 5/8/2017
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
POI 6	Pr. POI 6	Outlet	2.4	87	0.1

Total area: 2.40 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

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MSK Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

==========

MSK Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)	10-Yr (cfs)	50-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
POI 6	6.08	10.82	17.18	20.55
REACHES				
OUTLET	6.08	10.82	17.18	20.55

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs)	(hr)	10-Yr (cfs)	(hr)	50-Yr (cfs)	(hr)	100-Yr (cfs)	(hr)
SUBAREAS								
POI 6	6.08	12.12	10.82	12.12	17.18	12.12	20.55	12.12
REACHES								
OUTLET	6.08		10.82		17.18		20.55	

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
POI 6	2.40	0.100	87	Outlet	Pr. POI 6

Total Area: 2.40 (ac)

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
POI 6							
SHEET	100	0.0200	0.011				0.020
CHANNEL	750	0.0220	0.030	1.42	4.91	3.205	0.065
						Time of Concentration	0.1

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
POI 6	Open space; grass cover > 75%	(good)	D	.85	80
	Paved parking lots, roofs, driveways		D	1.06	98
	Woods	(good)	D	.49	77
	Total Area / Weighted Curve Number			2.4	87

WinTR-55 Current Data Description

--- Identification Data ---

User: MSK
Project: Marriottsville Rd Phase 3
SubTitle: Proposed Conditions
State: Maryland
County: Howard NOAA-C
Filename: \\stvgroup.stvinc.com\V3\BAMD\vol3\PROJECTS\4014362\4014362_0003\50_Discipline Information\63_E

Date: 5/8/2017
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
POI 7	Pr. POI 7	Outlet	0.29	90	0.1

Total area: .29 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

==========

MSK Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

==========

MSK Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)	10-Yr (cfs)	50-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
POI 7	0.81	1.38	2.14	2.54
REACHES				
OUTLET	0.81	1.38	2.14	2.54

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs)	(hr)	10-Yr (cfs)	(hr)	50-Yr (cfs)	(hr)	100-Yr (cfs)	(hr)
SUBAREAS								
POI 7	0.81	12.12	1.38	12.12	2.14	12.12	2.54	12.12
REACHES								
OUTLET	0.81		1.38		2.14		2.54	

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
POI 7	.29	0.100	90	Outlet	Pr. POI 7

Total Area: .29 (ac)

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
POI 7							
SHEET	100	0.2500	0.150				0.060
						Time of Concentration	0.1

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
POI 7	Open space; grass cover > 75%	(good)	D	.01	80
	Paved parking lots, roofs, driveways		D	.18	98
	Woods	(good)	D	.1	77
	Total Area / Weighted Curve Number			.29	90

WinTR-55 Current Data Description

--- Identification Data ---

User: MSK
Project: Marriottsville Rd Phase 3
SubTitle: Proposed Conditions
State: Maryland
County: Howard NOAA-C
Filename: \\stvgroup.stvinc.com\V3\BAMD\vol3\PROJECTS\4014362\4014362_0003\50_Discipline Information\63_E

Date: 5/25/2017
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
POI 8	Pr. POI 8	Outlet	2.42	84	0.100

Total area: 2.42 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

==========

MSK Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

==========

MSK Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)	10-Yr (cfs)	50-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
POI 8	5.43	10.14	16.60	20.01
REACHES				
OUTLET	5.43	10.14	16.60	20.01

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs)	(hr)	10-Yr (cfs)	(hr)	50-Yr (cfs)	(hr)	100-Yr (cfs)	(hr)
SUBAREAS								
POI 8	5.43	12.12	10.14	12.12	16.60	12.12	20.01	12.12
REACHES								
OUTLET	5.43		10.14		16.60		20.01	

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
POI 8	2.42	0.100	84	Outlet	Pr. POI 8

Total Area: 2.42 (ac)

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
POI 8							
SHEET	25	0.2500	0.150				0.020
CHANNEL	790					3.500	0.063
					Time of Concentration		0.100

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
POI 8	Open space; grass cover > 75%	(good)	D	.7	80
	Paved parking lots, roofs, driveways		D	.69	98
	Woods	(good)	D	1.03	77
	Total Area / Weighted Curve Number			2.42	84

WinTR-55 Current Data Description

--- Identification Data ---

User: MSK
Project: Marriottsville Rd Phase 3
SubTitle: Proposed Conditions
State: Maryland
County: Howard NOAA-C
Filename: \\stvgroup.stvinc.com\V3\BAMD\vol3\PROJECTS\4014362\4014362_0003\50_Discipline Information\63_E

Date: 5/8/2017
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
POI 9	Pr. POI 9	Outlet	1.65	84	0.1

Total area: 1.65 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

==========

MSK Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

==========

MSK Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)	10-Yr (cfs)	50-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
POI 9	3.71	6.92	11.33	13.66
REACHES				
OUTLET	3.71	6.92	11.33	13.66

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs)	(hr)	10-Yr (cfs)	(hr)	50-Yr (cfs)	(hr)	100-Yr (cfs)	(hr)
SUBAREAS								
POI 9	3.71	12.12	6.92	12.12	11.33	12.12	13.66	12.12
REACHES								
OUTLET	3.71		6.92		11.33		13.66	

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
POI 9	1.65	0.100	84	Outlet	Pr. POI 9

Total Area: 1.65 (ac)

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
POI 9							
SHEET	100	0.0360	0.011				0.016
SHALLOW	88	0.0360	0.050				0.008
CHANNEL	175					3.000	0.016
					Time of Concentration		0.1

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
POI 9	Open space; grass cover > 75%	(good)	D	.51	80
	Paved parking lots, roofs, driveways		D	.45	98
	Woods	(good)	D	.69	77
	Total Area / Weighted Curve Number			1.65	84

WinTR-55 Current Data Description

--- Identification Data ---

User: MSK
Project: Marriottsville Rd Phase 3
SubTitle: Proposed Conditions
State: Maryland
County: Howard NOAA-C
Filename: \\stvgroup.stvinc.com\V3\BAMD\vol3\PROJECTS\4014362\4014362_0003\50_Discipline Information\63_E

Date: 5/8/2017
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
POI 10	Pr. POI 10	Outlet	3	81	.164

Total area: 3 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

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MSK Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

==========

MSK Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)	10-Yr (cfs)	50-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
POI 10	5.11	10.12	17.13	20.89
REACHES				
OUTLET	5.11	10.12	17.13	20.89

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs)	(hr)	10-Yr (cfs)	(hr)	50-Yr (cfs)	(hr)	100-Yr (cfs)	(hr)
SUBAREAS								
POI 10	5.11	12.15	10.12	12.15	17.13	12.15	20.89	12.15
REACHES								
OUTLET	5.11		10.12		17.13		20.89	

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
POI 10	3.00	0.164	81	Outlet	Pr. POI 10

Total Area: 3 (ac)

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
POI 10							
SHEET	100	0.0500	0.150				0.113
SHALLOW	240	0.0500	0.050				0.018
CHANNEL	530					4.500	0.033
					Time of Concentration		.164

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
POI 10	Open space; grass cover > 75%	(good)	C	.08	74
	Open space; grass cover > 75%	(good)	D	.43	80
	Paved parking lots, roofs, driveways		D	.51	98
	User defined urban (Click button or		D	1.34	77
	Woods	(good)	C	.12	70
	Woods	(good)	D	.52	77
	Total Area / Weighted Curve Number			3	81
				=	==

WinTR-55 Current Data Description

--- Identification Data ---

User: MSK
Project: Marriottsville Rd Phase 3
SubTitle: Proposed Conditions
State: Maryland
County: Howard NOAA-C
Filename: \\stvgroup.stvinc.com\V3\BAMD\vol3\PROJECTS\4014362\4014362_0003\50_Discipline Information\63_E

Date: 5/8/2017
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
POI 11	Pr. POI 11	Outlet	0.24	86	0.1

Total area: .24 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

==========

MSK Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

==========

MSK Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)	10-Yr (cfs)	50-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
POI 11	0.59	1.07	1.72	2.06
REACHES				
OUTLET	0.59	1.07	1.72	2.06

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs)	(hr)	10-Yr (cfs)	(hr)	50-Yr (cfs)	(hr)	100-Yr (cfs)	(hr)
SUBAREAS								
POI 11	0.59	12.12	1.07	12.12	1.72	12.12	2.06	12.12
REACHES								
OUTLET	0.59		1.07		1.72		2.06	

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
POI 11	.24	0.100	86	Outlet	Pr. POI 11

Total Area: .24 (ac)

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
POI 11							
SHEET	100	0.0300	0.011				0.017
						Time of Concentration	0.1

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
POI 11	Open space; grass cover > 75%	(good)	D	.04	80
	Paved parking lots, roofs, driveways		D	.1	98
	Woods	(good)	D	.1	77
	Total Area / Weighted Curve Number			.24	86

WinTR-55 Current Data Description

--- Identification Data ---

User: MSK
Project: Marriottsville Rd Phase 3
SubTitle: Proposed Conditions
State: Maryland
County: Howard NOAA-C
Filename: \\stvgroup.stvinc.com\V3\BAMD\vol3\PROJECTS\4014362\4014362_0003\50_Discipline Information\63_E

Date: 5/8/2017
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
POI 12	Pr. POI 12	Outlet	0.6	97	0.100

Total area: .60 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

==========

MSK Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.19	4.1	4.91	6.14	7.23	8.47	2.64

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

==========

MSK Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)	10-Yr (cfs)	50-Yr (cfs)	100-Yr (cfs)
SUBAREAS				
POI 12	2.03	3.17	4.70	5.51
REACHES				
OUTLET	2.03	3.17	4.70	5.51

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs)	(hr)	10-Yr (cfs)	(hr)	50-Yr (cfs)	(hr)	100-Yr (cfs)	(hr)
SUBAREAS								
POI 12	2.03	12.12	3.17	12.12	4.70	12.12	5.51	12.11
REACHES								
OUTLET	2.03		3.17		4.70		5.51	

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
POI 12	.60	0.100	97	Outlet	Pr. POI 12

Total Area: .60 (ac)

==========

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
POI 12							
SHEET	100	0.0300	0.011				0.017
						Time of Concentration	0.100

MSK

Marriottsville Rd Phase 3
Proposed Conditions
Howard NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
POI 12	Open space; grass cover > 75% (good)	D	.05	80
	Paved parking lots, roofs, driveways	D	.55	98
	Total Area / Weighted Curve Number		.6	97

IX. APPENDIX B – Soil Survey

United States Department of Agriculture

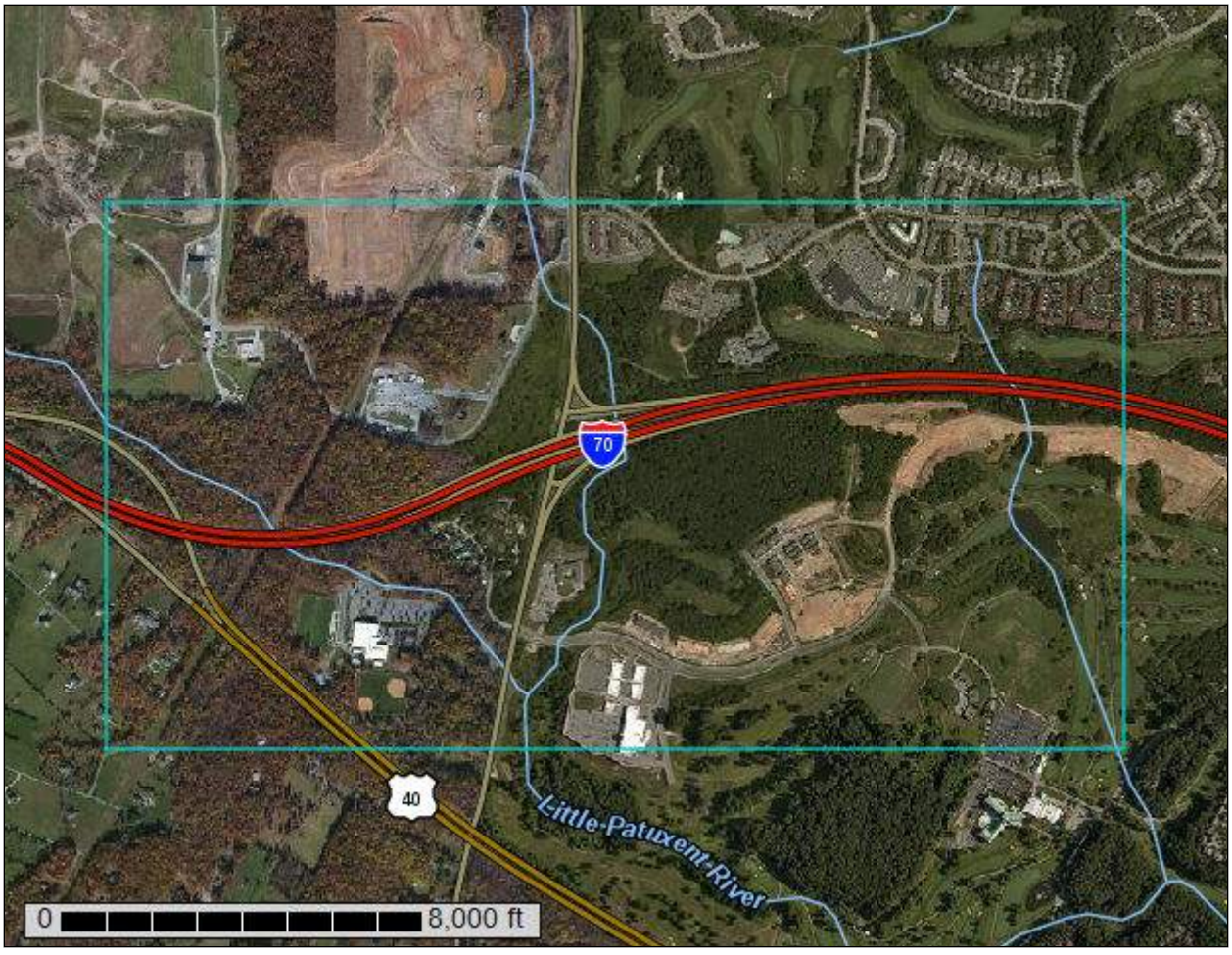
NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Howard County, Maryland

Marriottsville Road Phase 3



May 16, 2017

Custom Soil Resource Report
Soil Map

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:12,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Howard County, Maryland
Survey Area Data: Version 11, Sep 20, 2016

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 26, 2011—Aug 15, 2014

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

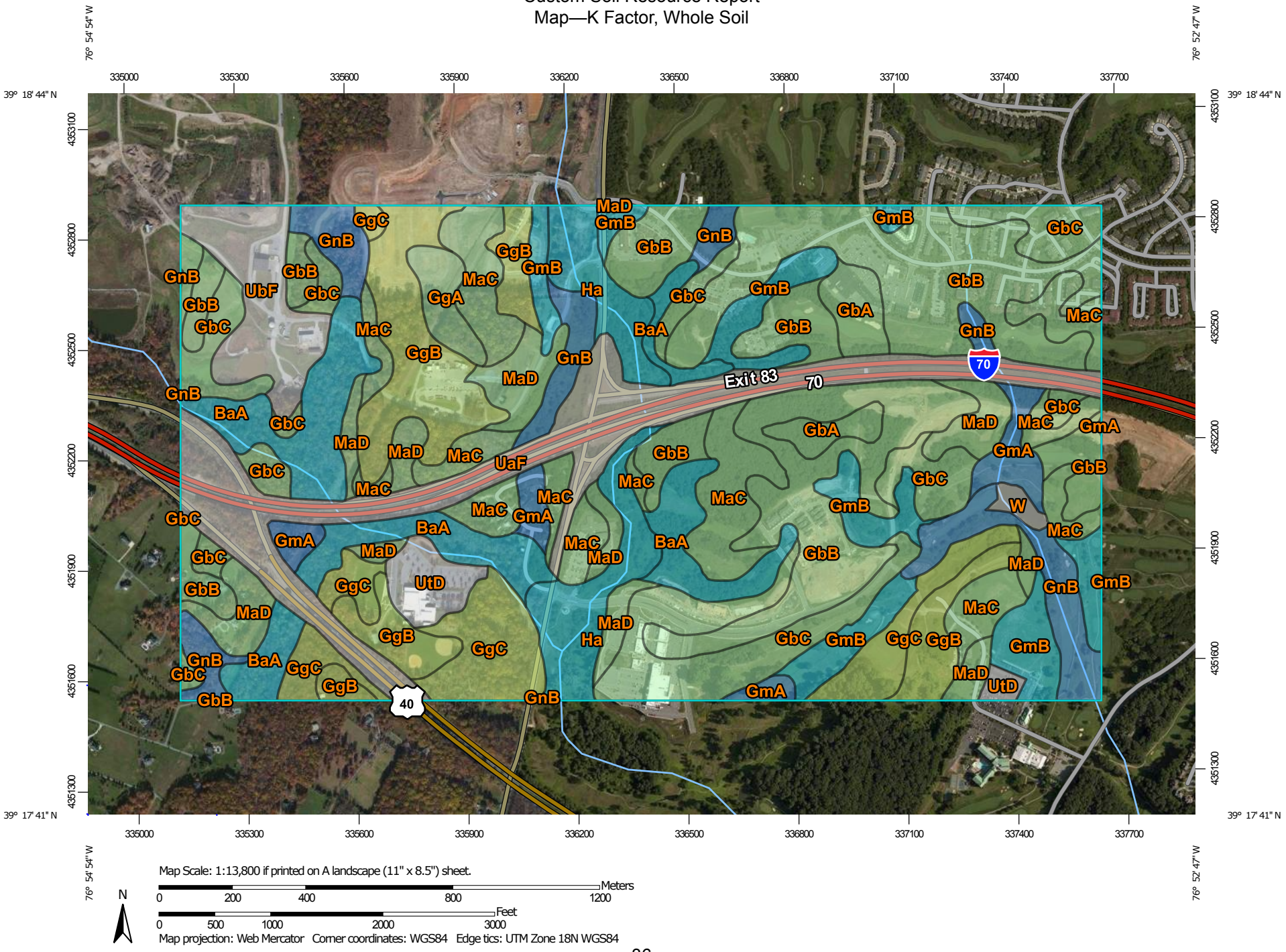
Map Unit Legend

Howard County, Maryland (MD027)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
BaA	Baile silt loam, 0 to 3 percent slopes	67.0	8.0%
GbA	Gladstone loam, 0 to 3 percent slopes	14.5	1.7%
GbB	Gladstone loam, 3 to 8 percent slopes	162.8	19.4%
GbC	Gladstone loam, 8 to 15 percent slopes	78.8	9.4%
GgA	Glenelg loam, 0 to 3 percent slopes	8.6	1.0%
GgB	Glenelg loam, 3 to 8 percent slopes	64.5	7.7%
GgC	Glenelg loam, 8 to 15 percent slopes	45.7	5.4%
GmA	Glenville silt loam, 0 to 3 percent slopes	17.2	2.0%
GmB	Glenville silt loam, 3 to 8 percent slopes	50.8	6.1%
GnB	Glenville-Baile silt loams, 0 to 8 percent slopes	44.6	5.3%
Ha	Hatboro-Codorus silt loams, 0 to 3 percent slopes	38.4	4.6%
MaC	Manor loam, 8 to 15 percent slopes	76.4	9.1%
MaD	Manor loam, 15 to 25 percent slopes	44.5	5.3%
UaF	Udorthents, Highway, 0 to 65 percent slopes	80.8	9.6%
UbF	Udorthents, Refuse, 0 to 65 percent slopes	29.0	3.5%
UtD	Urban land-Udorthents complex, 0 to 15 percent slopes	12.6	1.5%
W	Water	2.5	0.3%
Totals for Area of Interest		**838.5**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

Map—K Factor, Whole Soil



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

.02
.05
.10
.15
.17
.20
.24
.28
.32
.37
.43
.49
.55
.64
Not rated or not available

Soil Rating Lines

.02
.05
.10
.15
.17
.20
.24
.28
.32
.37
.43
.49
.55
.64
Not rated or not available

Soil Rating Points

.02
.05
.10
.15
.17
.20
.24
.28
.32
.37
.43
.49
.55
.64
Not rated or not available

Water Features

Streams and Canals

Transportation

Rails
Interstate Highways
US Routes
Major Roads
Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:12,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Howard County, Maryland
Survey Area Data: Version 11, Sep 20, 2016

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 26, 2011—Aug 15, 2014

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—K Factor, Whole Soil

K Factor, Whole Soil— Summary by Map Unit — Howard County, Maryland (MD027)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
BaA	Baile silt loam, 0 to 3 percent slopes	.37	67.0	8.0%
GbA	Gladstone loam, 0 to 3 percent slopes	.28	14.5	1.7%
GbB	Gladstone loam, 3 to 8 percent slopes	.28	162.8	19.4%
GbC	Gladstone loam, 8 to 15 percent slopes	.28	78.8	9.4%
GgA	Glenelg loam, 0 to 3 percent slopes	.28	8.6	1.0%
GgB	Glenelg loam, 3 to 8 percent slopes	.24	64.5	7.7%
GgC	Glenelg loam, 8 to 15 percent slopes	.24	45.7	5.4%
GmA	Glenville silt loam, 0 to 3 percent slopes	.43	17.2	2.0%
GmB	Glenville silt loam, 3 to 8 percent slopes	.37	50.8	6.1%
GnB	Glenville-Baile silt loams, 0 to 8 percent slopes	.43	44.6	5.3%
Ha	Hatboro-Codorus silt loams, 0 to 3 percent slopes	.37	38.4	4.6%
MaC	Manor loam, 8 to 15 percent slopes	.28	76.4	9.1%
MaD	Manor loam, 15 to 25 percent slopes	.28	44.5	5.3%
UaF	Udorthents, Highway, 0 to 65 percent slopes		80.8	9.6%
UbF	Udorthents, Refuse, 0 to 65 percent slopes		29.0	3.5%
UtD	Urban land-Udorthents complex, 0 to 15 percent slopes		12.6	1.5%
W	Water		2.5	0.3%
Totals for Area of Interest			**838.5**	**100.0%**

Rating Options—K Factor, Whole Soil

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Layer Options (Horizon Aggregation Method): Surface Layer (Not applicable)

Soil Qualities and Features

Soil qualities are behavior and performance attributes that are not directly measured, but are inferred from observations of dynamic conditions and from soil properties. Example soil qualities include natural drainage, and frost action. Soil features are attributes that are not directly part of the soil. Example soil features include slope and depth to restrictive layer. These features can greatly impact the use and management of the soil.

Hydrologic Soil Group

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

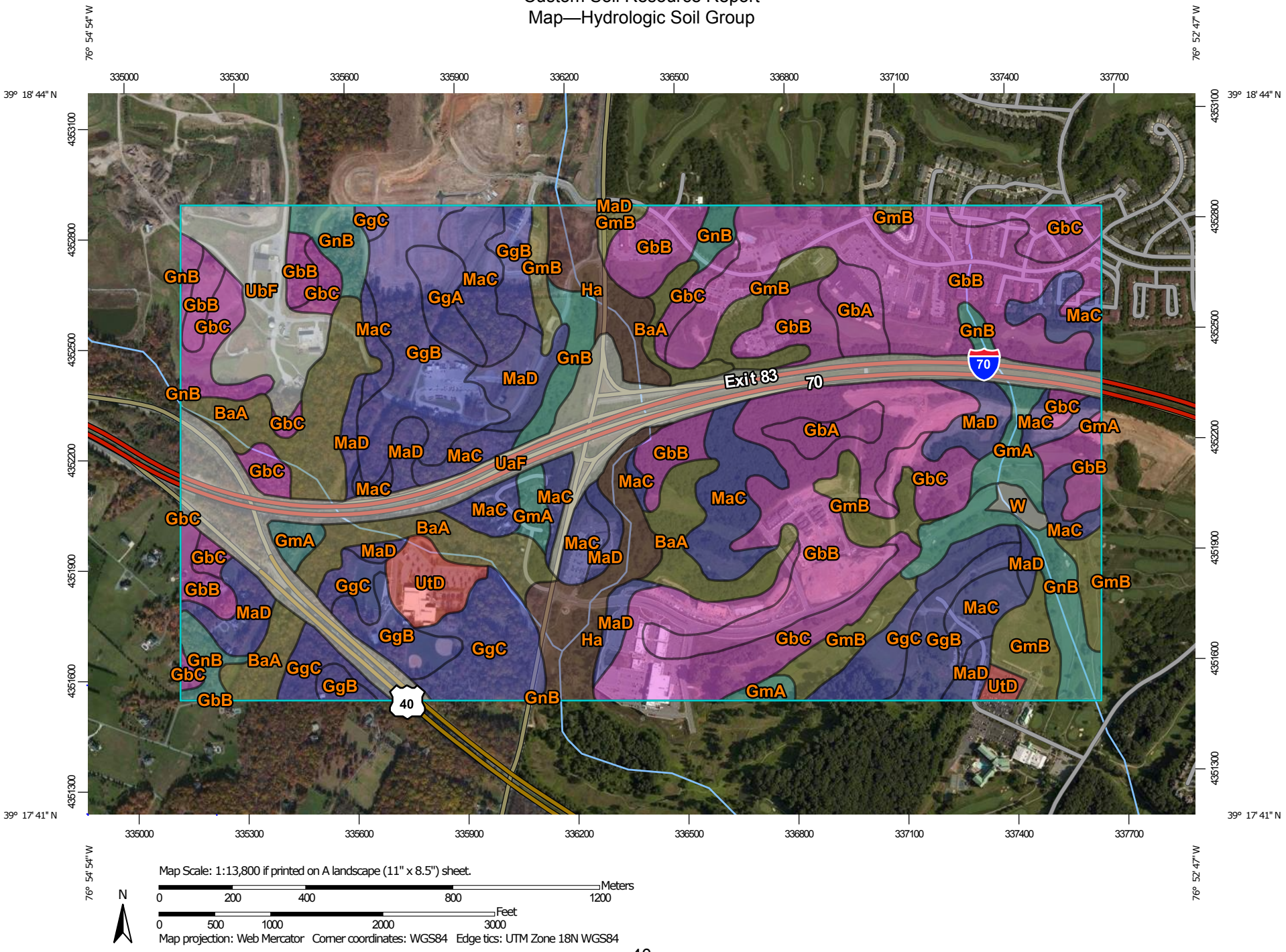
Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Map—Hydrologic Soil Group



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Lines

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Points

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:12,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Howard County, Maryland
Survey Area Data: Version 11, Sep 20, 2016

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 26, 2011—Aug 15, 2014

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Howard County, Maryland (MD027)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
BaA	Baile silt loam, 0 to 3 percent slopes	C/D	67.0	8.0%
GbA	Gladstone loam, 0 to 3 percent slopes	A	14.5	1.7%
GbB	Gladstone loam, 3 to 8 percent slopes	A	162.8	19.4%
GbC	Gladstone loam, 8 to 15 percent slopes	A	78.8	9.4%
GgA	Glenelg loam, 0 to 3 percent slopes	B	8.6	1.0%
GgB	Glenelg loam, 3 to 8 percent slopes	B	64.5	7.7%
GgC	Glenelg loam, 8 to 15 percent slopes	B	45.7	5.4%
GmA	Glenville silt loam, 0 to 3 percent slopes	C	17.2	2.0%
GmB	Glenville silt loam, 3 to 8 percent slopes	C/D	50.8	6.1%
GnB	Glenville-Baile silt loams, 0 to 8 percent slopes	C	44.6	5.3%
Ha	Hatboro-Codorus silt loams, 0 to 3 percent slopes	B/D	38.4	4.6%
MaC	Manor loam, 8 to 15 percent slopes	B	76.4	9.1%
MaD	Manor loam, 15 to 25 percent slopes	B	44.5	5.3%
UaF	Udorthents, Highway, 0 to 65 percent slopes		80.8	9.6%
UbF	Udorthents, Refuse, 0 to 65 percent slopes		29.0	3.5%
UtD	Urban land-Udorthents complex, 0 to 15 percent slopes	D	12.6	1.5%
W	Water		2.5	0.3%
Totals for Area of Interest			**838.5**	**100.0%**

Rating Options—Hydrologic Soil Group

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

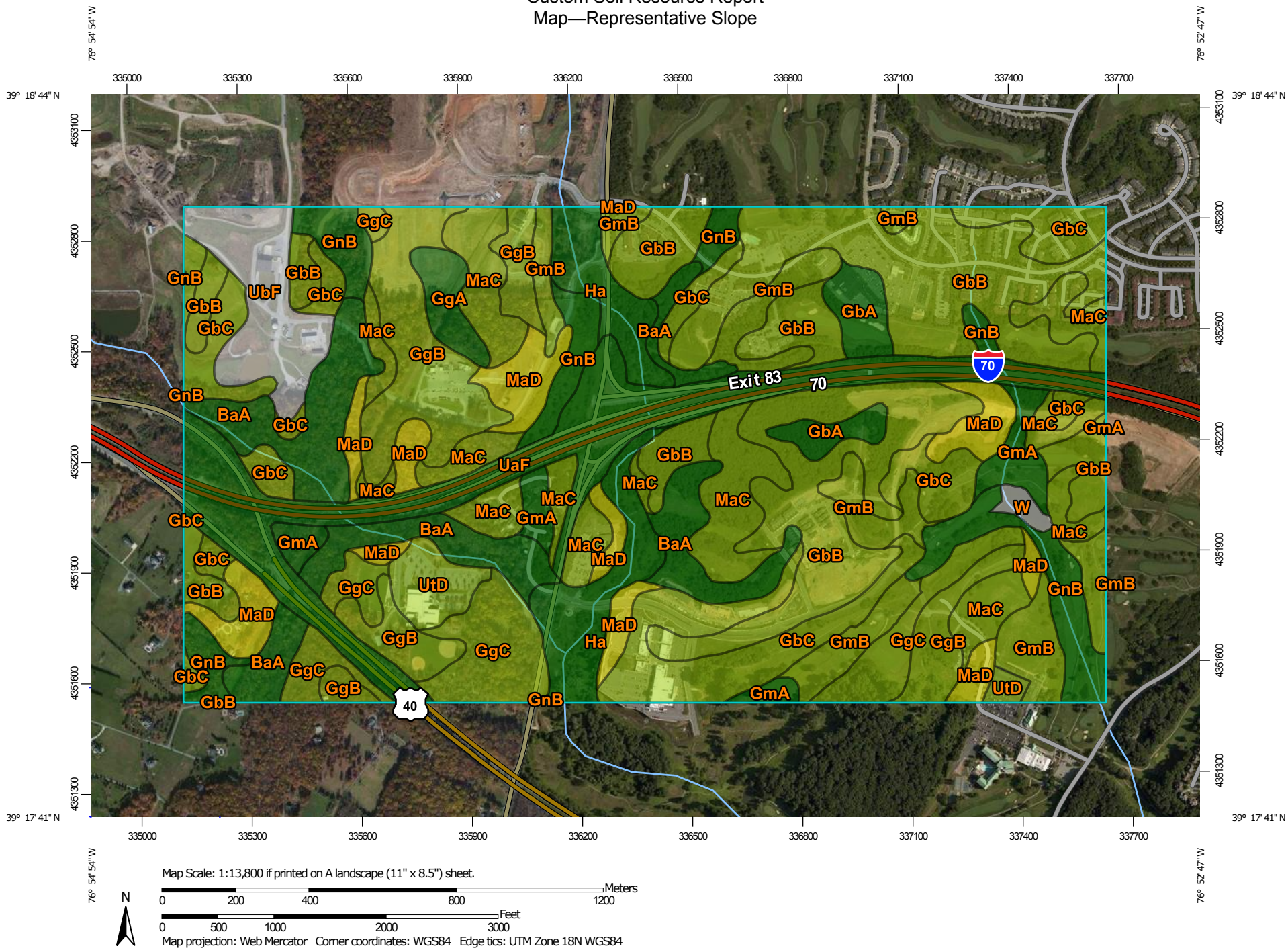
Tie-break Rule: Higher

Representative Slope

Slope gradient is the difference in elevation between two points, expressed as a percentage of the distance between those points.

The slope gradient is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

Custom Soil Resource Report
Map—Representative Slope



MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- 60 - 100
- 45 - 60
- 15 - 45
- 5 - 15
- 0 - 5
- Not rated or not available

Soil Rating Lines

- 60 - 100
- 45 - 60
- 15 - 45
- 5 - 15
- 0 - 5
- Not rated or not available

Soil Rating Points

- 60 - 100
- 45 - 60
- 15 - 45
- 5 - 15
- 0 - 5
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:12,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Howard County, Maryland
Survey Area Data: Version 11, Sep 20, 2016

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 26, 2011—Aug 15, 2014

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Representative Slope

Representative Slope— Summary by Map Unit — Howard County, Maryland (MD027)				
Map unit symbol	**Map unit name**	**Rating (percent)**	**Acres in AOI**	**Percent of AOI**
BaA	Baile silt loam, 0 to 3 percent slopes	2.0	67.0	8.0%
GbA	Gladstone loam, 0 to 3 percent slopes	2.0	14.5	1.7%
GbB	Gladstone loam, 3 to 8 percent slopes	5.0	162.8	19.4%
GbC	Gladstone loam, 8 to 15 percent slopes	12.0	78.8	9.4%
GgA	Glenelg loam, 0 to 3 percent slopes	2.0	8.6	1.0%
GgB	Glenelg loam, 3 to 8 percent slopes	6.0	64.5	7.7%
GgC	Glenelg loam, 8 to 15 percent slopes	12.0	45.7	5.4%
GmA	Glenville silt loam, 0 to 3 percent slopes	2.0	17.2	2.0%
GmB	Glenville silt loam, 3 to 8 percent slopes	6.0	50.8	6.1%
GnB	Glenville-Baile silt loams, 0 to 8 percent slopes	4.0	44.6	5.3%
Ha	Hatboro-Codorus silt loams, 0 to 3 percent slopes	2.0	38.4	4.6%
MaC	Manor loam, 8 to 15 percent slopes	12.0	76.4	9.1%
MaD	Manor loam, 15 to 25 percent slopes	20.0	44.5	5.3%
UaF	Udorthents, Highway, 0 to 65 percent slopes	4.0	80.8	9.6%
UbF	Udorthents, Refuse, 0 to 65 percent slopes		29.0	3.5%
UtD	Urban land-Udorthents complex, 0 to 15 percent slopes	8.0	12.6	1.5%
W	Water		2.5	0.3%
Totals for Area of Interest			**838.5**	**100.0%**

Rating Options—Representative Slope

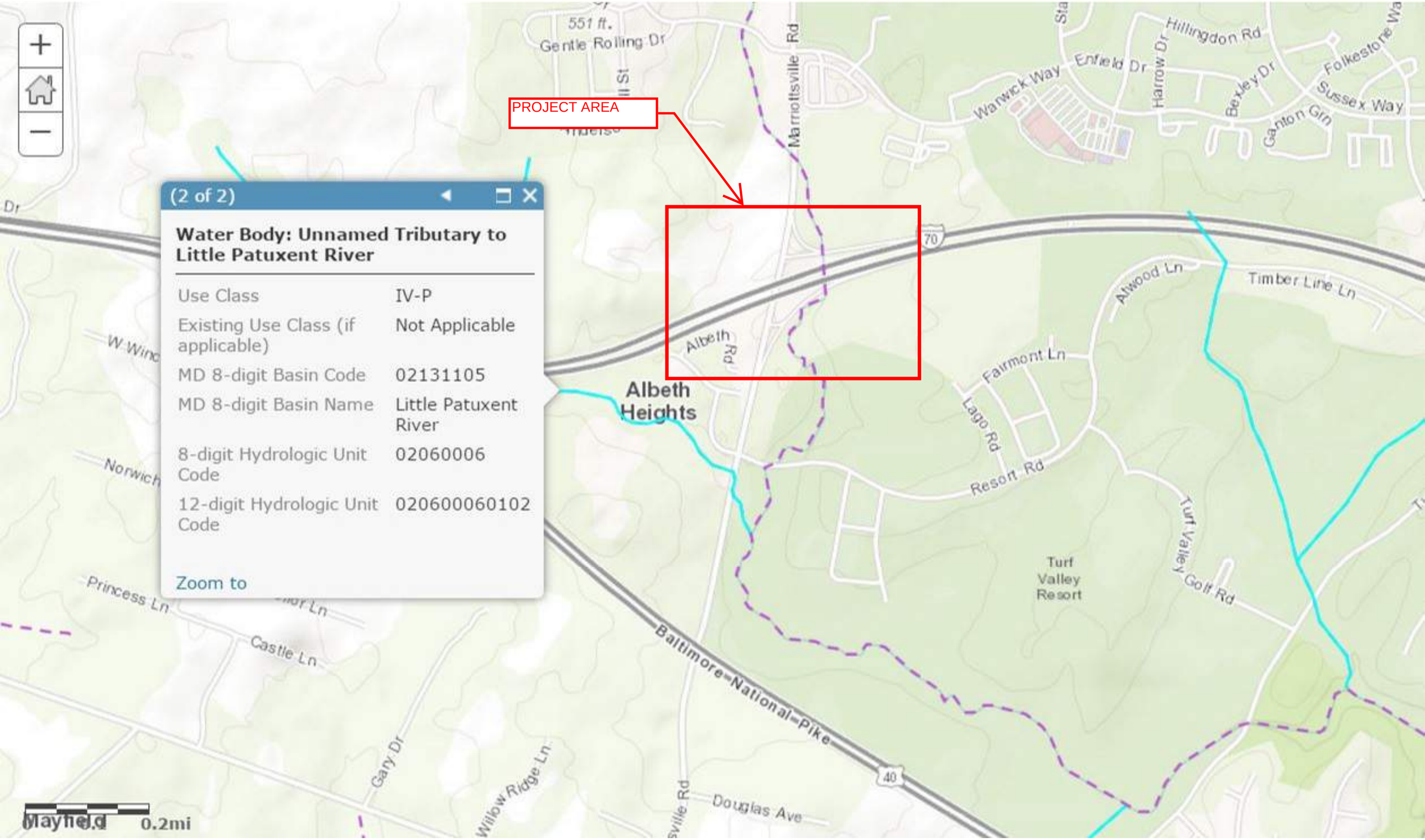
Units of Measure: percent

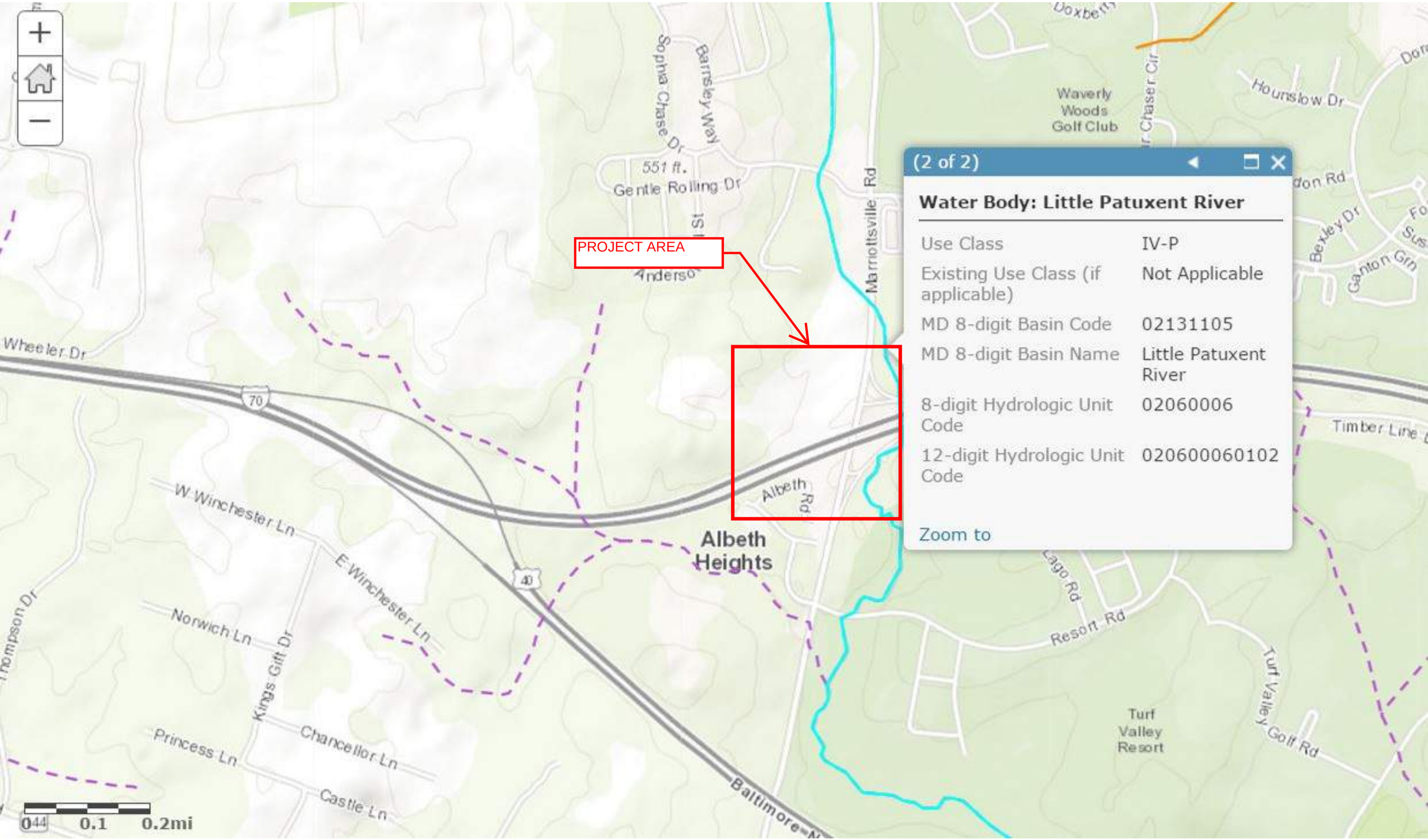
Aggregation Method: Dominant Component

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

X. APPENDIX C – Stream Designation Information


PROJECT AREA
(2 of 2)
Water Body: Unnamed Tributary to Little Patuxent River
Use Class IV-P
Existing Use Class (if applicable) Not Applicable
MD 8-digit Basin Code 02131105
MD 8-digit Basin Name Little Patuxent River
8-digit Hydrologic Unit Code 02060006
12-digit Hydrologic Unit Code 020600060102
Zoom to
Albeth Heights
Turf Valley Resort
Marriottsville Rd
Baltimore-National-Pike
Resort Rd
Turf Valley Golf Rd
Douglas Ave
Fairmont Ln
Timber Line Ln
Allwood Ln
Warwick Way
Enfield Dr
Harrow Dr
Hillingdon Rd
Bexley Dr
Folkestone Wa
Sussex Way
Ganton Grn
Albeth Rd
Lago Rd
Gary Dr
Willow Ridge Ln
Princess Ln
Castle Ln
Gentle Rolling Dr
551 ft.
70
40
0.2mi


PROJECT AREA
(2 of 2)
Water Body: Little Patuxent River
Use Class IV-P
Existing Use Class (if applicable) Not Applicable
MD 8-digit Basin Code 02131105
MD 8-digit Basin Name Little Patuxent River
8-digit Hydrologic Unit Code 02060006
12-digit Hydrologic Unit Code 020600060102
Zoom to
Waverly Woods Golf Club
Sophia Chase Dr
Barnsley Way
551 ft.
Gentle Rolling Dr
Marriottsville Rd
Hounslow Dr
Bexley Dr
Albeth Rd
Albeth Heights
Wheeler Dr
W Winchester Ln
E Winchester Ln
Norwich Ln
Kings Gift Dr
Princess Ln
Chancellor Ln
Castle Ln
Resort Rd
Turf Valley Resort
Turf Valley Golf Rd
Timber Line
70
40
0 0.1 0.2mi

XI. APPENDIX D – ESD Computations

			Page 1 of 2
		Date:	5/26/2017
		Project:	Marriottsville
		By:	MSK
POI :	POI 1	Chk:	MTS
County :	Howard	USER INPUT CELLS	

SWM REQUIREMENTS PER POI

CLASSIFICATION OF POI

Design Criteria Classification	Percentage Existing Impervious within Site Area
New Development	< 40%
Redevelopment	> 40% with no net increase in impervious area
Redevelopment - Combination	> 40% with a net increase in impervious area

Per POI: New Development, Redevelopment, Redevelopment - Combination

Total Site Area (Proposed DA within LOD)	Existing Conditions Impervious Area within the Site Area (Proposed Drainage Area within the LOD)	DA - LOW (ac)	Imp. Area-LOW (ac)
A, (ac)	Ex Imp, (ac)	9.39	5.05
1.630	0.050	**Existing % Impervious:**	**53.8%**
	Proposed Conditions Impervious Area within the Site Area (Proposed Drainage Area within the LOD)		
	Pr Imp, (ac)		
	0.820	**Proposed % Impervious:**	**50.3%**
	Net Change in Impervious Area between Existing and Proposed Conditions within the Site Area		
	Net Imp Δ (ac)		
	0.770		
POI Classification:	**REDEVELOPMENT - COMBINATION**		

HYDROLOGY FOR SITE AREA (PROPOSED DRAINAGE AREA WITHIN THE LOD)

	HSG A	HSG B	HSG C	HSG D
Pr Area within LOD (ac)	0.00	0.00	0.00	1.63
% Total Area	0%	0%	0%	100%

Data from the existing and proposed TR-55 analyses for the site area.

Development Status	RCN	t_c (hr)
Existing Conditions		
Proposed Conditions		

HYDROLOGY FOR ENTIRE DRAINAGE AREA TO THE POI

Data from the existing and proposed TR-55 analyses for the entire drainage area.

Development Status	Drainage Area (ac)	RCN	t_c (hr)
Existing Conditions	11.47	76	0.20
Proposed Conditions	11.47	77	0.20

RAINFALL TARGET

New Development: Target Pe				
% Proposed Impervious Area within Site Area Rounded Up to the Nearest 5%, Use in Table 5.3			=	55%
	HSG A	HSG B	HSG C	HSG D
Target Pe/HSG (in)	2.0	1.8	1.8	1.8
Weighted Pe (in)				N/A
Redevelopment: Target Pe				N/A
Redevelopment - Combination: Target Pe for Net Increase				
Net Imp Δ = 100% Imp	HSG A	HSG B	HSG C	HSG D
Target Pe/HSG (in)	2.6	2.6	2.2	2.0
Weighted Pe (in)				2.0

SWM REQUIREMENTS PER POI

ESD COMPUTATIONS

New Development , Ex Imp < 40%			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	Impervious Area Requiring Treatment 100% Pr Imp
Pe, (in)	Rv, (unitless)	ESDv, (cf)	IART, (ac)
N/A	N/A	N/A	N/A
New Development - Minimum Treatment That Must Be Provided by ESD facilities			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	
Pe, (in)	Rv, (unitless)	ESDv, (cf)	
N/A	N/A	N/A	

Redevelopment, Ex Imp > 40% and Net Imp Δ <= 0			
Rainfall Target Pe = 1" for Redev	Volumetric Runoff Coefficient 0.05 + 0.009 * (100%)	ESD Volume Pe/12 * Rv * IART	Impervious Area Requiring Treatment 50% Ex Imp+Net Imp Δ
Pe, (in)	Rv, (unitless)	ESDv, (cf)	IART, (ac)
N/A	N/A	N/A	N/A

Redevelopment - Combination, Ex Imp > 40% and Net Imp Δ > 0			
Redevelopment Portion			
Rainfall Target Pe = 1" for Redev	Volumetric Runoff Coefficient 0.05 + 0.009 * (Ex Imp %)	Redevelopment ESD Volume Pe/12*Rv*(50% Ex Imp)	Impervious Area Requiring Treatment 50% Ex Imp
Pe, (in)	Rv, (unitless)	ReDev ESDv, (cf)	ReDev IART, (ac)
1.0	0.53	48.4628	0.025
New Development Portion			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (100%)	New Development ESD Volume Pe/12 * Rv * Net Imp Δ	New Dev Impervious Area Requiring Treatment Net Imp Δ
Pe, (in)	Rv, (unitless)	New ESDv, (cf)	New IART, (ac)
2.0	0.95	5310.7	0.770
Sum of Partial Requirements:		5359.15281948882 cf	0.795 ac
New Development Portion - Minimum Treatment That Must Be Provided by ESD facilities			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	
Pe, (in)	Rv, (unitless)	ESDv, (cf)	
1.0	0.95	2655.3	

SWM REQUIREMENTS SUMMARY FOR: REDEVELOPMENT - COMBINATION			
Total ESDv Required	**Minimum ESDv for P_e = 1.0"**	**IART**	**Target P_e**
See above, (cf)	See above, (cf)	See above, (ac)	See above, (in)
5359	**2655**	**0.795**	**1 & 2**
Cp_v	**Re_v**	**Qp_2**	**Qp_{10}**
See Cpv Calcs (cf)	See Rev Calcs (cf)	See Qp Calcs (cf)	See Qp Calcs (cf)
4076	**186**	**No Qp2 Required**	**No Qp10 Required**

			Page 1 of 2
		Date:	5/17/2017
		Project:	Marriottsville
		By:	MSK
POI :	POI 2	Chk:	MTS
County :	Howard	USER INPUT CELLS	

SWM REQUIREMENTS PER POI

CLASSIFICATION OF POI

Design Criteria Classification	Percentage Existing Impervious within Site Area
New Development	< 40%
Redevelopment	> 40% with no net increase in impervious area
Redevelopment - Combination	> 40% with a net increase in impervious area

Per POI: New Development, Redevelopment, Redevelopment - Combination

Total Site Area (Proposed DA within LOD)	Existing Conditions Impervious Area within the Site Area (Proposed Drainage Area within the LOD)	DA - LOW (ac)	Imp. Area-LOW (ac)
A, (ac)	Ex Imp, (ac)	9.39	5.05
0.870	0.270	**Existing % Impervious:**	**53.8%**
	Proposed Conditions Impervious Area within the Site Area (Proposed Drainage Area within the LOD)		
	Pr Imp, (ac)		
	0.370	**Proposed % Impervious:**	**42.5%**
	Net Change in Impervious Area between Existing and Proposed Conditions within the Site Area		
	Net Imp Δ (ac)		
	0.100		
POI Classification:	**REDEVELOPMENT - COMBINATION**		

HYDROLOGY FOR SITE AREA (PROPOSED DRAINAGE AREA WITHIN THE LOD)

	HSG A	HSG B	HSG C	HSG D
Pr Area within LOD (ac)				0.87
% Total Area	0%	0%	0%	100%
Data from the existing and proposed TR-55 analyses for the site area.				
Development Status	RCN	t_c (hr)		
Existing Conditions		0.10		
Proposed Conditions		0.10		

HYDROLOGY FOR ENTIRE DRAINAGE AREA TO THE POI

Data from the existing and proposed TR-55 analyses for the entire drainage area.			
Development Status	Drainage Area (ac)	RCN	t_c (hr)
Existing Conditions	3.58	80	0.16
Proposed Conditions	3.58	80	0.16

RAINFALL TARGET

New Development: Target Pe				
% Proposed Impervious Area within Site Area Rounded Up to the Nearest 5%, Use in Table 5.3			=	45%
	HSG A	HSG B	HSG C	HSG D
Target Pe/HSG (in)	1.8	1.8	1.8	1.8
Weighted Pe (in)				N/A
Redevelopment: Target Pe				N/A
Redevelopment - Combination: Target Pe for Net Increase				
Net Imp Δ = 100% Imp	HSG A	HSG B	HSG C	HSG D
Target Pe/HSG (in)	2.6	2.6	2.2	2.0
Weighted Pe (in)				2.0

SWM REQUIREMENTS PER POI

ESD COMPUTATIONS

New Development , Ex Imp < 40%			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	Impervious Area Requiring Treatment 100% Pr Imp
Pe, (in)	Rv, (unitless)	ESDv, (cf)	IART, (ac)
N/A	N/A	N/A	N/A
New Development - Minimum Treatment That Must Be Provided by ESD facilities			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	
Pe, (in)	Rv, (unitless)	ESDv, (cf)	
N/A	N/A	N/A	

Redevelopment, Ex Imp > 40% and Net Imp Δ <= 0			
Rainfall Target Pe = 1" for Redev	Volumetric Runoff Coefficient 0.05 + 0.009 * (100%)	ESD Volume Pe/12 * Rv * IART	Impervious Area Requiring Treatment 50% Ex Imp+Net Imp Δ
Pe, (in)	Rv, (unitless)	ESDv, (cf)	IART, (ac)
N/A	N/A	N/A	N/A

Redevelopment - Combination, Ex Imp > 40% and Net Imp Δ > 0			
Redevelopment Portion			
Rainfall Target Pe = 1" for Redev	Volumetric Runoff Coefficient 0.05 + 0.009 * (Ex Imp %)	Redevelopment ESD Volume Pe/12*Rv*(50% Ex Imp)	Impervious Area Requiring Treatment 50% Ex Imp
Pe, (in)	Rv, (unitless)	ReDev ESDv, (cf)	ReDev IART, (ac)
1.0	0.53	261.6992	0.135
New Development Portion			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (100%)	New Development ESD Volume Pe/12 * Rv * Net Imp Δ	New Dev Impervious Area Requiring Treatment Net Imp Δ
Pe, (in)	Rv, (unitless)	New ESDv, (cf)	New IART, (ac)
2.0	0.95	689.7	0.100
Sum of Partial Requirements:		951.399225239616 cf	0.235 ac
New Development Portion - Minimum Treatment That Must Be Provided by ESD facilities			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	
Pe, (in)	Rv, (unitless)	ESDv, (cf)	
1.0	0.95	344.9	

SWM REQUIREMENTS SUMMARY FOR: REDEVELOPMENT - COMBINATION			
Total ESDv Required	**Minimum ESDv for P_e = 1.0"**	**IART**	**Target P_e**
See above, (cf)	See above, (cf)	See above, (ac)	See above, (in)
951	**345**	**0.235**	**1 & 2**
Cp_v	**Re_v**	**Qp_2**	**Qp_{10}**
See Cpv Calcs (cf)	See Rev Calcs (cf)	See Qp Calcs (cf)	See Qp Calcs (cf)
0	**24**	**No Qp2 Required**	**No Qp10 Required**

			Page 1 of 2
		Date:	5/26/2017
		Project:	Marriottsville
		By:	MSK
POI :	POI 3	Chk:	MTS
County :	Howard	USER INPUT CELLS	

SWM REQUIREMENTS PER POI

CLASSIFICATION OF POI

Design Criteria Classification	Percentage Existing Impervious within Site Area
New Development	< 40%
Redevelopment	> 40% with no net increase in impervious area
Redevelopment - Combination	> 40% with a net increase in impervious area

Per POI: New Development, Redevelopment, Redevelopment - Combination

Total Site Area (Proposed DA within LOD)	Existing Conditions Impervious Area within the Site Area (Proposed Drainage Area within the LOD)	DA - LOW (ac)	Imp. Area-LOW (ac)
A, (ac)	Ex Imp, (ac)	9.39	5.05
0.330	0.090	**Existing % Impervious:**	**53.8%**
	Proposed Conditions Impervious Area within the Site Area (Proposed Drainage Area within the LOD)		
	Pr Imp, (ac)		
	0.120	**Proposed % Impervious:**	**36.4%**
	Net Change in Impervious Area between Existing and Proposed Conditions within the Site Area		
	Net Imp Δ (ac)		
	0.030		
POI Classification:	**REDEVELOPMENT - COMBINATION**		

HYDROLOGY FOR SITE AREA (PROPOSED DRAINAGE AREA WITHIN THE LOD)

	HSG A	HSG B	HSG C	HSG D
Pr Area within LOD (ac)				0.33
% Total Area	0%	0%	0%	100%

Data from the existing and proposed TR-55 analyses for the site area.

Development Status	RCN	t_c (hr)
Existing Conditions		
Proposed Conditions		

HYDROLOGY FOR ENTIRE DRAINAGE AREA TO THE POI

Data from the existing and proposed TR-55 analyses for the entire drainage area.

Development Status	Drainage Area (ac)	RCN	t_c (hr)
Existing Conditions	0.59	85	0.10
Proposed Conditions	0.61	81	0.10

RAINFALL TARGET

New Development: Target Pe				
% Proposed Impervious Area within Site Area Rounded Up to the Nearest 5%, Use in Table 5.3			=	40%
	HSG A	HSG B	HSG C	HSG D
Target Pe/HSG (in)	1.8	1.8	1.8	1.6
Weighted Pe (in)				N/A
Redevelopment: Target Pe				N/A
Redevelopment - Combination: Target Pe for Net Increase				
Net Imp Δ = 100% Imp	HSG A	HSG B	HSG C	HSG D
Target Pe/HSG (in)	2.6	2.6	2.2	2.0
Weighted Pe (in)				2.0

SWM REQUIREMENTS PER POI

ESD COMPUTATIONS

New Development , Ex Imp < 40%			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	Impervious Area Requiring Treatment 100% Pr Imp
Pe, (in)	Rv, (unitless)	ESDv, (cf)	IART, (ac)
N/A	N/A	N/A	N/A
New Development - Minimum Treatment That Must Be Provided by ESD facilities			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	
Pe, (in)	Rv, (unitless)	ESDv, (cf)	
N/A	N/A	N/A	

Redevelopment, Ex Imp > 40% and Net Imp Δ <= 0			
Rainfall Target Pe = 1" for Redev	Volumetric Runoff Coefficient 0.05 + 0.009 * (100%)	ESD Volume Pe/12 * Rv * IART	Impervious Area Requiring Treatment 50% Ex Imp+Net Imp Δ
Pe, (in)	Rv, (unitless)	ESDv, (cf)	IART, (ac)
N/A	N/A	N/A	N/A

Redevelopment - Combination, Ex Imp > 40% and Net Imp Δ > 0			
Redevelopment Portion			
Rainfall Target Pe = 1" for Redev	Volumetric Runoff Coefficient 0.05 + 0.009 * (Ex Imp %)	Redevelopment ESD Volume Pe/12*Rv*(50% Ex Imp)	Impervious Area Requiring Treatment 50% Ex Imp
Pe, (in)	Rv, (unitless)	ReDev ESDv, (cf)	ReDev IART, (ac)
1.0	0.53	87.2331	0.045
New Development Portion			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (100%)	New Development ESD Volume Pe/12 * Rv * Net Imp Δ	New Dev Impervious Area Requiring Treatment Net Imp Δ
Pe, (in)	Rv, (unitless)	New ESDv, (cf)	New IART, (ac)
2.0	0.95	206.9	0.030
Sum of Partial Requirements:		294.143075079872 cf	0.075 ac
New Development Portion - Minimum Treatment That Must Be Provided by ESD facilities			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	
Pe, (in)	Rv, (unitless)	ESDv, (cf)	
1.0	0.95	103.5	

SWM REQUIREMENTS SUMMARY FOR: REDEVELOPMENT - COMBINATION			
Total ESDv Required	**Minimum ESDv for P_e = 1.0"**	**IART**	**Target P_e**
See above, (cf)	See above, (cf)	See above, (ac)	See above, (in)
294	**103**	**0.075**	**1 & 2**
Cp_v	**Re_v**	**Qp_2**	**Qp_{10}**
See Cpv Calcs (cf)	See Rev Calcs (cf)	See Qp Calcs (cf)	See Qp Calcs (cf)
0	**7**	**No Qp2 Required**	**No Qp10 Required**

			Page 1 of 2
		Date:	5/17/2017
		Project:	Marriottsville
		By:	MSK
POI :	POI 4	Chk:	MTS
County :	Howard	USER INPUT CELLS	

SWM REQUIREMENTS PER POI

CLASSIFICATION OF POI

Design Criteria Classification	Percentage Existing Impervious within Site Area
New Development	< 40%
Redevelopment	> 40% with no net increase in impervious area
Redevelopment - Combination	> 40% with a net increase in impervious area

Per POI: New Development, Redevelopment, Redevelopment - Combination

Total Site Area (Proposed DA within LOD)	Existing Conditions Impervious Area within the Site Area (Proposed Drainage Area within the LOD)	DA - LOW (ac)	Imp. Area-LOW (ac)
A, (ac)	Ex Imp, (ac)	9.39	5.05
0.690	0.350	**Existing % Impervious:**	**53.8%**
	Proposed Conditions Impervious Area within the Site Area (Proposed Drainage Area within the LOD)		
	Pr Imp, (ac)		
	0.350	**Proposed % Impervious:**	**50.7%**
	Net Change in Impervious Area between Existing and Proposed Conditions within the Site Area		
	Net Imp Δ (ac)		
	0.000		
POI Classification:	**REDEVELOPMENT**		

HYDROLOGY FOR SITE AREA (PROPOSED DRAINAGE AREA WITHIN THE LOD)

	HSG A	HSG B	HSG C	HSG D
Pr Area within LOD (ac)				0.69
% Total Area	0%	0%	0%	100%

Data from the existing and proposed TR-55 analyses for the site area.		
Development Status	RCN	t_c (hr)
Existing Conditions		
Proposed Conditions		

HYDROLOGY FOR ENTIRE DRAINAGE AREA TO THE POI

Data from the existing and proposed TR-55 analyses for the entire drainage area.			
Development Status	Drainage Area (ac)	RCN	t_c (hr)
Existing Conditions	2.86	75	0.10
Proposed Conditions	2.86	75	0.10

RAINFALL TARGET

New Development: Target Pe				
% Proposed Impervious Area within Site Area Rounded Up to the Nearest 5%, Use in Table 5.3			=	55%
	HSG A	HSG B	HSG C	HSG D
Target Pe/HSG (in)	2.0	1.8	1.8	1.8
Weighted Pe (in)				N/A
Redevelopment: Target Pe				1.0
Redevelopment - Combination: Target Pe for Net Increase				
Net Imp Δ = 100% Imp	HSG A	HSG B	HSG C	HSG D
Target Pe/HSG (in)	2.6	2.6	2.2	2.0
Weighted Pe (in)				N/A

SWM REQUIREMENTS PER POI

ESD COMPUTATIONS

New Development , Ex Imp < 40%			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	Impervious Area Requiring Treatment 100% Pr Imp
Pe, (in)	Rv, (unitless)	ESDv, (cf)	IART, (ac)
N/A	N/A	N/A	N/A
New Development - Minimum Treatment That Must Be Provided by ESD facilities			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	
Pe, (in)	Rv, (unitless)	ESDv, (cf)	
N/A	N/A	N/A	

Redevelopment, Ex Imp > 40% and Net Imp Δ <= 0			
Rainfall Target Pe = 1" for Redev	Volumetric Runoff Coefficient 0.05 + 0.009 * (100%)	ESD Volume Pe/12 * Rv * IART	Impervious Area Requiring Treatment 50% Ex Imp+Net Imp Δ
Pe, (in)	Rv, (unitless)	ESDv, (cf)	IART, (ac)
1.0	0.95	603.49	0.175

Redevelopment - Combination, Ex Imp > 40% and Net Imp Δ > 0			
Redevelopment Portion			
Rainfall Target Pe = 1" for Redev	Volumetric Runoff Coefficient 0.05 + 0.009 * (Ex Imp %)	Redevelopment ESD Volume Pe/12*Rv*(50% Ex Imp)	Impervious Area Requiring Treatment 50% Ex Imp
Pe, (in)	Rv, (unitless)	ReDev ESDv, (cf)	ReDev IART, (ac)
N/A	N/A	N/A	N/A
New Development Portion			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (100%)	New Development ESD Volume Pe/12 * Rv * Net Imp Δ	New Dev Impervious Area Requiring Treatment Net Imp Δ
Pe, (in)	Rv, (unitless)	New ESDv, (cf)	New IART, (ac)
N/A	N/A	N/A	N/A
Sum of Partial Requirements:		N/A	N/A
New Development Portion - Minimum Treatment That Must Be Provided by ESD facilities			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	
Pe, (in)	Rv, (unitless)	ESDv, (cf)	
N/A	N/A	N/A	

SWM REQUIREMENTS SUMMARY FOR: REDEVELOPMENT			
Total ESDv Required	**Minimum ESDv for P_e = 1.0"**	**IART**	**Target P_e**
See above, (cf)	See above, (cf)	See above, (ac)	See above, (in)
603	**N/A**	**0.175**	**1.0**
Cp_v	**Re_v**	**Qp_2**	**Qp_{10}**
See Cpv Calcs (cf)	See Rev Calcs (cf)	See Qp Calcs (cf)	See Qp Calcs (cf)
No Cpv Required	**No Rev Requirement**	**No Qp2 Required**	**No Qp10 Required**

			Page 1 of 2
		Date:	5/18/2017
		Project:	Marriottsville
		By:	MSK
POI :	POI 5	Chk:	MTS
County :	Howard	USER INPUT CELLS	

SWM REQUIREMENTS PER POI

CLASSIFICATION OF POI

Design Criteria Classification	Percentage Existing Impervious within Site Area
New Development	< 40%
Redevelopment	> 40% with no net increase in impervious area
Redevelopment - Combination	> 40% with a net increase in impervious area

Per POI: New Development, Redevelopment, Redevelopment - Combination

Total Site Area (Proposed DA within LOD)	Existing Conditions Impervious Area within the Site Area (Proposed Drainage Area within the LOD)	DA - LOW (ac)	Imp. Area-LOW (ac)
A, (ac)	Ex Imp, (ac)	9.39	5.05
0.200	0.010	**Existing % Impervious:**	**53.8%**
	Proposed Conditions Impervious Area within the Site Area (Proposed Drainage Area within the LOD)		
	Pr Imp, (ac)		
	0.110	**Proposed % Impervious:**	**55.0%**
	Net Change in Impervious Area between Existing and Proposed Conditions within the Site Area		
	Net Imp Δ (ac)		
	0.100		
POI Classification:	**REDEVELOPMENT - COMBINATION**		

HYDROLOGY FOR SITE AREA (PROPOSED DRAINAGE AREA WITHIN THE LOD)

	HSG A	HSG B	HSG C	HSG D
Pr Area within LOD (ac)				0.20
% Total Area	0%	0%	0%	100%

Data from the existing and proposed TR-55 analyses for the site area.

Development Status	RCN	t_c (hr)
Existing Conditions		
Proposed Conditions		

HYDROLOGY FOR ENTIRE DRAINAGE AREA TO THE POI

Data from the existing and proposed TR-55 analyses for the entire drainage area.

Development Status	Drainage Area (ac)	RCN	t_c (hr)
Existing Conditions	0.41	77	0.10
Proposed Conditions	0.40	88	0.10

RAINFALL TARGET

New Development: Target Pe				
% Proposed Impervious Area within Site Area Rounded Up to the Nearest 5%, Use in Table 5.3			=	55%
	HSG A	HSG B	HSG C	HSG D
Target Pe/HSG (in)	2.0	1.8	1.8	1.8
Weighted Pe (in)				N/A
Redevelopment: Target Pe				N/A
Redevelopment - Combination: Target Pe for Net Increase				
Net Imp Δ = 100% Imp	HSG A	HSG B	HSG C	HSG D
Target Pe/HSG (in)	2.6	2.6	2.2	2.0
Weighted Pe (in)				2.0

SWM REQUIREMENTS PER POI

ESD COMPUTATIONS

New Development , Ex Imp < 40%			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	Impervious Area Requiring Treatment 100% Pr Imp
Pe, (in)	Rv, (unitless)	ESDv, (cf)	IART, (ac)
N/A	N/A	N/A	N/A
New Development - Minimum Treatment That Must Be Provided by ESD facilities			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	
Pe, (in)	Rv, (unitless)	ESDv, (cf)	
N/A	N/A	N/A	

Redevelopment, Ex Imp > 40% and Net Imp Δ <= 0			
Rainfall Target Pe = 1" for Redev	Volumetric Runoff Coefficient 0.05 + 0.009 * (100%)	ESD Volume Pe/12 * Rv * IART	Impervious Area Requiring Treatment 50% Ex Imp+Net Imp Δ
Pe, (in)	Rv, (unitless)	ESDv, (cf)	IART, (ac)
N/A	N/A	N/A	N/A

Redevelopment - Combination, Ex Imp > 40% and Net Imp Δ > 0			
Redevelopment Portion			
Rainfall Target Pe = 1" for Redev	Volumetric Runoff Coefficient 0.05 + 0.009 * (Ex Imp %)	Redevelopment ESD Volume Pe/12*Rv*(50% Ex Imp)	Impervious Area Requiring Treatment 50% Ex Imp
Pe, (in)	Rv, (unitless)	ReDev ESDv, (cf)	ReDev IART, (ac)
1.0	0.53	9.6926	0.005
New Development Portion			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (100%)	New Development ESD Volume Pe/12 * Rv * Net Imp Δ	New Dev Impervious Area Requiring Treatment Net Imp Δ
Pe, (in)	Rv, (unitless)	New ESDv, (cf)	New IART, (ac)
2.0	0.95	689.7	0.100
Sum of Partial Requirements:		699.392563897763 cf	0.105 ac
New Development Portion - Minimum Treatment That Must Be Provided by ESD facilities			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	
Pe, (in)	Rv, (unitless)	ESDv, (cf)	
1.0	0.95	344.9	

SWM REQUIREMENTS SUMMARY FOR: REDEVELOPMENT - COMBINATION			
Total ESDv Required	**Minimum ESDv for P_e = 1.0"**	**IART**	**Target P_e**
See above, (cf)	See above, (cf)	See above, (ac)	See above, (in)
699	**345**	**0.105**	**1 & 2**
Cp_v	**Re_v**	**Qp_2**	**Qp_{10}**
See Cpv Calcs (cf)	See Rev Calcs (cf)	See Qp Calcs (cf)	See Qp Calcs (cf)
555	**24**	**676.6**	**1048.9**

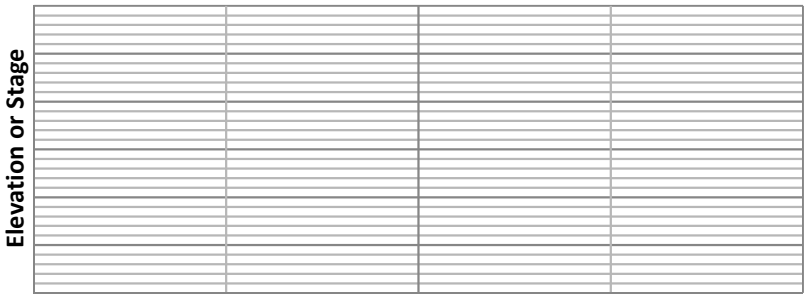
U.S. Department of Agriculture
Natural Resources Conservation Service

FL-ENG-21F
06/04

Overbank Flood Protection Requirements - TR 55 Worksheet 6B: Detention Basin Storage, Peak Outflow Discharge (qo) Known

Project: Marriottsville Location: POI 5

Circle one: Present Developed



1. Data:

Drainage area, A_m ... = 0.001 mi^2

Rainfall distribution Type (II, III, DMV) ... = II

	1st Stage	2nd Stage
2. Frequency ..... yr	2	10
3. Peak inflow discharge, qi ..... cfs (From WIN TR-55, Entire Proposed DA)	1.06	1.86
4. Peak outflow discharge, q_o [1] ..... cfs (From WIN TR-55, Entire Existing DA)	0.66	1.40
5. Compute q_o/q_i	0.62	0.75
6. V_s/V_r ..... (Use q_o/q_i with Figure 6-1 equation)	0.23	0.19
7. Runoff, Q ..... in (Use Figure 2-1 equation)	2.0	3.8
8. Runoff Volume, V_r , ac-ft ($Vr = 53.33\ QA_m$)	0.1	0.1
9. Storage Volume, V_s, ft^3 $V_s = V_r\ (V_s / V_r)$	676.58	1048.91
10. Maximum stage, E_{max} ... (From plot)		

[1] 2nd stage q_o includes 1st stage q_o.

Designed By:	MSK	Date:	5/18/2017
Checked By:	MTS	Date:	5/18/2017

Steps 6 and 7 were derived from TR-55 Appendix F, Figure 6-1 and Figure 2-1 equations, respectively.

Figure 2-1 (runoff equations):

$$Q = \frac{\left[P - 0.2\left(\frac{1000}{CN} - 10\right)\right]^2}{P + 0.8\left(\frac{1000}{CN} - 10\right)}$$

See lookup tables for P, rainfall

Figure 6-1 (approximate detention basin routing through single- and multiple-stage structures for 24-hour rainfalls of the indicated type):

$$\frac{V_s}{V_r} = C_0 + C_1\left(\frac{q_0}{q_1}\right) + C_2\left(\frac{q_0}{q_1}\right)^2 + C_3\left(\frac{q_0}{q_1}\right)^3$$

See lookup tables for C_0, C_1, C_2, & C_3

			Page 1 of 2
		Date:	5/18/2017
		Project:	Marriottsville
		By:	MSK
POI :	POI 6	Chk:	MTS
County :	Howard	USER INPUT CELLS	

SWM REQUIREMENTS PER POI

CLASSIFICATION OF POI

Design Criteria Classification	Percentage Existing Impervious within Site Area
New Development	< 40%
Redevelopment	> 40% with no net increase in impervious area
Redevelopment - Combination	> 40% with a net increase in impervious area

Per POI: New Development, Redevelopment, Redevelopment - Combination

Total Site Area (Proposed DA within LOD)	Existing Conditions Impervious Area within the Site Area (Proposed Drainage Area within the LOD)	DA - LOW (ac)	Imp. Area-LOW (ac)
A, (ac)	Ex Imp, (ac)	9.39	5.05
0.840	0.050	**Existing % Impervious:**	**53.8%**
	Proposed Conditions Impervious Area within the Site Area (Proposed Drainage Area within the LOD)		
	Pr Imp, (ac)		
	0.210	**Proposed % Impervious:**	**25.0%**
	Net Change in Impervious Area between Existing and Proposed Conditions within the Site Area		
	Net Imp Δ (ac)		
	0.160		
POI Classification:	**REDEVELOPMENT - COMBINATION**		

HYDROLOGY FOR SITE AREA (PROPOSED DRAINAGE AREA WITHIN THE LOD)

	HSG A	HSG B	HSG C	HSG D
Pr Area within LOD (ac)				0.84
% Total Area	0%	0%	0%	100%

Data from the existing and proposed TR-55 analyses for the site area.

Development Status	RCN	t_c (hr)
Existing Conditions		
Proposed Conditions		

HYDROLOGY FOR ENTIRE DRAINAGE AREA TO THE POI

Data from the existing and proposed TR-55 analyses for the entire drainage area.

Development Status	Drainage Area (ac)	RCN	t_c (hr)
Existing Conditions	2.44	86	0.10
Proposed Conditions	2.40	87	0.10

RAINFALL TARGET

New Development: Target Pe				
% Proposed Impervious Area within Site Area Rounded Up to the Nearest 5%, Use in Table 5.3			=	25%
	HSG A	HSG B	HSG C	HSG D
Target Pe/HSG (in)	1.6	1.6	1.2	1.2
Weighted Pe (in)				N/A
Redevelopment: Target Pe				N/A
Redevelopment - Combination: Target Pe for Net Increase				
Net Imp Δ = 100% Imp	HSG A	HSG B	HSG C	HSG D
Target Pe/HSG (in)	2.6	2.6	2.2	2.0
Weighted Pe (in)				2.0

SWM REQUIREMENTS PER POI

ESD COMPUTATIONS

New Development , Ex Imp < 40%			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	Impervious Area Requiring Treatment 100% Pr Imp
Pe, (in)	Rv, (unitless)	ESDv, (cf)	IART, (ac)
N/A	N/A	N/A	N/A
New Development - Minimum Treatment That Must Be Provided by ESD facilities			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	
Pe, (in)	Rv, (unitless)	ESDv, (cf)	
N/A	N/A	N/A	

Redevelopment, Ex Imp > 40% and Net Imp Δ <= 0			
Rainfall Target Pe = 1" for Redev	Volumetric Runoff Coefficient 0.05 + 0.009 * (100%)	ESD Volume Pe/12 * Rv * IART	Impervious Area Requiring Treatment 50% Ex Imp+Net Imp Δ
Pe, (in)	Rv, (unitless)	ESDv, (cf)	IART, (ac)
N/A	N/A	N/A	N/A

Redevelopment - Combination, Ex Imp > 40% and Net Imp Δ > 0			
Redevelopment Portion			
Rainfall Target Pe = 1" for Redev	Volumetric Runoff Coefficient 0.05 + 0.009 * (Ex Imp %)	Redevelopment ESD Volume Pe/12*Rv*(50% Ex Imp)	Impervious Area Requiring Treatment 50% Ex Imp
Pe, (in)	Rv, (unitless)	ReDev ESDv, (cf)	ReDev IART, (ac)
1.0	0.53	48.4628	0.025
New Development Portion			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (100%)	New Development ESD Volume Pe/12 * Rv * Net Imp Δ	New Dev Impervious Area Requiring Treatment Net Imp Δ
Pe, (in)	Rv, (unitless)	New ESDv, (cf)	New IART, (ac)
2.0	0.95	1103.5	0.160
Sum of Partial Requirements:		1151.98281948882 cf	0.185 ac
New Development Portion - Minimum Treatment That Must Be Provided by ESD facilities			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	
Pe, (in)	Rv, (unitless)	ESDv, (cf)	
1.0	0.95	551.8	

SWM REQUIREMENTS SUMMARY FOR: REDEVELOPMENT - COMBINATION			
Total ESDv Required	**Minimum ESDv for P_e = 1.0"**	**IART**	**Target P_e**
See above, (cf)	See above, (cf)	See above, (ac)	See above, (in)
1152	**552**	**0.185**	**1 & 2**
Cp_v	**Re_v**	**Qp_2**	**Qp_{10}**
See Cpv Calcs (cf)	See Rev Calcs (cf)	See Qp Calcs (cf)	See Qp Calcs (cf)
1329	**39**	**1662.7**	**2938.2**

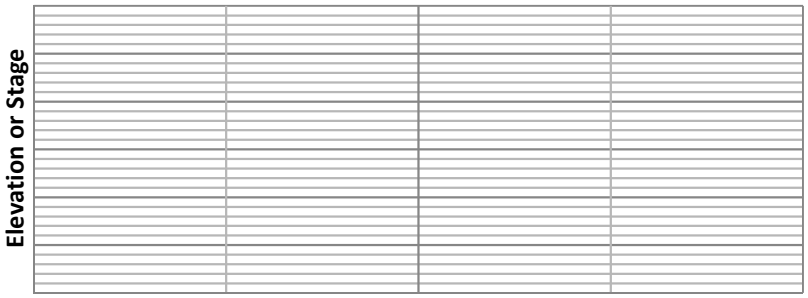
U.S. Department of Agriculture
Natural Resources Conservation Service

FL-ENG-21F
06/04

Overbank Flood Protection Requirements - TR 55 Worksheet 6B: Detention Basin Storage, Peak Outflow Discharge (qo) Known

Project: Marriottsville Location: POI 6

Circle one: Present Developed



1. Data:

Drainage area, A_m ... = 0.004 mi^2

Rainfall distribution

Type (II, III, DMV) ... = II

	1st Stage	2nd Stage
2. Frequency ..... yr	2	10
3. Peak inflow discharge, qi ..... cfs (From WIN TR-55, Entire Proposed DA)	6.08	10.82
4. Peak outflow discharge, q_o [1] ..... cfs (From WIN TR-55, Entire Existing DA)	5.95	10.74
5. Compute q_o/q_i	0.98	0.99

6. V_s/V_r .....

(Use q_o with Figure 6-1 equation)

q_i

1st Stage	2nd Stage
0.10	0.09

7. Runoff, Q ..... in (Use Figure 2-1 equation)	1.9	3.7
8. Runoff Volume, V_r , ac-ft ($Vr = 53.33\ QA_m$)	0.4	0.7
9. Storage Volume, V_s, ft^3 $V_s = V_r\ (V_s / V_r)$	1662.66	2938.19
10. Maximum stage, E_{max} ... (From plot)		

[1] 2nd stage q_o includes 1st stage q_o.

Designed By:		Date:	
Checked By:		Date:	

Steps 6 and 7 were derived from TR-55 Appendix F, Figure 6-1 and Figure 2-1 equations, respectively.

Figure 2-1 (runoff equations):

$$Q = \frac{\left[P - 0.2\left(\frac{1000}{CN} - 10\right)\right]^2}{P + 0.8\left(\frac{1000}{CN} - 10\right)}$$

See lookup tables for P, rainfall

Figure 6-1 (approximate detention basin routing through single- and multiple-stage structures for 24-hour rainfalls of the indicated type):

$$\frac{V_s}{V_r} = C_0 + C_1\left(\frac{q_0}{q_1}\right) + C_2\left(\frac{q_0}{q_1}\right)^2 + C_3\left(\frac{q_0}{q_1}\right)^3$$

See lookup tables for C_0, C_1, C_2, & C_3

			Page 1 of 2
		Date:	5/18/2017
		Project:	Marriottsville
		By:	MSK
POI :	POI 7	Chk:	MTS
County :	Howard	USER INPUT CELLS	

SWM REQUIREMENTS PER POI

CLASSIFICATION OF POI

Design Criteria Classification	Percentage Existing Impervious within Site Area
New Development	< 40%
Redevelopment	> 40% with no net increase in impervious area
Redevelopment - Combination	> 40% with a net increase in impervious area

Per POI: New Development, Redevelopment, Redevelopment - Combination

Total Site Area (Proposed DA within LOD)	Existing Conditions Impervious Area within the Site Area (Proposed Drainage Area within the LOD)	DA - LOW (ac)	Imp. Area-LOW (ac)
A, (ac)	Ex Imp, (ac)	9.39	5.05
0.100	0.010	**Existing % Impervious:**	**53.8%**
	Proposed Conditions Impervious Area within the Site Area (Proposed Drainage Area within the LOD)		
	Pr Imp, (ac)		
	0.070	**Proposed % Impervious:**	**70.0%**
	Net Change in Impervious Area between Existing and Proposed Conditions within the Site Area		
	Net Imp Δ (ac)		
	0.060		
POI Classification:	**REDEVELOPMENT - COMBINATION**		

HYDROLOGY FOR SITE AREA (PROPOSED DRAINAGE AREA WITHIN THE LOD)

	HSG A	HSG B	HSG C	HSG D
Pr Area within LOD (ac)				0.10
% Total Area	0%	0%	0%	100%

Data from the existing and proposed TR-55 analyses for the site area.		
Development Status	RCN	t_c (hr)
Existing Conditions		
Proposed Conditions		

HYDROLOGY FOR ENTIRE DRAINAGE AREA TO THE POI

Data from the existing and proposed TR-55 analyses for the entire drainage area.			
Development Status	Drainage Area (ac)	RCN	t_c (hr)
Existing Conditions	0.24	83	0.10
Proposed Conditions	0.29	90	0.10

RAINFALL TARGET

New Development: Target Pe				
% Proposed Impervious Area within Site Area Rounded Up to the Nearest 5%, Use in Table 5.3			=	70%
	HSG A	HSG B	HSG C	HSG D
Target Pe/HSG (in)	2.2	2.2	2.0	1.8
Weighted Pe (in)				N/A
Redevelopment: Target Pe				N/A
Redevelopment - Combination: Target Pe for Net Increase				
Net Imp Δ = 100% Imp	HSG A	HSG B	HSG C	HSG D
Target Pe/HSG (in)	2.6	2.6	2.2	2.0
Weighted Pe (in)				2.0

SWM REQUIREMENTS PER POI

ESD COMPUTATIONS

New Development , Ex Imp < 40%			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	Impervious Area Requiring Treatment 100% Pr Imp
Pe, (in)	Rv, (unitless)	ESDv, (cf)	IART, (ac)
N/A	N/A	N/A	N/A
New Development - Minimum Treatment That Must Be Provided by ESD facilities			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	
Pe, (in)	Rv, (unitless)	ESDv, (cf)	
N/A	N/A	N/A	

Redevelopment, Ex Imp > 40% and Net Imp Δ <= 0			
Rainfall Target Pe = 1" for Redev	Volumetric Runoff Coefficient 0.05 + 0.009 * (100%)	ESD Volume Pe/12 * Rv * IART	Impervious Area Requiring Treatment 50% Ex Imp+Net Imp Δ
Pe, (in)	Rv, (unitless)	ESDv, (cf)	IART, (ac)
N/A	N/A	N/A	N/A

Redevelopment - Combination, Ex Imp > 40% and Net Imp Δ > 0			
Redevelopment Portion			
Rainfall Target Pe = 1" for Redev	Volumetric Runoff Coefficient 0.05 + 0.009 * (Ex Imp %)	Redevelopment ESD Volume Pe/12*Rv*(50% Ex Imp)	Impervious Area Requiring Treatment 50% Ex Imp
Pe, (in)	Rv, (unitless)	ReDev ESDv, (cf)	ReDev IART, (ac)
1.0	0.53	9.6926	0.005
New Development Portion			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (100%)	New Development ESD Volume Pe/12 * Rv * Net Imp Δ	New Dev Impervious Area Requiring Treatment Net Imp Δ
Pe, (in)	Rv, (unitless)	New ESDv, (cf)	New IART, (ac)
2.0	0.95	413.8	0.060
Sum of Partial Requirements:		423.512563897764 cf	0.065 ac
New Development Portion - Minimum Treatment That Must Be Provided by ESD facilities			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	
Pe, (in)	Rv, (unitless)	ESDv, (cf)	
1.0	0.95	206.9	

SWM REQUIREMENTS SUMMARY FOR: REDEVELOPMENT - COMBINATION			
Total ESDv Required	**Minimum ESDv for P_e = 1.0"**	**IART**	**Target P_e**
See above, (cf)	See above, (cf)	See above, (ac)	See above, (in)
424	**207**	**0.065**	**1 & 2**
Cp_v	**Re_v**	**Qp_2**	**Qp_{10}**
See Cpv Calcs (cf)	See Rev Calcs (cf)	See Qp Calcs (cf)	See Qp Calcs (cf)
478	**14**	**518.5**	**850.2**

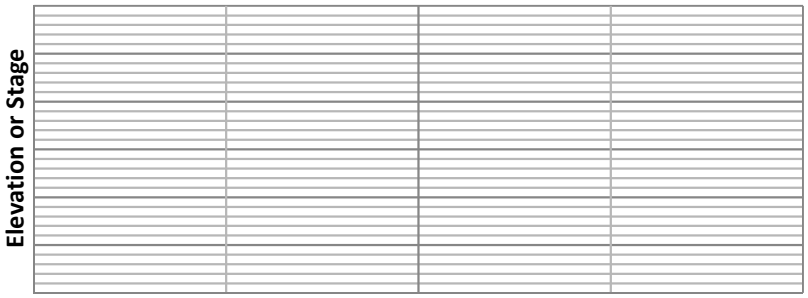
U.S. Department of Agriculture
Natural Resources Conservation Service

FL-ENG-21F
06/04

Overbank Flood Protection Requirements - TR 55 Worksheet 6B: Detention Basin Storage, Peak Outflow Discharge (qo) Known

Project: Marriottsville Location: POI 7

Circle one: Present Developed



1. Data:

Drainage area, A_m ... = 0.000 mi^2

Rainfall distribution

Type (II, III, DMV) ... = II

	1st Stage	2nd Stage
2. Frequency ..... yr	2	10
3. Peak inflow discharge, qi ..... cfs (From WIN TR-55, Entire Proposed DA)	0.81	1.38
4. Peak outflow discharge, q_o [1] ..... cfs (From WIN TR-55, Entire Existing DA)	0.52	0.99
5. Compute $\frac{q_o}{q_i}$	0.64	0.72

6. $\frac{V_s}{V_r}$ .....

(Use $\frac{q_o}{q_i}$ with Figure 6-1 equation)

7. Runoff, Q ..... in (Use Figure 2-1 equation)

8. Runoff Volume, V_r , ac-ft ($Vr = 53.33\ QA_m$)

9. Storage Volume, V_s, ft^3 $V_s = V_r\ (V_s / V_r)$

10. Maximum stage, E_{max} ... (From plot)

	1st Stage	2nd Stage
6. $\frac{V_s}{V_r}$	0.23	0.20
7. Runoff, Q ..... in	2.2	4.0
8. Runoff Volume, V_r , ac-ft	0.1	0.1
9. Storage Volume, V_s, ft^3	518.53	850.25
10. Maximum stage, E_{max} ...		

[1] 2nd stage q_o includes 1st stage q_o.

Designed By:		Date:	
Checked By:		Date:	

Steps 6 and 7 were derived from TR-55 Appendix F, Figure 6-1 and Figure 2-1 equations, respectively.

Figure 2-1 (runoff equations):

$$Q = \frac{\left[P - 0.2\left(\frac{1000}{CN} - 10\right)\right]^2}{P + 0.8\left(\frac{1000}{CN} - 10\right)}$$

See lookup tables for P, rainfall

Figure 6-1 (approximate detention basin routing through single- and multiple-stage structures for 24-hour rainfalls of the indicated type):

$$\frac{V_s}{V_r} = C_0 + C_1\left(\frac{q_0}{q_1}\right) + C_2\left(\frac{q_0}{q_1}\right)^2 + C_3\left(\frac{q_0}{q_1}\right)^3$$

See lookup tables for C_0, C_1, C_2, & C_3

			Page 1 of 2
		Date:	5/18/2017
		Project:	Marriottsville
		By:	MSK
POI :	POI 8	Chk:	MTS
County :	Howard	USER INPUT CELLS	

SWM REQUIREMENTS PER POI

CLASSIFICATION OF POI

Design Criteria Classification	Percentage Existing Impervious within Site Area
New Development	< 40%
Redevelopment	> 40% with no net increase in impervious area
Redevelopment - Combination	> 40% with a net increase in impervious area

Per POI: New Development, Redevelopment, Redevelopment - Combination

Total Site Area (Proposed DA within LOD)	Existing Conditions Impervious Area within the Site Area (Proposed Drainage Area within the LOD)	DA - ROW (ac)	Imp. Area-ROW (ac)
A, (ac)	Ex Imp, (ac)	9.39	5.05
0.170	0.030	**Existing % Impervious:**	**53.8%**
	Proposed Conditions Impervious Area within the Site Area (Proposed Drainage Area within the LOD)		
	Pr Imp, (ac)		
	0.050	**Proposed % Impervious:**	**29.4%**
	Net Change in Impervious Area between Existing and Proposed Conditions within the Site Area		
	Net Imp Δ (ac)		
	0.020		
POI Classification:	**REDEVELOPMENT - COMBINATION**		

HYDROLOGY FOR SITE AREA (PROPOSED DRAINAGE AREA WITHIN THE LOD)

	HSG A	HSG B	HSG C	HSG D
Pr Area within LOD (ac)				0.17
% Total Area	0%	0%	0%	100%

Data from the existing and proposed TR-55 analyses for the site area.

Development Status	RCN	t_c (hr)
Existing Conditions		
Proposed Conditions		

HYDROLOGY FOR ENTIRE DRAINAGE AREA TO THE POI

Data from the existing and proposed TR-55 analyses for the entire drainage area.

Development Status	Drainage Area (ac)	RCN	t_c (hr)
Existing Conditions	2.41	84	0.10
Proposed Conditions	2.36	84	0.10

RAINFALL TARGET

New Development: Target Pe				
% Proposed Impervious Area within Site Area Rounded Up to the Nearest 5%, Use in Table 5.3			=	30%
	HSG A	HSG B	HSG C	HSG D
Target Pe/HSG (in)	1.6	1.6	1.6	1.2
Weighted Pe (in)				N/A
Redevelopment: Target Pe				N/A
Redevelopment - Combination: Target Pe for Net Increase				
Net Imp Δ = 100% Imp	HSG A	HSG B	HSG C	HSG D
Target Pe/HSG (in)	2.6	2.6	2.2	2.0
Weighted Pe (in)				2.0

SWM REQUIREMENTS PER POI

ESD COMPUTATIONS

New Development , Ex Imp < 40%			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	Impervious Area Requiring Treatment 100% Pr Imp
Pe, (in)	Rv, (unitless)	ESDv, (cf)	IART, (ac)
N/A	N/A	N/A	N/A
New Development - Minimum Treatment That Must Be Provided by ESD facilities			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	
Pe, (in)	Rv, (unitless)	ESDv, (cf)	
N/A	N/A	N/A	

Redevelopment, Ex Imp > 40% and Net Imp Δ <= 0			
Rainfall Target Pe = 1" for Redev	Volumetric Runoff Coefficient 0.05 + 0.009 * (100%)	ESD Volume Pe/12 * Rv * IART	Impervious Area Requiring Treatment 50% Ex Imp+Net Imp Δ
Pe, (in)	Rv, (unitless)	ESDv, (cf)	IART, (ac)
N/A	N/A	N/A	N/A

Redevelopment - Combination, Ex Imp > 40% and Net Imp Δ > 0			
Redevelopment Portion			
Rainfall Target Pe = 1" for Redev	Volumetric Runoff Coefficient 0.05 + 0.009 * (Ex Imp %)	Redevelopment ESD Volume Pe/12*Rv*(50% Ex Imp)	Impervious Area Requiring Treatment 50% Ex Imp
Pe, (in)	Rv, (unitless)	ReDev ESDv, (cf)	ReDev IART, (ac)
1.0	0.53	29.0777	0.015
New Development Portion			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (100%)	New Development ESD Volume Pe/12 * Rv * Net Imp Δ	New Dev Impervious Area Requiring Treatment Net Imp Δ
Pe, (in)	Rv, (unitless)	New ESDv, (cf)	New IART, (ac)
2.0	0.95	137.9	0.020
Sum of Partial Requirements:		167.017691693291 cf	0.035 ac
New Development Portion - Minimum Treatment That Must Be Provided by ESD facilities			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	
Pe, (in)	Rv, (unitless)	ESDv, (cf)	
1.0	0.95	69.0	

SWM REQUIREMENTS SUMMARY FOR: REDEVELOPMENT - COMBINATION			
Total ESDv Required	**Minimum ESDv for P_e = 1.0"**	**IART**	**Target P_e**
See above, (cf)	See above, (cf)	See above, (ac)	See above, (in)
167	**69**	**0.035**	**1 & 2**
Cp_v	**Re_v**	**Qp_2**	**Qp_{10}**
See Cpv Calcs (cf)	See Rev Calcs (cf)	See Qp Calcs (cf)	See Qp Calcs (cf)
0	**5**	**No Qp2 Required**	**No Qp10 Required**

			Page 1 of 2
		Date:	5/18/2017
		Project:	Marriottsville
		By:	MSK
POI :	POI 9	Chk:	MTS
County :	Howard	USER INPUT CELLS	

SWM REQUIREMENTS PER POI

CLASSIFICATION OF POI

Design Criteria Classification	Percentage Existing Impervious within Site Area
New Development	< 40%
Redevelopment	> 40% with no net increase in impervious area
Redevelopment - Combination	> 40% with a net increase in impervious area

Per POI: New Development, Redevelopment, Redevelopment - Combination

Total Site Area (Proposed DA within LOD)	Existing Conditions Impervious Area within the Site Area (Proposed Drainage Area within the LOD)	DA - ROW (ac)	Imp. Area-ROW (ac)
A, (ac)	Ex Imp, (ac)	9.39	5.05
0.670	0.140	**Existing % Impervious:**	**53.8%**
	Proposed Conditions Impervious Area within the Site Area (Proposed Drainage Area within the LOD)		
	Pr Imp, (ac)		
	0.180	**Proposed % Impervious:**	**26.9%**
	Net Change in Impervious Area between Existing and Proposed Conditions within the Site Area		
	Net Imp Δ (ac)		
	0.040		
POI Classification:	**REDEVELOPMENT - COMBINATION**		

HYDROLOGY FOR SITE AREA (PROPOSED DRAINAGE AREA WITHIN THE LOD)

	HSG A	HSG B	HSG C	HSG D
Pr Area within LOD (ac)				0.67
% Total Area	0%	0%	0%	100%

Data from the existing and proposed TR-55 analyses for the site area.		
Development Status	RCN	t_c (hr)
Existing Conditions		
Proposed Conditions		

HYDROLOGY FOR ENTIRE DRAINAGE AREA TO THE POI

Data from the existing and proposed TR-55 analyses for the entire drainage area.			
Development Status	Drainage Area (ac)	RCN	t_c (hr)
Existing Conditions	1.68	84	0.10
Proposed Conditions	1.65	84	0.10

RAINFALL TARGET

New Development: Target Pe				
% Proposed Impervious Area within Site Area Rounded Up to the Nearest 5%, Use in Table 5.3			=	30%
	HSG A	HSG B	HSG C	HSG D
Target Pe/HSG (in)	1.6	1.6	1.6	1.2
Weighted Pe (in)				N/A
Redevelopment: Target Pe				N/A
Redevelopment - Combination: Target Pe for Net Increase				
Net Imp Δ = 100% Imp	HSG A	HSG B	HSG C	HSG D
Target Pe/HSG (in)	2.6	2.6	2.2	2.0
Weighted Pe (in)				2.0

SWM REQUIREMENTS PER POI

ESD COMPUTATIONS

New Development , Ex Imp < 40%			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	Impervious Area Requiring Treatment 100% Pr Imp
Pe, (in)	Rv, (unitless)	ESDv, (cf)	IART, (ac)
N/A	N/A	N/A	N/A
New Development - Minimum Treatment That Must Be Provided by ESD facilities			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	
Pe, (in)	Rv, (unitless)	ESDv, (cf)	
N/A	N/A	N/A	

Redevelopment, Ex Imp > 40% and Net Imp Δ <= 0			
Rainfall Target Pe = 1" for Redev	Volumetric Runoff Coefficient 0.05 + 0.009 * (100%)	ESD Volume Pe/12 * Rv * IART	Impervious Area Requiring Treatment 50% Ex Imp+Net Imp Δ
Pe, (in)	Rv, (unitless)	ESDv, (cf)	IART, (ac)
N/A	N/A	N/A	N/A

Redevelopment - Combination, Ex Imp > 40% and Net Imp Δ > 0			
Redevelopment Portion			
Rainfall Target Pe = 1" for Redev	Volumetric Runoff Coefficient 0.05 + 0.009 * (Ex Imp %)	Redevelopment ESD Volume Pe/12*Rv*(50% Ex Imp)	Impervious Area Requiring Treatment 50% Ex Imp
Pe, (in)	Rv, (unitless)	ReDev ESDv, (cf)	ReDev IART, (ac)
1.0	0.53	135.6959	0.070
New Development Portion			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (100%)	New Development ESD Volume Pe/12 * Rv * Net Imp Δ	New Dev Impervious Area Requiring Treatment Net Imp Δ
Pe, (in)	Rv, (unitless)	New ESDv, (cf)	New IART, (ac)
2.0	0.95	275.9	0.040
Sum of Partial Requirements:		411.57589456869 cf	0.11 ac
New Development Portion - Minimum Treatment That Must Be Provided by ESD facilities			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	
Pe, (in)	Rv, (unitless)	ESDv, (cf)	
1.0	0.95	137.9	

SWM REQUIREMENTS SUMMARY FOR: REDEVELOPMENT - COMBINATION			
Total ESDv Required	**Minimum ESDv for P_e = 1.0"**	**IART**	**Target P_e**
See above, (cf)	See above, (cf)	See above, (ac)	See above, (in)
412	**138**	**0.110**	**1 & 2**
Cp_v	**Re_v**	**Qp_2**	**Qp_{10}**
See Cpv Calcs (cf)	See Rev Calcs (cf)	See Qp Calcs (cf)	See Qp Calcs (cf)
0	**10**	**No Qp2 Required**	**No Qp10 Required**

			Page 1 of 2
		Date:	5/26/2017
		Project:	Marriottsville
		By:	MSK
POI :	POI 10	Chk:	MTS
County :	Howard	USER INPUT CELLS	

SWM REQUIREMENTS PER POI

CLASSIFICATION OF POI

Design Criteria Classification	Percentage Existing Impervious within Site Area
New Development	< 40%
Redevelopment	> 40% with no net increase in impervious area
Redevelopment - Combination	> 40% with a net increase in impervious area

Per POI: New Development, Redevelopment, Redevelopment - Combination

Total Site Area (Proposed DA within LOD)	Existing Conditions Impervious Area within the Site Area (Proposed Drainage Area within the LOD)	DA - LOW (ac)	Imp. Area-LOW (ac)
A, (ac)	Ex Imp, (ac)	9.39	5.05
1.610	0.410	**Existing % Impervious:**	**53.8%**
	Proposed Conditions Impervious Area within the Site Area (Proposed Drainage Area within the LOD)		
	Pr Imp, (ac)		
	0.790	**Proposed % Impervious:**	**49.1%**
	Net Change in Impervious Area between Existing and Proposed Conditions within the Site Area		
	Net Imp Δ (ac)		
	0.380		
POI Classification:	**REDEVELOPMENT - COMBINATION**		

HYDROLOGY FOR SITE AREA (PROPOSED DRAINAGE AREA WITHIN THE LOD)

	HSG A	HSG B	HSG C	HSG D
Pr Area within LOD (ac)				1.61
% Total Area	0%	0%	0%	100%

Data from the existing and proposed TR-55 analyses for the site area.

Development Status	RCN	t_c (hr)
Existing Conditions		0.10
Proposed Conditions		0.10

HYDROLOGY FOR ENTIRE DRAINAGE AREA TO THE POI

Data from the existing and proposed TR-55 analyses for the entire drainage area.

Development Status	Drainage Area (ac)	RCN	t_c (hr)
Existing Conditions	2.94	85	0.10
Proposed Conditions	3.00	81	0.10

RAINFALL TARGET

New Development: Target Pe				
% Proposed Impervious Area within Site Area Rounded Up to the Nearest 5%, Use in Table 5.3			=	50%
	HSG A	HSG B	HSG C	HSG D
Target Pe/HSG (in)	1.8	1.8	1.8	1.8
Weighted Pe (in)				N/A
Redevelopment: Target Pe				N/A
Redevelopment - Combination: Target Pe for Net Increase				
Net Imp Δ = 100% Imp	HSG A	HSG B	HSG C	HSG D
Target Pe/HSG (in)	2.6	2.6	2.2	2.0
Weighted Pe (in)				2.0

SWM REQUIREMENTS PER POI

ESD COMPUTATIONS

New Development , Ex Imp < 40%			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	Impervious Area Requiring Treatment 100% Pr Imp
Pe, (in)	Rv, (unitless)	ESDv, (cf)	IART, (ac)
N/A	N/A	N/A	N/A
New Development - Minimum Treatment That Must Be Provided by ESD facilities			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	
Pe, (in)	Rv, (unitless)	ESDv, (cf)	
N/A	N/A	N/A	

Redevelopment, Ex Imp > 40% and Net Imp Δ <= 0			
Rainfall Target Pe = 1" for Redev	Volumetric Runoff Coefficient 0.05 + 0.009 * (100%)	ESD Volume Pe/12 * Rv * IART	Impervious Area Requiring Treatment 50% Ex Imp+Net Imp Δ
Pe, (in)	Rv, (unitless)	ESDv, (cf)	IART, (ac)
N/A	N/A	N/A	N/A

Redevelopment - Combination, Ex Imp > 40% and Net Imp Δ > 0			
Redevelopment Portion			
Rainfall Target Pe = 1" for Redev	Volumetric Runoff Coefficient 0.05 + 0.009 * (Ex Imp %)	Redevelopment ESD Volume Pe/12*Rv*(50% Ex Imp)	Impervious Area Requiring Treatment 50% Ex Imp
Pe, (in)	Rv, (unitless)	ReDev ESDv, (cf)	ReDev IART, (ac)
1.0	0.53	397.3951	0.205
New Development Portion			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (100%)	New Development ESD Volume Pe/12 * Rv * Net Imp Δ	New Dev Impervious Area Requiring Treatment Net Imp Δ
Pe, (in)	Rv, (unitless)	New ESDv, (cf)	New IART, (ac)
2.0	0.95	2620.9	0.380
Sum of Partial Requirements:		3018.25511980831 cf	0.585 ac
New Development Portion - Minimum Treatment That Must Be Provided by ESD facilities			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	
Pe, (in)	Rv, (unitless)	ESDv, (cf)	
1.0	0.95	1310.4	

SWM REQUIREMENTS SUMMARY FOR: REDEVELOPMENT - COMBINATION			
Total ESDv Required	**Minimum ESDv for P_e = 1.0"**	**IART**	**Target P_e**
See above, (cf)	See above, (cf)	See above, (ac)	See above, (in)
3018	**1310**	**0.585**	**1 & 2**
Cp_v	**Re_v**	**Qp_2**	**Qp_{10}**
See Cpv Calcs (cf)	See Rev Calcs (cf)	See Qp Calcs (cf)	See Qp Calcs (cf)
0	**92**	**No Qp2 Required**	**No Qp10 Required**

			Page 1 of 2
		Date:	5/18/2017
		Project:	Marriottsville
		By:	MSK
POI :	LOI 11	Chk:	MTS
County :	Howard	USER INPUT CELLS	

SWM REQUIREMENTS PER POI

CLASSIFICATION OF POI

Design Criteria Classification	Percentage Existing Impervious within Site Area
New Development	< 40%
Redevelopment	> 40% with no net increase in impervious area
Redevelopment - Combination	> 40% with a net increase in impervious area

Per POI: New Development, Redevelopment, Redevelopment - Combination

Total Site Area (Proposed DA within LOD)	Existing Conditions Impervious Area within the Site Area (Proposed Drainage Area within the LOD)	DA - LOW (ac)	Imp. Area-LOW (ac)
A, (ac)	Ex Imp, (ac)	9.39	5.05
0.090	0.000	**Existing % Impervious:**	**53.8%**
	Proposed Conditions Impervious Area within the Site Area (Proposed Drainage Area within the LOD)		
	Pr Imp, (ac)		
	0.000	**Proposed % Impervious:**	**0.0%**
	Net Change in Impervious Area between Existing and Proposed Conditions within the Site Area		
	Net Imp Δ (ac)		
	0.000		
POI Classification:	**REDEVELOPMENT**		

HYDROLOGY FOR SITE AREA (PROPOSED DRAINAGE AREA WITHIN THE LOD)

	HSG A	HSG B	HSG C	HSG D
Pr Area within LOD (ac)				0.09
% Total Area	0%	0%	0%	100%

Data from the existing and proposed TR-55 analyses for the site area.		
Development Status	RCN	t_c (hr)
Existing Conditions		
Proposed Conditions		

HYDROLOGY FOR ENTIRE DRAINAGE AREA TO THE POI

Data from the existing and proposed TR-55 analyses for the entire drainage area.			
Development Status	Drainage Area (ac)	RCN	t_c (hr)
Existing Conditions	0.24	86	0.10
Proposed Conditions	0.24	86	0.10

RAINFALL TARGET

New Development: Target Pe				
% Proposed Impervious Area within Site Area Rounded Up to the Nearest 5%, Use in Table 5.3			=	0%
	HSG A	HSG B	HSG C	HSG D
Target Pe/HSG (in)	1.0	1.0	1.0	1.0
Weighted Pe (in)				N/A
Redevelopment: Target Pe				1.0
Redevelopment - Combination: Target Pe for Net Increase				
Net Imp Δ = 100% Imp	HSG A	HSG B	HSG C	HSG D
Target Pe/HSG (in)	2.6	2.6	2.2	2.0
Weighted Pe (in)				N/A

SWM REQUIREMENTS PER POI

ESD COMPUTATIONS

New Development , Ex Imp < 40%			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	Impervious Area Requiring Treatment 100% Pr Imp
Pe, (in)	Rv, (unitless)	ESDv, (cf)	IART, (ac)
N/A	N/A	N/A	N/A
New Development - Minimum Treatment That Must Be Provided by ESD facilities			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	
Pe, (in)	Rv, (unitless)	ESDv, (cf)	
N/A	N/A	N/A	

Redevelopment, Ex Imp > 40% and Net Imp Δ <= 0			
Rainfall Target Pe = 1" for Redev	Volumetric Runoff Coefficient 0.05 + 0.009 * (100%)	ESD Volume Pe/12 * Rv * IART	Impervious Area Requiring Treatment 50% Ex Imp+Net Imp Δ
Pe, (in)	Rv, (unitless)	ESDv, (cf)	IART, (ac)
1.0	0.95	0.00	0.000

Redevelopment - Combination, Ex Imp > 40% and Net Imp Δ > 0			
Redevelopment Portion			
Rainfall Target Pe = 1" for Redev	Volumetric Runoff Coefficient 0.05 + 0.009 * (Ex Imp %)	Redevelopment ESD Volume Pe/12*Rv*(50% Ex Imp)	Impervious Area Requiring Treatment 50% Ex Imp
Pe, (in)	Rv, (unitless)	ReDev ESDv, (cf)	ReDev IART, (ac)
N/A	N/A	N/A	N/A
New Development Portion			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (100%)	New Development ESD Volume Pe/12 * Rv * Net Imp Δ	New Dev Impervious Area Requiring Treatment Net Imp Δ
Pe, (in)	Rv, (unitless)	New ESDv, (cf)	New IART, (ac)
N/A	N/A	N/A	N/A
Sum of Partial Requirements:		N/A	N/A
New Development Portion - Minimum Treatment That Must Be Provided by ESD facilities			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	
Pe, (in)	Rv, (unitless)	ESDv, (cf)	
N/A	N/A	N/A	

SWM REQUIREMENTS SUMMARY FOR: REDEVELOPMENT			
Total ESDv Required	**Minimum ESDv for P_e = 1.0"**	**IART**	**Target P_e**
See above, (cf)	See above, (cf)	See above, (ac)	See above, (in)
0	**N/A**	**0.000**	**1.0**
Cp_v	**Re_v**	**Qp_2**	**Qp_{10}**
See Cpv Calcs (cf)	See Rev Calcs (cf)	See Qp Calcs (cf)	See Qp Calcs (cf)
No Cpv Required	**No Rev Requirement**	**No Qp2 Required**	**No Qp10 Required**

			Page 1 of 2
		Date:	5/18/2017
		Project:	Marriottsville
		By:	MSK
POI :	LOI 12	Chk:	MTS
County :	Howard	USER INPUT CELLS	

SWM REQUIREMENTS PER POI

CLASSIFICATION OF POI

Design Criteria Classification	Percentage Existing Impervious within Site Area
New Development	< 40%
Redevelopment	> 40% with no net increase in impervious area
Redevelopment - Combination	> 40% with a net increase in impervious area

Per POI: New Development, Redevelopment, Redevelopment - Combination

Total Site Area (Proposed DA within LOD)	Existing Conditions Impervious Area within the Site Area (Proposed Drainage Area within the LOD)	DA - LOW (ac)	Imp. Area-LOW (ac)
A, (ac)	Ex Imp, (ac)	9.39	5.05
0.140	0.050	**Existing % Impervious:**	**53.8%**
	Proposed Conditions Impervious Area within the Site Area (Proposed Drainage Area within the LOD)		
	Pr Imp, (ac)		
	0.050	**Proposed % Impervious:**	**35.7%**
	Net Change in Impervious Area between Existing and Proposed Conditions within the Site Area		
	Net Imp Δ (ac)		
	0.000		
POI Classification:	**REDEVELOPMENT**		

HYDROLOGY FOR SITE AREA (PROPOSED DRAINAGE AREA WITHIN THE LOD)

	HSG A	HSG B	HSG C	HSG D
Pr Area within LOD (ac)				0.14
% Total Area	0%	0%	0%	100%

Data from the existing and proposed TR-55 analyses for the site area.		
Development Status	RCN	t_c (hr)
Existing Conditions		
Proposed Conditions		

HYDROLOGY FOR ENTIRE DRAINAGE AREA TO THE POI

Data from the existing and proposed TR-55 analyses for the entire drainage area.			
Development Status	Drainage Area (ac)	RCN	t_c (hr)
Existing Conditions	0.56	97	0.10
Proposed Conditions	0.48	96	0.10

RAINFALL TARGET

New Development: Target Pe				
% Proposed Impervious Area within Site Area Rounded Up to the Nearest 5%, Use in Table 5.3			=	40%
	HSG A	HSG B	HSG C	HSG D
Target Pe/HSG (in)	1.8	1.8	1.8	1.6
Weighted Pe (in)				N/A
Redevelopment: Target Pe				1.0
Redevelopment - Combination: Target Pe for Net Increase				
Net Imp Δ = 100% Imp	HSG A	HSG B	HSG C	HSG D
Target Pe/HSG (in)	2.6	2.6	2.2	2.0
Weighted Pe (in)				N/A

SWM REQUIREMENTS PER POI

ESD COMPUTATIONS

New Development , Ex Imp < 40%			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	Impervious Area Requiring Treatment 100% Pr Imp
Pe, (in)	Rv, (unitless)	ESDv, (cf)	IART, (ac)
N/A	N/A	N/A	N/A
New Development - Minimum Treatment That Must Be Provided by ESD facilities			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	
Pe, (in)	Rv, (unitless)	ESDv, (cf)	
N/A	N/A	N/A	

Redevelopment, Ex Imp > 40% and Net Imp Δ <= 0			
Rainfall Target Pe = 1" for Redev	Volumetric Runoff Coefficient 0.05 + 0.009 * (100%)	ESD Volume Pe/12 * Rv * IART	Impervious Area Requiring Treatment 50% Ex Imp+Net Imp Δ
Pe, (in)	Rv, (unitless)	ESDv, (cf)	IART, (ac)
1.0	0.95	86.21	0.025

Redevelopment - Combination, Ex Imp > 40% and Net Imp Δ > 0			
Redevelopment Portion			
Rainfall Target Pe = 1" for Redev	Volumetric Runoff Coefficient 0.05 + 0.009 * (Ex Imp %)	Redevelopment ESD Volume Pe/12*Rv*(50% Ex Imp)	Impervious Area Requiring Treatment 50% Ex Imp
Pe, (in)	Rv, (unitless)	ReDev ESDv, (cf)	ReDev IART, (ac)
N/A	N/A	N/A	N/A
New Development Portion			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (100%)	New Development ESD Volume Pe/12 * Rv * Net Imp Δ	New Dev Impervious Area Requiring Treatment Net Imp Δ
Pe, (in)	Rv, (unitless)	New ESDv, (cf)	New IART, (ac)
N/A	N/A	N/A	N/A
Sum of Partial Requirements:		N/A	N/A
New Development Portion - Minimum Treatment That Must Be Provided by ESD facilities			
Rainfall Target Table 5.3	Volumetric Runoff Coefficient 0.05 + 0.009 * (Pr Imp %)	ESD Volume Pe/12 * Rv * A	
Pe, (in)	Rv, (unitless)	ESDv, (cf)	
N/A	N/A	N/A	

SWM REQUIREMENTS SUMMARY FOR: REDEVELOPMENT			
Total ESDv Required	**Minimum ESDv for P_e = 1.0"**	**IART**	**Target P_e**
See above, (cf)	See above, (cf)	See above, (ac)	See above, (in)
86	**N/A**	**0.025**	**1.0**
Cp_v	**Re_v**	**Qp_2**	**Qp_{10}**
See Cpv Calcs (cf)	See Rev Calcs (cf)	See Qp Calcs (cf)	See Qp Calcs (cf)
No Cpv Required	**No Rev Requirement**	**No Qp2 Required**	**No Qp10 Required**

Determination of Reduced RCN Quantities for POI's with SWM Facilities

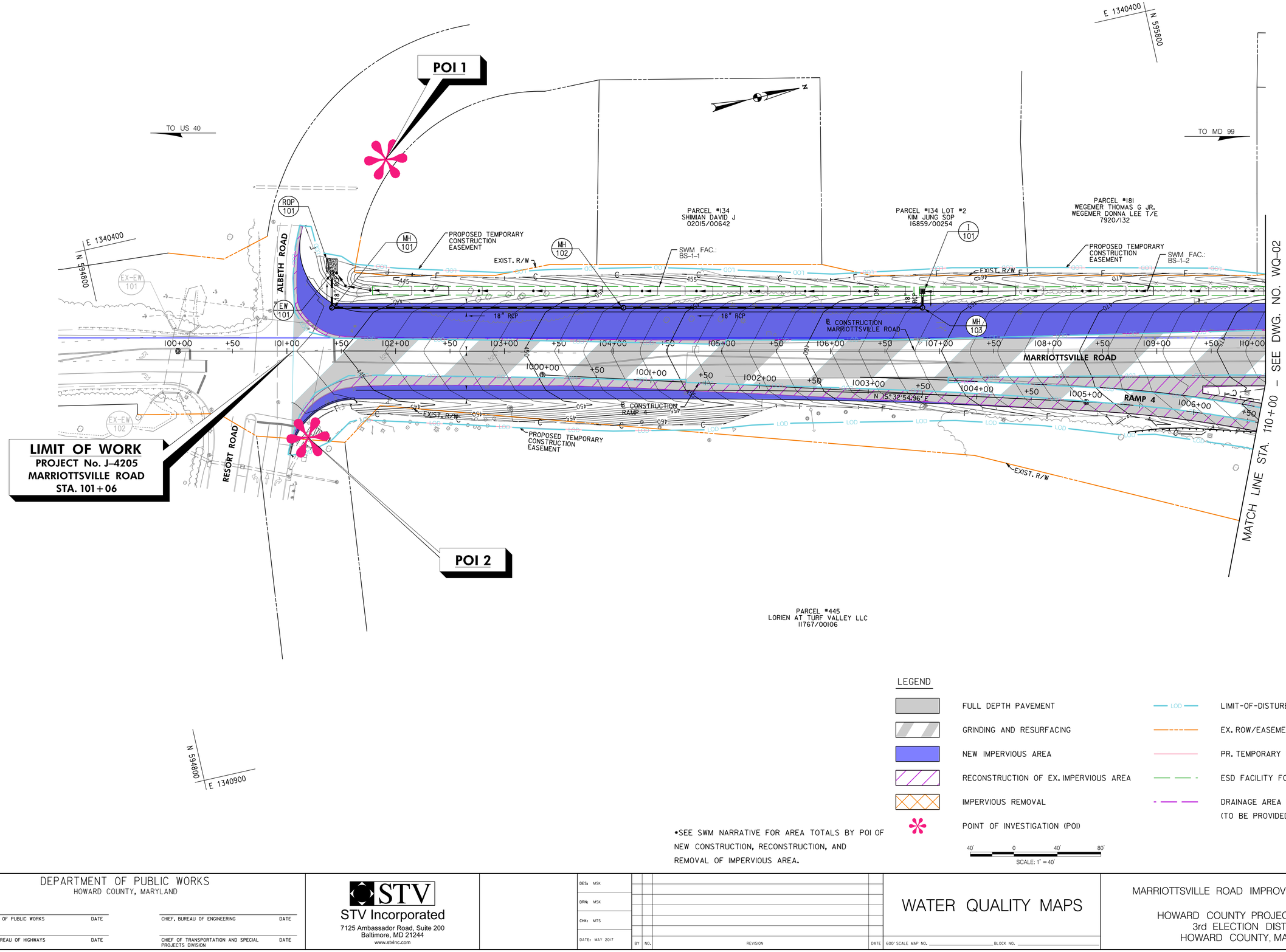
1. The following tables were used to determine reduced RCN's for the POI's that provided a Pe>1" using micro-scale facilities. The areas subject to the reduced curve numbers are only those that drain to the SWM facilities.
2. A reduced RCN was not used for POI 9 because the RCN was unchanged between existing and proposed conditions and drainage patterns remained the same resulting in no change to the peak discharges.

POI 1					
Land Use**	DA to SWM Facility (acres)	*Reduced RCN (HSG A)	*Reduced RCN (HSG B)	*Reduced RCN (HSG C)	Reduced RCN (HSG D)
Open Space	0.28	N/A	55	N/A	N/A
Open Space	0.26	N/A	N/A	N/A	77
Impervious	1.06	N/A	N/A	N/A	77
Total	1.60				
* See MDE SWM Manual for methodology of determining the Reduced RCN Numbers					
** The above listed Land Use areas were removed from the TR-55 input and inserted using their corresponding Reduced RCN in a the "User-defined" input areas.					

POI 3					
Land Use**	DA to SWM Facility (acres)	*Reduced RCN (HSG A)	*Reduced RCN (HSG B)	*Reduced RCN (HSG C)	Reduced RCN (HSG D)
Open Space	0.19	N/A	N/A	N/A	77
Impervious	0.14	N/A	N/A	N/A	77
Total	0.33				
* See MDE SWM Manual for methodology of determining the Reduced RCN Numbers					
** The above listed Land Use areas were removed from the TR-55 input and inserted using their corresponding Reduced RCN in a the "User-defined" input areas.					

POI 10					
Land Use**	DA to SWM Facility (acres)	*Reduced RCN (HSG A)	*Reduced RCN (HSG B)	*Reduced RCN (HSG C)	Reduced RCN (HSG D)
Open Space	0.44	N/A	N/A	N/A	77
Impervious	0.9	N/A	N/A	N/A	77
Total	1.34				
* See MDE SWM Manual for methodology of determining the Reduced RCN Numbers					
** The above listed Land Use areas were removed from the TR-55 input and inserted using their corresponding Reduced RCN in a the "User-defined" input areas.					

XII. APPENDIX E – Water Quality Maps



LIMIT OF WORK
PROJECT No. J-4205
MARRIOTTSVILLE ROAD
STA. 101+06

LEGEND

- FULL DEPTH PAVEMENT
- GRINDING AND RESURFACING
- NEW IMPERVIOUS AREA
- RECONSTRUCTION OF EX. IMPERVIOUS AREA
- IMPERVIOUS REMOVAL
- POINT OF INVESTIGATION (POI)
- LIMIT-OF-DISTURBANCE (LOD)
- EX. ROW/EASEMENT
- PR. TEMPORARY EASEMENT
- ESD FACILITY FOOTPRINT
- DRAINAGE AREA TO SWM FACILITY (TO BE PROVIDED WITH FUTURE SUBMITTALS)

*SEE SWM NARRATIVE FOR AREA TOTALS BY POI OF NEW CONSTRUCTION, RECONSTRUCTION, AND REMOVAL OF IMPERVIOUS AREA.

40' 0 40' 80'
SCALE: 1" = 40'

WQ-01

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HOWARD COUNTY, MARYLAND

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CHIEF, BUREAU OF HIGHWAYS — DATE
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WATER QUALITY MAPS

600' SCALE MAP NO. _____ BLOCK NO. _____

MARRIOTTSVILLE ROAD IMPROVEMENTS, PHASE III

HOWARD COUNTY PROJECT No. J-4205
3rd ELECTION DISTRICT
HOWARD COUNTY, MARYLAND

SCALE: AS SHOWN

SHEET 1 OF 4

PRELIMINARY INVESTIGATION

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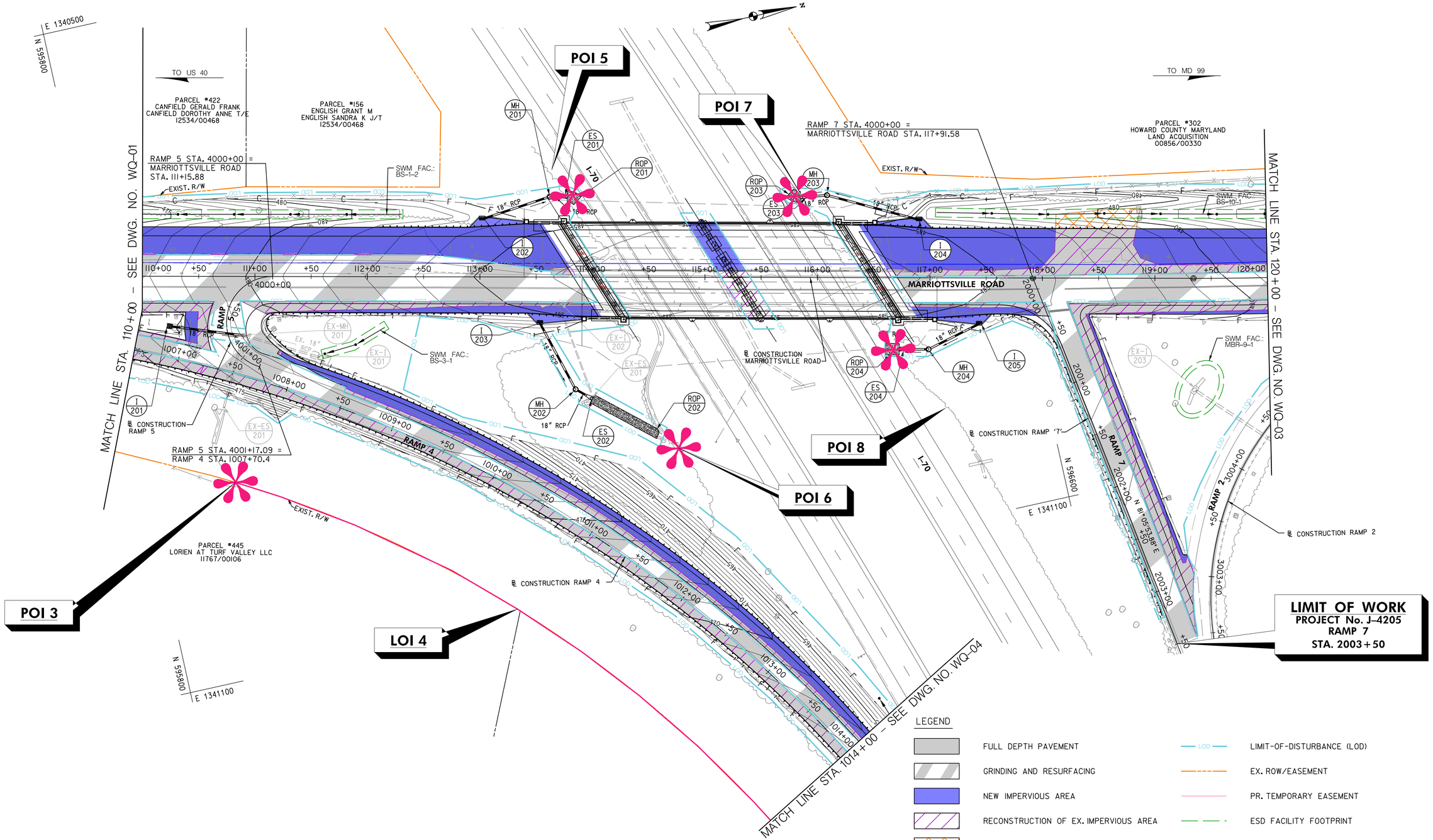

*SEE SWM NARRATIVE FOR AREA TOTALS BY POI OF NEW CONSTRUCTION, RECONSTRUCTION, AND REMOVAL OF IMPERVIOUS AREA.

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WATER QUALITY MAPS

600' SCALE MAP NO. _____ BLOCK NO. _____

MARRIOTTSVILLE ROAD IMPROVEMENTS, PHASE III

HOWARD COUNTY PROJECT No. J-4205
3rd ELECTION DISTRICT
HOWARD COUNTY, MARYLAND

WQ-02

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SHEET 2 OF 4

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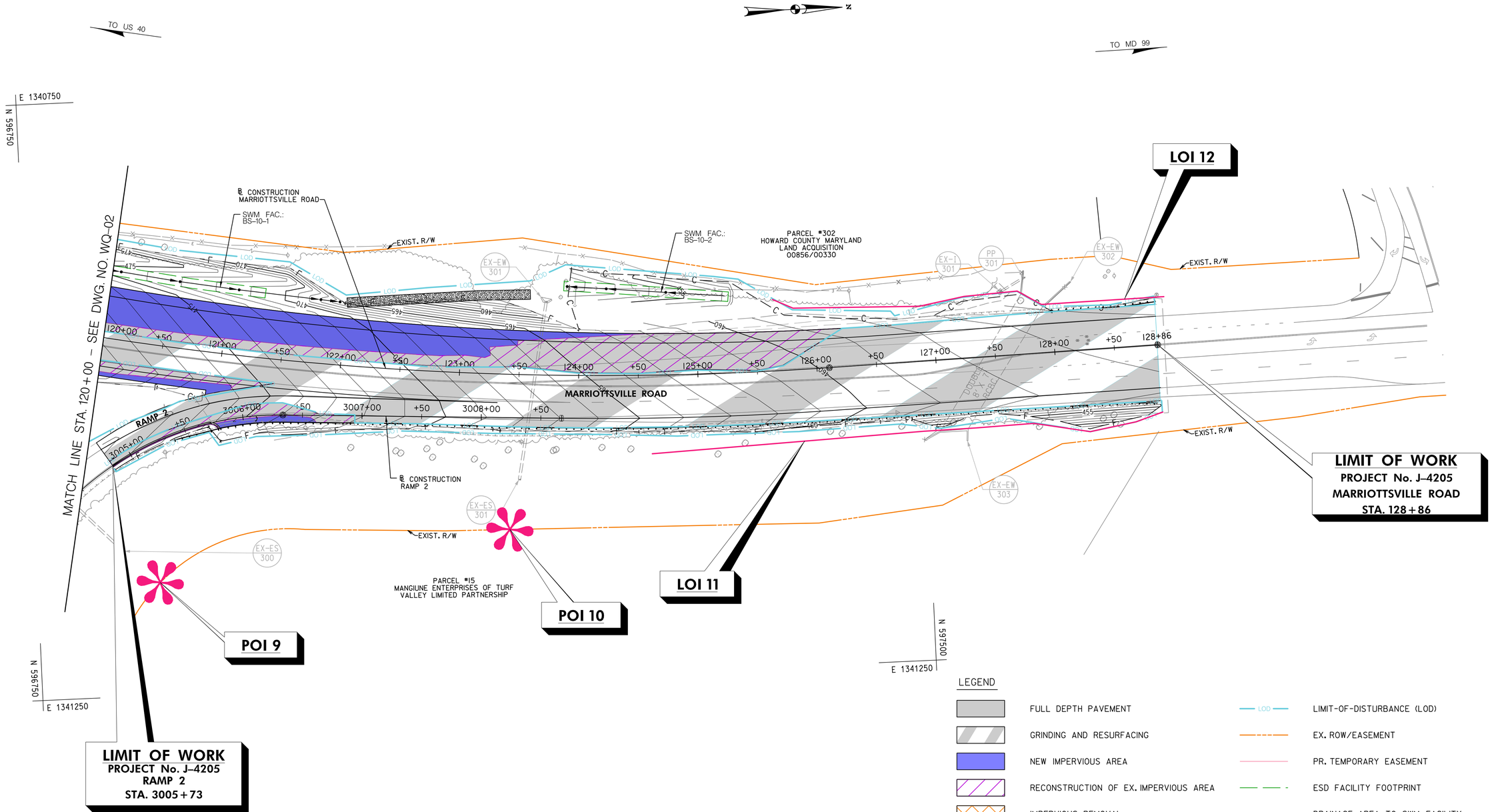

LEGEND

- FULL DEPTH PAVEMENT
- GRINDING AND RESURFACING
- NEW IMPERVIOUS AREA
- RECONSTRUCTION OF EX. IMPERVIOUS AREA
- IMPERVIOUS REMOVAL
- POINT OF INVESTIGATION (POI)
- LOD — LIMIT-OF-DISTURBANCE (LOD)
- EX. ROW/EASEMENT
- PR. TEMPORARY EASEMENT
- ESD FACILITY FOOTPRINT
- DRAINAGE AREA TO SWM FACILITY (TO BE PROVIDED WITH FUTURE SUBMITTALS)

*SEE SWM NARRATIVE FOR AREA TOTALS BY POI OF NEW CONSTRUCTION, RECONSTRUCTION, AND REMOVAL OF IMPERVIOUS AREA.

40' 0 40' 80'
SCALE: 1" = 40'

WQ-03

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600' SCALE MAP NO. _____ BLOCK NO. _____

WATER QUALITY MAPS

MARRIOTTSVILLE ROAD IMPROVEMENTS, PHASE III

HOWARD COUNTY PROJECT No. J-4205
3rd ELECTION DISTRICT
HOWARD COUNTY, MARYLAND

SCALE: AS SHOWN

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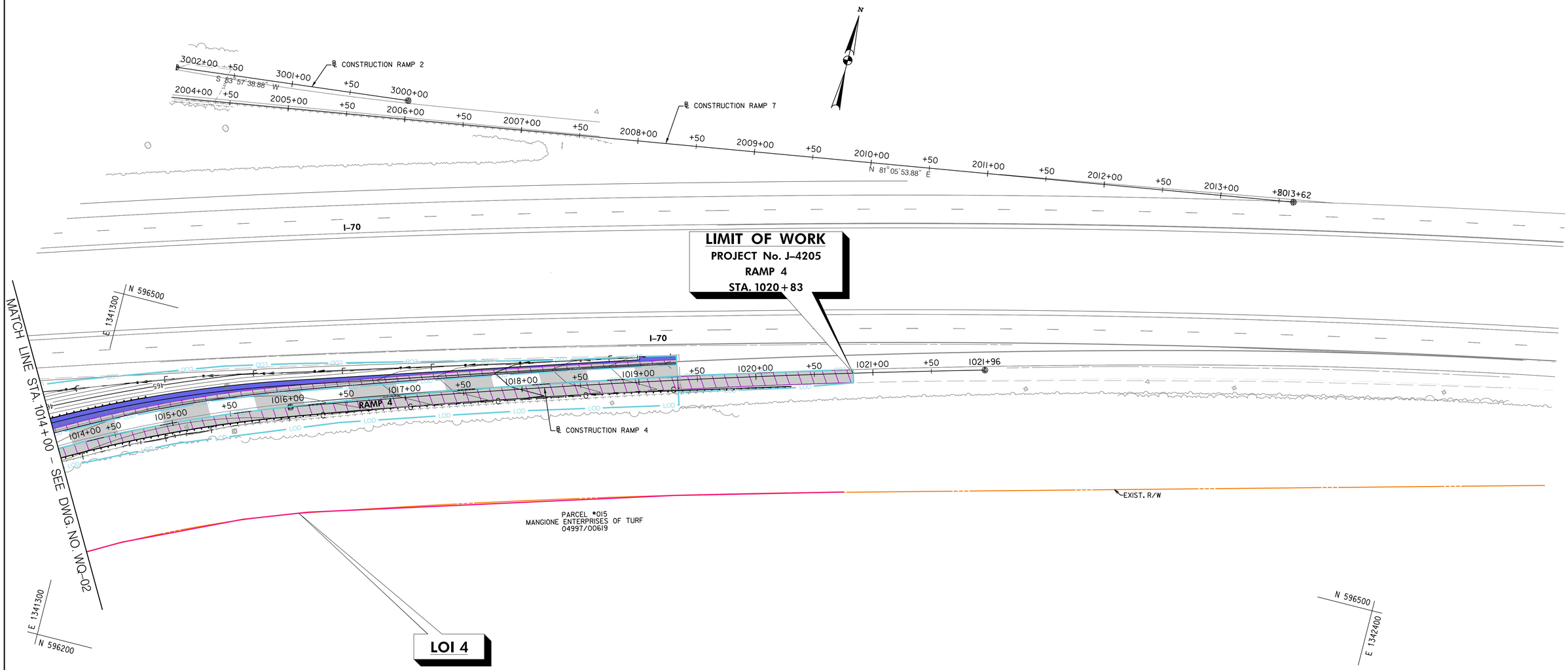

LEGEND

- FULL DEPTH PAVEMENT
- GRINDING AND RESURFACING
- NEW IMPERVIOUS AREA
- RECONSTRUCTION OF EX. IMPERVIOUS AREA
- IMPERVIOUS REMOVAL
- POINT OF INVESTIGATION (POI)
- LOD — LIMIT-OF-DISTURBANCE (LOD)
- EX. ROW/EASEMENT
- PR. TEMPORARY EASEMENT
- ESD FACILITY FOOTPRINT
- DRAINAGE AREA TO SWM FACILITY (TO BE PROVIDED WITH FUTURE SUBMITTALS)

*SEE SWM NARRATIVE FOR AREA TOTALS BY POI OF NEW CONSTRUCTION, RECONSTRUCTION, AND REMOVAL OF IMPERVIOUS AREA.

40' 0 40' 80'
SCALE: 1" = 40'

WQ-04

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600' SCALE MAP NO. _____ BLOCK NO. _____

WATER QUALITY MAPS

MARRIOTTSVILLE ROAD IMPROVEMENTS, PHASE III
HOWARD COUNTY PROJECT No. J-4205
3rd ELECTION DISTRICT
HOWARD COUNTY, MARYLAND

SCALE: AS SHOWN

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XIII. APPENDIX F – Site Resource/Existing Drainage Area Map

POI 1
DA = 11.47 AC
Q2 = 13.85 CFS
Q10 = 30.51 CFS
RCN = 76

POI 2
DA = 3.58 AC
Q2 = 5.85 CFS
Q10 = 11.80 CFS
RCN = 80

POI 3
DA = 0.59 AC
Q2 = 1.38 CFS
Q10 = 2.53 CFS
RCN = 85

POI 5
DA = 0.41 AC
Q2 = 0.66 CFS
Q10 = 1.40 CFS
RCN = 77

POI 6
DA = 2.44 AC
Q2 = 5.95 CFS
Q10 = 10.74 CFS
RCN = 86

POI 7
DA = 0.24 AC
Q2 = 0.52 CFS
Q10 = 0.99 CFS
RCN = 83

POI 8
DA = 2.42 AC
Q2 = 5.43 CFS
Q10 = 10.14 CFS
RCN = 84

POI 9
DA = 1.68 AC
Q2 = 3.78 CFS
Q10 = 7.05 CFS
RCN = 84

POI 10
DA = 2.94 AC
Q2 = 5.97 CFS
Q10 = 11.02 CFS
RCN = 85

LOI 4
DA = 2.86 AC
Q2 = 4.12 CFS
Q10 = 9.14 CFS
RCN = 75

LOI 11
DA = 0.24 AC
Q2 = 0.59 CFS
Q10 = 1.07 CFS
RCN = 86

LOI 12
DA = 0.60 AC
Q2 = 2.03 CFS
Q10 = 3.17 CFS
RCN = 97

ALBETH ROAD
RESORT ROAD
MARRIOTTSVILLE ROAD
RAMP 3
RAMP 4
RAMP 1
RAMP 2
I-70
WUS
STM
50M

LEGEND

- FULL DEPTH PAVEMENT
- OPEN SPACE
- WOODS
- 1/2 ACRE RESIDENTIAL
- COMMERCIAL
- HYDROLOGIC SOIL GROUP (HSG)
- SOIL (HSG) BOUNDARY
- Tc PATH
- POINT OF INVESTIGATION (POI)
- DRAINAGE AREA BOUNDARY
- EX. ROW/EASEMENT
- FEMA 100-YR FLOODPLAIN
- WUS — WATERS OF THE U.S. (W.U.S.)
- WETLAND BOUNDARY
- B — WETLAND BUFFER BOUNDARY
- EXIST. CONTOUR

*SEE SOIL REPORT FOR STEEP SLOPES AND SOIL ERODIBILITY INFORMATION/MAPS LOCATED IN APPENDIX B OF THE SWM/ESC REPORT

100' 0 100' 200'
SCALE: 1" = 100'

DA-E

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EXISTING SITE RESOURCES/DRAINAGE AREA MAPS

600' SCALE MAP NO. _____ BLOCK NO. _____

MARRIOTTSVILLE ROAD IMPROVEMENTS, PHASE III

HOWARD COUNTY PROJECT No. J-4205
3rd ELECTION DISTRICT
HOWARD COUNTY, MARYLAND

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XIV. APPENDIX G – Proposed Drainage Area Map

POI 1
DA = 11.47 AC
Q2 = 13.07 CFS
Q10 = 29.50 CFS
RCN = 75

POI 2
DA = 3.58 AC
Q2 = 5.85 CFS
Q10 = 11.80 CFS
RCN = 80

POI 3
DA = 0.61 AC
Q2 = 1.20 CFS
Q10 = 2.35 CFS
RCN = 81

POI 5
DA = 0.40 AC
Q2 = 1.06 CFS
Q10 = 1.86 CFS
RCN = 88

POI 6
DA = 2.40 AC
Q2 = 6.08 CFS
Q10 = 10.82 CFS
RCN = 87

POI 7
DA = 0.29 AC
Q2 = 0.81 CFS
Q10 = 1.38 CFS
RCN = 90

POI 8
DA = 2.42 AC
Q2 = 5.43 CFS
Q10 = 10.14 CFS
RCN = 84

POI 9
DA = 1.65 AC
Q2 = 3.71 CFS
Q10 = 6.92 CFS
RCN = 84

POI 10
DA = 3.00 AC
Q2 = 5.11 CFS
Q10 = 10.12 CFS
RCN = 81

LOI 4
DA = 2.86 AC
Q2 = 4.12 CFS
Q10 = 9.14 CFS
RCN = 75

LOI 11
DA = 0.24 AC
Q2 = 0.59 CFS
Q10 = 1.07 CFS
RCN = 86

LOI 12
DA = 0.60 AC
Q2 = 2.03 CFS
Q10 = 3.17 CFS
RCN = 97

MARRIOTTSVILLE ROAD
ALBETH ROAD
RESORT ROAD
I-70
RAMP 1
RAMP 2
RAMP 3
RAMP 4
BS-1-1
BS-1-2
BS-3-1
BS-10-1
BS-10-2
MBR-9-1

LEGEND

- FULL DEPTH PAVEMENT
- OPEN SPACE
- WOODS
- 1/2 ACRE RESIDENTIAL
- COMMERCIAL
- HYDROLOGIC SOIL GROUP (HSG)
- SOIL (HSG) BOUNDARY
- Tc PATH
- POINT OF INVESTIGATION (POI)
- DRAINAGE AREA BOUNDARY
- EX. ROW/EASEMENT
- DRAINAGE AREA TO SWM FACILITY
- EXIST. CONTOURS
- PROP. CONTOURS

100' 0 100' 200'
SCALE: 1" = 100'

DA-P

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HOWARD COUNTY, MARYLAND

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CHIEF, BUREAU OF HIGHWAYS DATE
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PROPOSED DRAINAGE AREA MAPS

600' SCALE MAP NO. BLOCK NO.

MARRIOTTSVILLE ROAD IMPROVEMENTS, PHASE III

HOWARD COUNTY PROJECT No. J-4205
3rd ELECTION DISTRICT
HOWARD COUNTY, MARYLAND

SCALE: AS SHOWN

SHEET 1 OF 1

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XV. APPENDIX H – Outfall Photos

STA 101+50, LT - Approximate Location of POI 1

STA 101+25, RT– Approximate location of POI 2

STA 110+75, RT– Approximate location of POI 3

STA 1012+00, RT – Approximate location of LOI 4

STA 114+25, LT– Approximate Location of POI 5

STA 114+25, RT– Approximate Location of POI 6

STA 116+25, LT– Approximate Location of POI 7

Marriottsville Road – Phase 3

STA 116+75, RT– Approximate Location of POI 8

STA 3004+25, RT– Approximate Location of POI 9

STA 123+50, RT– Approximate Location of POI 10

STA 126+50, RT– Approximate Location of LOI 11

STA 127+50, LT– Approximate Location of LOI 12

XVI. APPENDIX I – Outfall Discharge Computations

To be included in future submittals.

XVII. APPENDIX J – Storm Drain Computations

HOWARD COUNTY - INLET DRAINAGE AREA RATIONAL METHOD COMPUTATIONS (2/10-YEAR STORM)

MSK =USER ENTRY

Inlet Number	Soil Type 'C'								Soil Type 'D'								Drainage Area Totals				2-YR STORM			10-YR STORM		
	Paved Area		Woods		Commercial		Open Space (Good)		Paved Area		Woods		Commercial		Open Space (Good)		Total Area (Ac)	Composite C-Value	CA	T_c (min)	I_2 (in/hr)	I_f	Q_2 (cfs)	I_{10} (in/hr)	I_f	Q_{10} (cfs)
	Area (Ac)	C	Area (Ac)	C	Area (Ac)	C	Area (Ac)	C	Area (Ac)	C	Area (Ac)	C	Area (Ac)	C	Area (Ac)	C										
I-101	0.00	0.86	0.00	0.13	0.00	0.72	0.00	0.19	0.53	0.86	0.00	0.15	0.00	0.72	0.27	0.24	**0.80**	**0.65**	**0.52**	5.00	**5.90**	**1.00**	**3.07**	**8.50**	**1.00**	**4.43**
I-201	0.00	0.86	0.00	0.13	0.00	0.72	0.00	0.19	0.09	0.86	0.00	0.15	0.00	0.72	0.02	0.24	**0.11**	**0.75**	**0.08**	5.00	**5.90**	**1.00**	**0.48**	**8.50**	**1.00**	**0.70**
I-202	0.00	0.86	0.00	0.13	0.00	0.72	0.00	0.19	0.24	0.86	0.00	0.15	0.00	0.72	0.00	0.24	**0.24**	**0.86**	**0.21**	5.00	**5.90**	**1.00**	**1.22**	**8.50**	**1.00**	**1.75**
I-203	0.00	0.86	0.00	0.13	0.00	0.72	0.00	0.19	0.16	0.86	0.00	0.15	0.00	0.72	0.00	0.24	**0.16**	**0.86**	**0.14**	5.00	**5.90**	**1.00**	**0.81**	**8.50**	**1.00**	**1.17**
I-204	0.00	0.86	0.00	0.13	0.00	0.72	0.00	0.19	0.20	0.86	0.00	0.15	0.00	0.72	0.00	0.24	**0.20**	**0.86**	**0.17**	5.00	**5.90**	**1.00**	**1.01**	**8.50**	**1.00**	**1.46**
I-205	0.00	0.86	0.00	0.13	0.00	0.72	0.00	0.19	0.18	0.86	0.00	0.15	0.00	0.72	0.00	0.24	**0.18**	**0.86**	**0.15**	5.00	**5.90**	**1.00**	**0.91**	**8.50**	**1.00**	**1.32**
EX-I-201	0.00	0.86	0.00	0.13	0.00	0.72	0.00	0.19	0.14	0.86	0.00	0.15	0.00	0.72	0.19	0.24	**0.33**	**0.50**	**0.17**	5.00	**5.90**	**1.00**	**0.98**	**8.50**	**1.00**	**1.41**

INLET SPREAD COMPUTATIONS (2-YEAR STORM)

EQUATIONS:

$$Q = CIA$$

$$T = \left(\frac{Q * n}{0.56 (S_X)^{1.67} (S_L)^{0.5}}\right)^{0.3745}$$

$$Y = dg = T \times S_X$$

GENERAL DESIGN ASSUMPTIONS

DESIGN FREQUENCY:	**10 YR**	
MAXIMUM SPREAD (FT):	**8.00**	
MANNING'S "n" (PAVED):	**0.015**	
INLET DEPRESSION (IN):	**1.50**	**CURB OPENING ONLY**
INTESITY FACTOR (If)	**1.00**	

CRITERIA

INLETS SHALL BE PLACED OR SIZED TO PICK UP ATLEAST 85% OF TOTAL GUTTER FLOW

MINIMUM TIME OF CONCENTRATION TO BE USED IS 5.0 MINUTES.

=USER ENTRY CELL

	COMPUTATION OF RUNOFF (RATIONAL METHOD)							INLET & ROADWAY DATA						INLET EVALUTION			INLET CAPACITY & BYPASS		CHECKING	
INLET	A	Coeff. "C"	Time of Conc.	Rain Int.	Runoff	Bypass	Total Runoff	Inlet	Inlet Length	Long Grade	Cross Slope	Gutter Slope	Gutter Width	Depth "Y" (ft)	Spread	Inlet Efficiency	Intercepted	Bypass	INLET	NOTES
ID	(acre)	Per Chart	Tc (Min)	I (In/Hr)	Q (cfs)	QB (CA)	QA (cfs)	Type	L (ft)	S_L (ft/ft)	S_X (ft/ft)	S_G (ft/ft)	W (ft)	at Curb	T	Flow in (%)	Flow (cfs)	Flow QB (CA)		
I-101	0.80	0.65	5.0	5.90	4.43	0.00	3.07	DBL Type K	3.5	0.0400	0.2500	N/A	N/A	0.12	0.00	100.00%	3.07	0.00	OK	
I-201	0.11	0.75	5.0	5.90	0.70	0.00	0.48	DBL Type K	3.50	0.0400	0.2500	N/A	N/A	0.09	0.00	100.00%	0.48	0.00	OK	
I-202	0.24	0.86	5.0	5.90	1.75	0.00	1.22	Comb. Type E	3.50	0.0220	0.0200	0.1000	9.33	0.75	2.37	100.00%	1.22	0.00	OK	
I-203	0.16	0.86	5.0	5.90	1.17	0.00	0.81	Comb. Type E	3.5	0.0220	0.0200	0.1000	9.33	0.75	2.34	100.00%	0.81	0.00	OK	
I-204	0.20	0.86	5.0	5.90	1.46	0.00	1.01	Comb. Type E	3.5	0.0220	0.0200	0.1000	9.33	0.75	2.55	100.00%	1.01	0.00	OK	
I-205	0.18	0.86	5.0	5.90	1.32	0.00	0.91	Comb. Type E	3.5	0.0220	0.0200	0.1000	9.33	0.75	2.45	100.00%	0.91	0.00	OK	

HOWARD COUNTY SOIL CONSERVATION DISTRICT

STORM SEWER DESIGN - Pipe Capacity Check

DESIGNED BY: MSK CONTRACT: J-4205

CHECKED BY: MTS PROJECT: Marriottsville Road Phase 3

RAINFALL FACTOR: 1

YEAR STORM EVENT: 10

Structure		Contributing Area								Pipe Data									Remarks
							T_c	I_f											
U/S	D/S	C	A	Δ	Σ	Σ	Time	Rain			Manning's	S_o	S_f	L	V_{10}	Time in	Capacity	Normal	Comments
FROM	TO	AREA	AREA	CA	A	CA	Conc.	Intens.	Q_{10}	Size	n-value	Slope	Slope	Length	Vel.	Pipe	Full	Depth	
			(AC.)				(MIN)	(IN/HR)	(CFS)	(IN)		(%)	(%)	(FT)	(FT/SEC)	(MIN)	(CFS)	(FT)	
I-101	MH-103	0.65	0.80	0.52	0.80	0.52	5.00	8.50	4.43	18.00	0.013	1.21%	1.21%	15.07	6.10	0.04	11.55	0.64	
MH-103	MH-102	0.65	--	--	0.80	0.52	5.04	8.50	4.43	18.00	0.013	3.32%	3.34%	275.00	8.82	0.52	19.14	0.49	
MH-102	MH-101	0.65	--	--	0.80	0.52	5.56	8.50	4.43	18.00	0.013	3.02%	3.08%	268.08	8.56	0.52	18.25	0.50	
MH-101	ES-101	0.65	--	--	0.80	0.52	6.08	8.00	4.16	18.00	0.013	5.20%	5.24%	26.60	10.20	0.05	23.95	0.42	

HYDRAULIC GRADIENT COMPUTATIONS (10-YEAR STORM)

PROJECT: MARRIOTTSVILLE ROAD PHASE 3
DESIGN FREQUENCY: 10 YEAR STORM
RAINFALL DATA: HOWARD COUNTY MANUAL
LOCATION: HOWARD COUNTY

DESIGN ENGINEER: MSK
DATE: 5/26/2017

10-YEAR HGL COMPUTATIONS

STRUCTURE		HYDROLOGY				PIPE DATA									HYDRAULIC GRADIENT						
From D/S Structure	To U/S Structure	Tc to U/S Structure (min)	RAINFALL INTENSITY FACTOR "I" (25-Yr)	ΣCA	Q (25-YR) (cfs)	Size (in)	n Manning's Coeff	So Slope (ft/ft)	Q(Full) (cfs)	Sf Slope (ft/ft)	Vf Vel (ft/sec)	L Length (ft)	dn Normal Depth (ft)	Kb	Description of Loss	Head Loss (ft)	Invert Elev (ft) U/S	Calc.HGL Elevation (ft)	Normal Depth Elevation (ft)	WSEL (ft) U/S of Str.	Top Elev (ft) U/S
ES-101						18									Assume Flowing Full		439.34	**440.84**		**440.84**	N/A
ES-101	MH-101	6.08	7.70	0.52	**4.01**	18	0.013	0.0520	**23.95**	**0.0000**	**10.08**	25	**0.41**		Pipe Flow	**0.00**	440.62	**440.84**	**441.03**	**441.03**	444.26
MH-101	MH-101										**10.08**		0.48	1.00	90° MH DEFLECT	**1.58**	440.83	**442.61**	**441.31**	**442.61**	444.26
MH-101	MH-102	5.56	7.85	0.52	**4.09**	18	0.013	0.0302	**18.25**	**0.0016**	**2.31**	264	**0.48**		Pipe Flow	**0.43**	448.80	**443.04**	**449.28**	**449.28**	452.50
MH-102	MH-102										**2.31**		0.48	0.15	0° MH DEFLECT	**0.02**	448.90	**449.30**	**449.38**	**449.38**	452.50
MH-102	MH-103	5.04	8.00	0.52	**4.16**	18	0.013	0.0332	**19.14**	**0.0016**	**2.36**	271	**0.48**		Pipe Flow	**0.44**	457.90	**449.82**	**458.38**	**458.38**	463.35
MH-103	MH-103										**2.36**		0.62	1.00	90° MH DEFLECT	**0.09**	458.00	**458.47**	**458.62**	**458.62**	463.35
MH-103	I-101	5.00	8.00	0.52	**4.16**	18	0.013	0.0121	**11.55**	**0.0016**	**2.36**	12	**0.62**		Pipe Flow	**0.02**	458.14	**458.64**	**458.76**	**458.76**	461.61
I-101	I-101										**2.36**		#N/A	1.50	Starting Inlet	**0.13**	#N/A	**458.89**	**#N/A**	**#N/A**	461.61
I-101		#N/A	#N/A	#N/A	**#N/A**	#N/A	0.013	#N/A	**#N/A**	**#N/A**	**#N/A**	#N/A	**#N/A**		Pipe Flow	**#N/A**	#N/A	**#N/A**	**#N/A**	**#N/A**	#N/A
ES-201						18									Assume Flowing Full		461.19	**462.69**		**462.69**	N/A
ES-201	MH-201	5.08	8.00	0.21	**1.65**	18	0.013	0.0097	**10.35**	**0.0003**	**0.93**	10	**0.41**		Pipe Flow	**0.01**	461.29	**462.70**	**461.70**	**462.70**	470.13
MH-201	MH-201										**0.93**		0.19	0.39	18° MH DEFLECT	**0.01**	467.78	**462.71**	**467.97**	**467.97**	470.13
MH-201	I-202	5.00	8.00	0.21	**1.65**	18	0.013	0.1932	**46.17**	**0.0003**	**0.93**	46	**0.19**		Pipe Flow	**0.02**	479.15	**467.99**	**479.34**	**479.34**	482.86
I-202	I-202										**0.93**		#N/A	1.50	90° INLET BEND	**0.03**	#N/A	**479.37**	**#N/A**	**#N/A**	482.86
I-202		#N/A	#N/A	#N/A	**#N/A**	#N/A	0.013	#N/A	**#N/A**	**#N/A**	**#N/A**	#N/A	**#N/A**		Pipe Flow	**#N/A**	#N/A	**#N/A**	**#N/A**	**#N/A**	#N/A
ES-202						18									Assume Flowing Full		459.38	**460.88**		**460.88**	N/A
ES-202	MH-202	5.09	8.00	0.14	**1.10**	18	0.013	0.0098	**10.40**	**0.0002**	**0.62**	10	**0.33**		Pipe Flow	**0.01**	459.47	**460.89**	**459.80**	**460.89**	464.67
MH-202	MH-202													0.42	20° MH DEFLECT	**0.00**	459.47	**461.96**	**459.47**	**461.96**	464.67
MH-202	I-203	5.00	8.00	0.14	**1.10**	18	0.013	0.2452	**52.01**	**0.0002**	**0.62**	52	**0.15**		Pipe Flow	**0.02**	461.96	**461.98**	**462.11**	**462.11**	464.67
I-203	I-203										**0.62**		#N/A	1.50	90° INLET BEND	**0.01**	29.43	**462.12**	**#N/A**	**#N/A**	483.92
I-203		#N/A	#N/A	#N/A	**#N/A**	#N/A	0.013	#N/A	**#N/A**	**#N/A**	**#N/A**	#N/A	**#N/A**		Pipe Flow	**#N/A**	#N/A	**#N/A**	**#N/A**	**#N/A**	#N/A
ES-203						18									Assume Flowing Full		463.01	**464.51**		**464.51**	N/A
ES-203	MH-203	5.14	7.97	0.17	**1.37**	18	0.013	0.0101	**10.56**	**0.0002**	**0.78**	11	**0.36**		Pipe Flow	**0.01**	463.23	**464.52**	**463.59**	**464.52**	474.26
MH-203	MH-203													0.39	18° MH DEFLECT	**0.00**	463.23	**471.45**	**463.23**	**471.45**	474.26
MH-203	I-204	5.00	8.00	0.17	**1.38**	18	0.013	0.1107	**34.95**	**0.0002**	**0.78**	35	**0.20**		Pipe Flow	**0.01**	471.45	**471.46**	**471.65**	**471.65**	474.26
I-204	I-204										**0.78**		#N/A	1.50	90° INLET BEND	**0.02**	19.78	**471.67**	**#N/A**	**#N/A**	483.87
I-204		#N/A	#N/A	#N/A	**#N/A**	#N/A	0.013	#N/A	**#N/A**	**#N/A**	**#N/A**	#N/A	**#N/A**		Pipe Flow	**#N/A**	#N/A	**#N/A**	**#N/A**	**#N/A**	#N/A
ES-204						18									Assume Flowing Full		466.38	**467.88**		**467.88**	N/A
ES-204	MH-204	5.10	7.97	0.15	**1.23**	18	0.013	0.0100	**10.50**	**0.0002**	**0.70**	11	**0.35**		Pipe Flow	**0.01**	466.62	**467.89**	**466.97**	**467.89**	477.20
MH-204	MH-204													0.39	18° MH DEFLECT	**0.00**	466.62	**473.32**	**466.62**	**473.32**	477.20
MH-204	I-205	5.00	8.00	0.15	**1.24**	18	0.013	0.0795	**29.62**	**0.0002**	**0.70**	30	**0.21**		Pipe Flow	**0.01**	473.32	**473.33**	**473.53**	**473.53**	477.20
I-205	I-205										**0.70**		#N/A	1.50	90° INLET BEND	**0.02**	16.76	**473.55**	**#N/A**	**#N/A**	483.41
I-205		#N/A	#N/A	#N/A	**#N/A**	#N/A	0.013	#N/A	**#N/A**	**#N/A**	**#N/A**	#N/A	**#N/A**		Pipe Flow	**#N/A**	#N/A	**#N/A**	**#N/A**	**#N/A**	#N/A

XVIII. APPENDIX K – Existing Culvert Analyses

WinTR-20 Printed Page File Beginning of Input Data List
C:\Users\kilarems\Desktop\MARRIOTSVILLE TR-20\Ex_STA100 Culvert_Marr.inp

WinTR-20: version 3.10 0 0 0
Marriottsville Road Phase 3: Existing Conditions - Ex. 14'x6' Box Culvert
Lat (dd): 39.2922 Lon (dd): -76.9862° MD Howard County"

SUB-AREA:

1	LOD	OUTLET	.00259375	74.886	0.1
1	OFF	OUTLET	.91707812	577.90	2.088

STORM ANALYSIS:

1_yr_stm	2.64	TYPE	NO_C	2	3.19
2_yr_stm	3.19	TYPE	NO_C	2	
5_yr_stm	4.10	TYPE	NO_C	2	
10_yr_stm	4.91	TYPE	NO_C	2	
25_yr_stm	6.14	TYPE	NO_C	2	
50_yr_stm	7.23	TYPE	NO_C	2	
100_yr_stm	8.47	TYPE	NO_C	2	
200_yr_stm	9.88	TYPE	NO_C	2	
500_yr_stm	12.05	TYPE	NO_C	2	

Marriottsville Road Phase 3: Existing Conditions - Ex. 14'x6' Box Culvert
Lat (dd): 39.2922 Lon (dd): -76.9862° MD Howard County"

Area or Reach Identifier	Drainage Area (sq mi)	Peak Flow by Storm 1_yr_stm (cfs)	2_yr_stm (cfs)	5_yr_stm (cfs)	10_yr_stm (cfs)	25_yr_stm (cfs)
1 LOD	0.003	1.55	2.37	3.87	5.28	7.53
1 OFF	0.917	146.03	217.57	345.86	466.82	658.63
OUTLET	0.920	146.03	217.51	345.83	466.81	659.17

Area or Reach Identifier	Drainage Area (sq mi)	Peak Flow by Storm 50_yr_stm (cfs)	100_yr_stm (cfs)	200_yr_stm (cfs)	500_yr_stm (cfs)	
1 LOD	0.003	9.57	11.91	14.61	18.73	
1 OFF	0.917	834.24	1036.07	1264.24	1624.03	
OUTLET	0.920	834.85	1036.81	1265.17	1624.80	

WinTR-20 Printed Page File Beginning of Input Data List
C:\Users\kilarems\Desktop\MARRIOTSVILLE TR-20\Pr_STA100 Culvert_Marr.inp

WinTR-20: version 3.10 0 0 0
Marriottsville Road Phase 3: Proposed Conditions - Ex. 14'x6' Box Culvert
Lat (dd): 39.2922 Lon (dd): -76.9862° MD Howard County"

SUB-AREA:

1	LOD	OUTLET	.00259375	83.361	0.1
1	OFF	OUTLET	.91707812	577.90	2.088

STORM ANALYSIS:

1_yr_stm	2.64	TYPE	NO_C	2	3.19
2_yr_stm	3.19	TYPE	NO_C	2	
5_yr_stm	4.10	TYPE	NO_C	2	
10_yr_stm	4.91	TYPE	NO_C	2	
25_yr_stm	6.14	TYPE	NO_C	2	
50_yr_stm	7.23	TYPE	NO_C	2	
100_yr_stm	8.47	TYPE	NO_C	2	
200_yr_stm	9.88	TYPE	NO_C	2	
500_yr_stm	12.05	TYPE	NO_C	2	

Marriottsville Road Phase 3: Proposed Conditions - Ex. 14'x6' Box Culvert
Lat (dd): 39.2922 Lon (dd): -76.9862° MD Howard County"

Area or Reach Identifier	Drainage Area (sq mi)	Peak Flow by Storm 1_yr_stm (cfs)	2_yr_stm (cfs)	5_yr_stm (cfs)	10_yr_stm (cfs)	25_yr_stm (cfs)
1 LOD	0.003	2.65	3.63	5.32	6.84	9.18
1 OFF	0.917	146.03	217.57	345.86	466.82	658.63
OUTLET	0.920	146.02	217.54	345.81	466.81	659.26

Area or Reach Identifier	Drainage Area (sq mi)	Peak Flow by Storm 50_yr_stm (cfs)	100_yr_stm (cfs)	200_yr_stm (cfs)	500_yr_stm (cfs)	
1 LOD	0.003	11.26	13.63	16.30	20.37	
1 OFF	0.917	834.24	1036.07	1264.24	1624.03	
OUTLET	0.920	834.88	1036.80	1265.23	1625.17	

HY-8 Culvert Analysis Report

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow
Minimum Flow: 0 cfs
Design Flow: 1036.77 cfs
Maximum Flow: 1265.08 cfs

Table 1 - Summary of Culvert Flows at Crossing: Ex 14'x6' Box Culvert

Headwater Elevatio	Total Discharge (c	Existing Condition Discharge (cfs)	Roadway Discharg (cfs)	Iterations
432.87	0.00	0.00	0.00	1
435.19	126.51	126.51	0.00	1
436.53	253.02	253.02	0.00	1
437.64	379.52	379.52	0.00	1
438.66	506.03	506.03	0.00	1
439.68	632.54	632.54	0.00	1
440.77	759.05	759.05	0.00	1
441.99	885.56	885.56	0.00	1
442.46	1012.06	931.32	80.50	5
442.53	1036.77	937.09	99.37	4
443.01	1265.08	981.03	283.80	4
442.05	891.64	891.64	0.00	Overtopping

Rating Curve Plot for Crossing: Ex 14'x6' Box Culvert

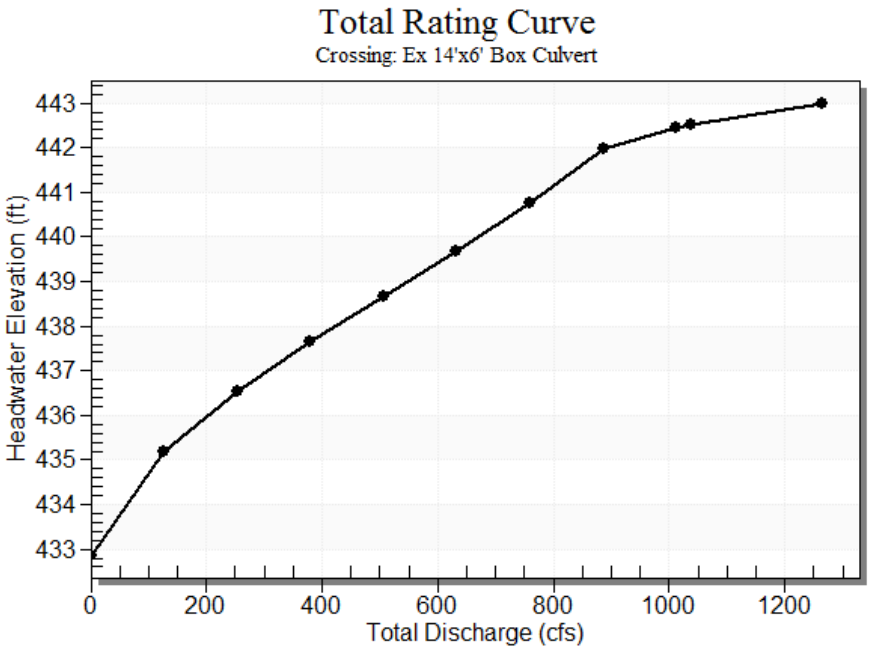


Table 2 - Culvert Summary Table: Existing Conditions

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (f	Outlet Control Depth (f	Flow Type	Normal Depth (f	Critical Depth (f	Outlet Depth (f	Tailwater Depth (f	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	432.87	0.000	0.000	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
126.51	126.51	435.19	2.316	0.791	1-S2	0.904	1.364	0.998	1.215	9.059	5.900
253.02	253.02	436.53	3.658	1.763	1-S2	1.406	2.165	1.637	1.786	11.038	7.320
379.52	379.52	437.64	4.770	2.721	1-S2	1.830	2.837	2.196	2.223	12.346	8.258
506.03	506.03	438.66	5.792	3.720	1-S2	2.213	3.436	2.709	2.590	13.345	8.976
632.54	632.54	439.68	6.814	4.786	5-S2	2.570	3.987	3.187	2.910	14.178	9.564
759.05	759.05	440.77	7.905	6.678	5-S2	2.908	4.503	3.641	3.197	14.890	10.066
885.56	885.56	441.99	9.118	7.665	5-S2	3.232	4.990	4.075	3.458	15.523	10.506
1012.06	931.32	442.46	9.594	8.047	5-S2	3.346	5.161	4.227	3.700	15.736	10.899
1036.71	937.09	442.53	9.656	8.096	5-S2	3.360	5.182	4.246	3.745	15.763	10.972
1265.08	981.03	443.01	10.137	8.477	5-S2	3.469	5.343	4.390	4.136	15.961	11.582

****

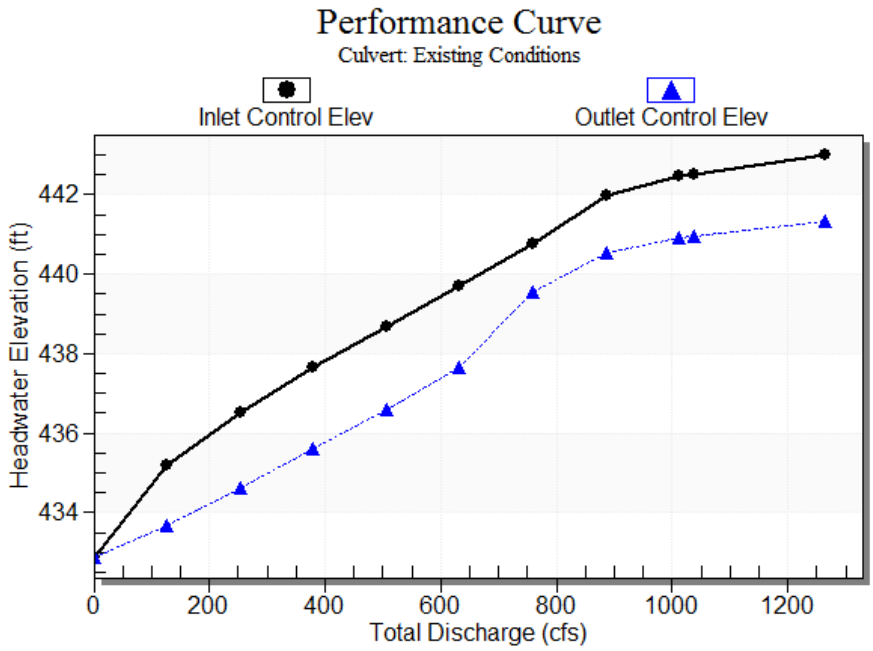
Straight Culvert

Inlet Elevation (invert): 432.87 ft, Outlet Elevation (invert): 432.24 ft

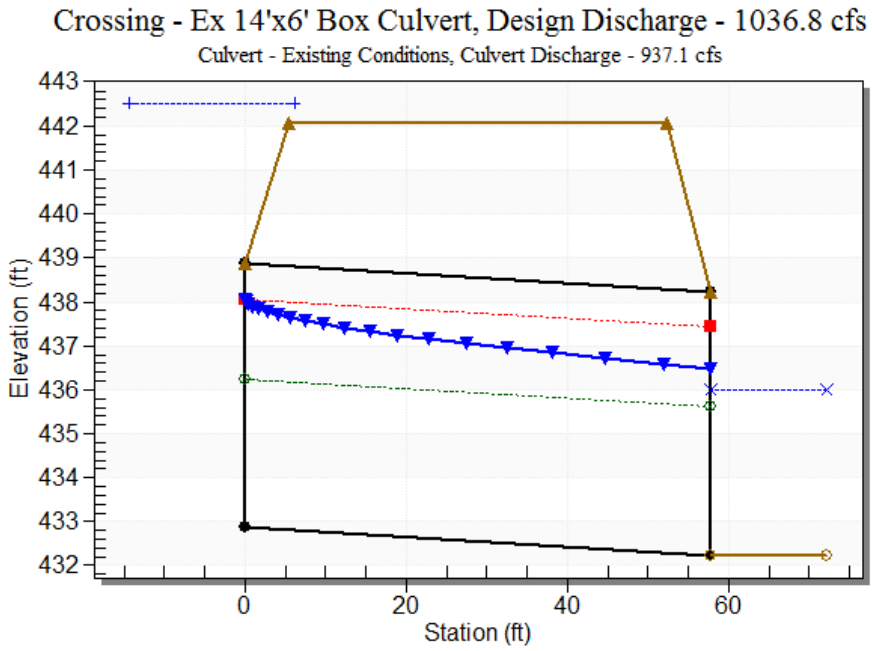
Culvert Length: 57.80 ft, Culvert Slope: 0.0109

****

Culvert Performance Curve Plot: Existing Conditions



Water Surface Profile Plot for Culvert: Existing Conditions



Site Data - Existing Conditions

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 ft
Inlet Elevation: 432.87 ft
Outlet Station: 57.80 ft
Outlet Elevation: 432.24 ft
Number of Barrels: 1

Culvert Data Summary - Existing Conditions

Barrel Shape: Concrete Box
Barrel Span: 14.00 ft
Barrel Rise: 6.00 ft
Barrel Material: Concrete
Embedment: 0.00 in
Barrel Manning's n: 0.0140
Culvert Type: Straight
Inlet Configuration: Square Edge (90º) Headwall
Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: Ex 14'x6' Box Culvert)

Flow (cfs)	Water Surfac Elev (ft)	Depth (ft)	Velocity (ft/s	Shear (psf)	Froude Number
0.00	432.24	0.00	0.00	0.00	0.00
126.51	433.46	1.22	5.90	3.03	1.04
253.02	434.03	1.79	7.32	4.46	1.09
379.52	434.46	2.22	8.26	5.55	1.12
506.03	434.83	2.59	8.98	6.46	1.14
632.54	435.15	2.91	9.56	7.26	1.16
759.05	435.44	3.20	10.07	7.98	1.18
885.56	435.70	3.46	10.51	8.63	1.19
1012.06	435.94	3.70	10.90	9.23	1.20
1036.77	435.98	3.74	10.97	9.35	1.20
1265.08	436.38	4.14	11.58	10.32	1.22

Tailwater Channel Data - Ex 14'x6' Box Culvert

Tailwater Channel Option: Trapezoidal Channel
Bottom Width: 14.00 ft
Side Slope (H:V): 3.00 (_:1)
Channel Slope: 0.0400
Channel Manning's n: 0.0500
Channel Invert Elevation: 432.24 ft

Roadway Data for Crossing: Ex 14'x6' Box Culvert

Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 100.00 ft
Crest Elevation: 442.05 ft
Roadway Surface: Paved
Roadway Top Width: 47.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow
Minimum Flow: 0 cfs
Design Flow: 1036.71 cfs
Maximum Flow: 1265.14 cfs

Table 4 - Summary of Culvert Flows at Crossing: Ex 14'x6' Box Culvert

Headwater Elevatio	Total Discharge (c	Proposed Conditio Discharge (cfs)	Roadway Dischar (cfs)	Iterations
432.87	0.00	0.00	0.00	1
435.19	126.51	126.51	0.00	1
436.53	253.03	253.03	0.00	1
437.64	379.54	379.54	0.00	1
438.66	506.06	506.06	0.00	1
439.68	632.57	632.57	0.00	1
440.78	759.08	759.08	0.00	1
441.99	885.60	885.60	0.00	1
442.46	1012.11	931.33	80.54	5
442.53	1036.71	937.08	99.32	4
443.01	1265.14	981.04	283.85	4
442.05	891.64	891.64	0.00	Overtopping

Rating Curve Plot for Crossing: Ex 14'x6' Box Culvert

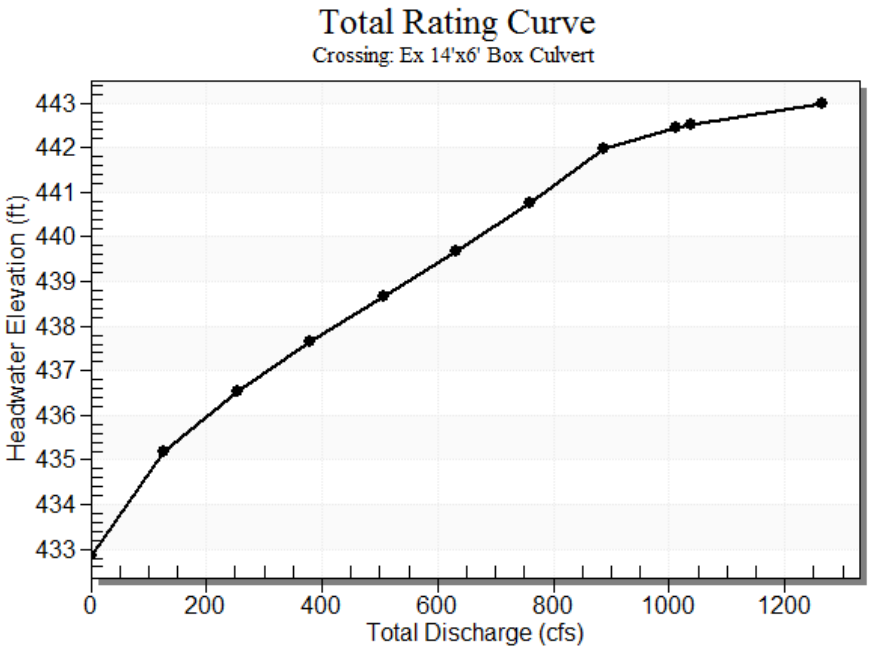


Table 5 - Culvert Summary Table: Proposed Conditions

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (f	Outlet Control Depth (f	Flow Type	Normal Depth (f	Critical Depth (f	Outlet Depth (f	Tailwater Depth (f	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	432.87	0.000	0.000	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
126.51	126.51	435.19	2.316	0.791	1-S2	0.904	1.364	0.998	1.215	9.059	5.900
253.03	253.03	436.53	3.658	1.763	1-S2	1.406	2.165	1.637	1.786	11.038	7.319
379.54	379.54	437.64	4.770	2.721	1-S2	1.830	2.837	2.196	2.223	12.346	8.258
506.06	506.06	438.66	5.792	3.721	1-S2	2.213	3.436	2.709	2.590	13.345	8.976
632.57	632.57	439.68	6.814	4.786	5-S2	2.570	3.988	3.187	2.910	14.179	9.564
759.08	759.08	440.78	7.905	6.678	5-S2	2.908	4.503	3.641	3.197	14.891	10.066
885.60	885.60	441.99	9.118	7.665	5-S2	3.232	4.990	4.075	3.458	15.523	10.506
1012.11	931.33	442.46	9.594	8.047	5-S2	3.346	5.161	4.227	3.700	15.736	10.899
1036.71	937.08	442.53	9.656	8.096	5-S2	3.360	5.182	4.246	3.745	15.762	10.971
1265.14	981.04	443.01	10.137	8.477	5-S2	3.469	5.343	4.390	4.136	15.961	11.582

****

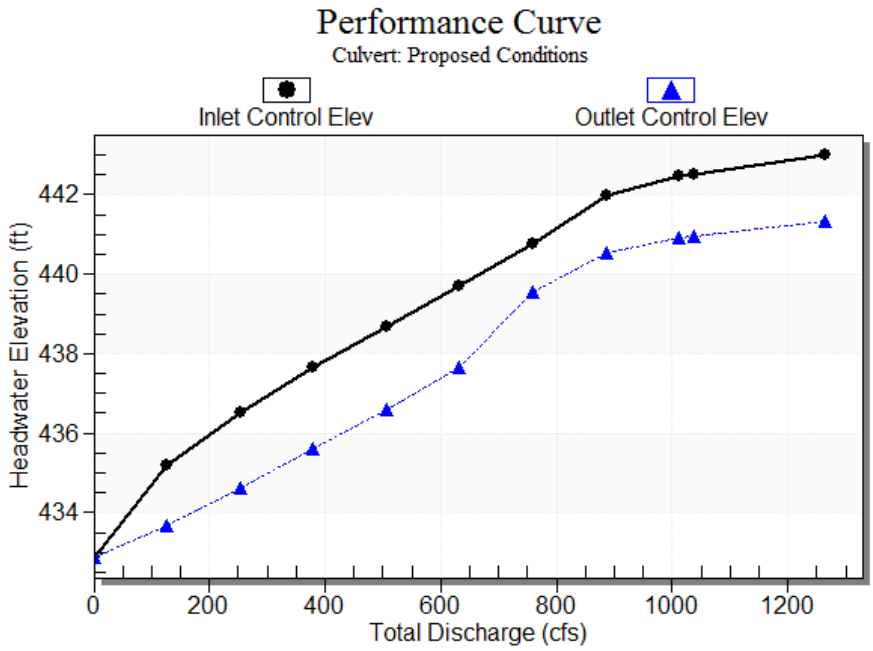
Straight Culvert

Inlet Elevation (invert): 432.87 ft, Outlet Elevation (invert): 432.24 ft

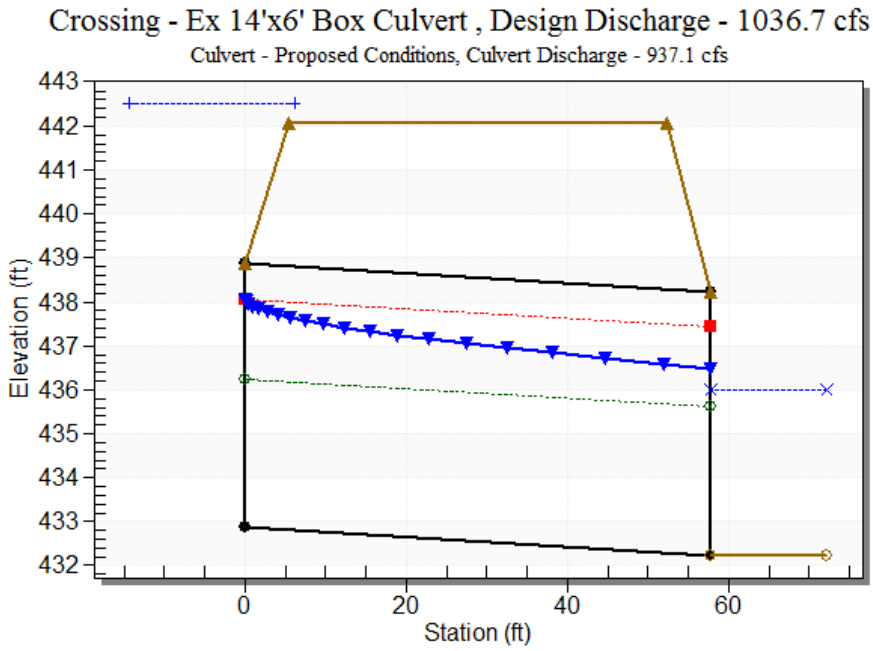
Culvert Length: 57.80 ft, Culvert Slope: 0.0109

****

Culvert Performance Curve Plot: Proposed Conditions



Water Surface Profile Plot for Culvert: Proposed Conditions



Site Data - Proposed Conditions

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 ft
Inlet Elevation: 432.87 ft
Outlet Station: 57.80 ft
Outlet Elevation: 432.24 ft
Number of Barrels: 1

Culvert Data Summary - Proposed Conditions

Barrel Shape: Concrete Box
Barrel Span: 14.00 ft
Barrel Rise: 6.00 ft
Barrel Material: Concrete
Embedment: 0.00 in
Barrel Manning's n: 0.0140
Culvert Type: Straight
Inlet Configuration: Square Edge (90º) Headwall
Inlet Depression: None

Table 6 - Downstream Channel Rating Curve (Crossing: Ex 14'x6' Box Culvert

Flow (cfs)	Water Surfac Elev (ft)	Depth (ft)	Velocity (ft/s	Shear (psf)	Froude Number
0.00	432.24	0.00	0.00	0.00	0.00
126.51	433.46	1.22	5.90	3.03	1.04
253.03	434.03	1.79	7.32	4.46	1.09
379.54	434.46	2.22	8.26	5.55	1.12
506.06	434.83	2.59	8.98	6.46	1.15
632.57	435.15	2.91	9.56	7.26	1.16
759.08	435.44	3.20	10.07	7.98	1.18
885.60	435.70	3.46	10.51	8.63	1.19
1012.11	435.94	3.70	10.90	9.23	1.20
1036.71	435.98	3.74	10.97	9.35	1.20
1265.14	436.38	4.14	11.58	10.32	1.22

Tailwater Channel Data - Ex 14'x6' Box Culvert

Tailwater Channel Option: Trapezoidal Channel
Bottom Width: 14.00 ft
Side Slope (H:V): 3.00 (_:1)
Channel Slope: 0.0400
Channel Manning's n: 0.0500
Channel Invert Elevation: 432.24 ft

Roadway Data for Crossing: Ex 14'x6' Box Culvert

Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 100.00 ft
Crest Elevation: 442.05 ft
Roadway Surface: Paved
Roadway Top Width: 47.00 ft

WinTR-20 Printed Page File Beginning of Input Data List
C:\Users\kilarems\Desktop\MARRIOTSVILLE TR-20\Ex_STA128 Culvert_Marr.inp

```
WinTR-20: version 3.10                  0         0                    0
Marriottsville Road Phase 3:  Existing Conditions - Ex. Double 8'x7' Box Culvert
Lat (dd): 39.2922 Lon (dd): -76.9862°  MD Howard County"

SUB-AREA:
          12        OUTLET              1.515625  69.517
                    SHEET     100.      0.005               I
                    SHALLOW   200.      0.013               U
                    CHANNEL   15000.    5.



STORM ANALYSIS:
          1_yr_stm                      2.64      TYPE NO_C 2         3.19
          2_yr_stm                      3.19      TYPE NO_C 2
          5_yr_stm                      4.10      TYPE NO_C 2
          10_yr_stm                     4.91      TYPE NO_C 2
          25_yr_stm                     6.14      TYPE NO_C 2
          50_yr_stm                     7.23      TYPE NO_C 2
          100_yr_stm                    8.47      TYPE NO_C 2
          200_yr_stm                    9.88      TYPE NO_C 2
          500_yr_stm                    12.05     TYPE NO_C 2
```

Marriottsville Road Phase 3: Existing Conditions - Ex. Double 8'x7' Box Culvert
Lat (dd): 39.2922 Lon (dd): -76.9862° MD Howard County"

Area or Reach Identifier	Drainage Area (sq mi)	Peak Flow by Storm 1_yr_stm (cfs)	2_yr_stm (cfs)	5_yr_stm (cfs)	10_yr_stm (cfs)	25_yr_stm (cfs)
12	1.516	126.65	216.27	395.09	577.70	875.35
OUTLET	1.516	126.65	216.27	395.09	577.70	875.35

Area or Reach Identifier	Drainage Area (sq mi)	Peak Flow by Storm 50_yr_stm (cfs)	100_yr_stm (cfs)	200_yr_stm (cfs)	500_yr_stm (cfs)	
12	1.516	1157.16	1487.48	1872.85	2474.37	
OUTLET	1.516	1157.16	1487.48	1872.85	2474.37	

HY-8 Culvert Analysis Report

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow
Minimum Flow: 0 cfs
Design Flow: 1487.48 cfs
Maximum Flow: 1872.85 cfs

Table 1 - Summary of Culvert Flows at Crossing: Ex 8'x7' Box Culvert

Headwater Elevatio	Total Discharge (c	Existing Condition Discharge (cfs)	Roadway Discharg (cfs)	Iterations
444.18	0.00	0.00	0.00	1
446.94	187.29	187.29	0.00	1
448.53	374.57	374.57	0.00	1
449.85	561.86	561.86	0.00	1
451.08	749.14	749.14	0.00	1
452.31	936.42	936.42	0.00	1
453.64	1123.71	1123.71	0.00	1
455.12	1310.99	1310.99	0.00	1
456.44	1487.48	1459.65	27.71	6
457.13	1685.57	1531.23	154.31	4
457.66	1872.85	1583.69	289.13	4
456.12	1424.51	1424.51	0.00	Overtopping

Rating Curve Plot for Crossing: Ex 8'x7' Box Culvert

Table 2 - Culvert Summary Table: Existing Conditions

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (f	Outlet Control Depth (f	Flow Type	Normal Depth (f	Critical Depth (f	Outlet Depth (f	Tailwater Depth (f	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	444.18	0.000	0.000	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
187.29	187.29	446.94	2.758	0.569	1-S2	1.188	1.620	1.240	1.393	9.440	2.482
374.57	374.57	448.53	4.352	1.757	1-S2	1.898	2.572	2.020	2.092	11.590	3.181
561.86	561.86	449.85	5.674	2.950	1-S2	2.523	3.371	2.712	2.649	12.949	3.661
749.14	749.14	451.08	6.896	4.214	1-S2	3.104	4.083	3.351	3.127	13.973	4.035
936.42	936.42	452.31	8.128	5.577	5-S2	3.658	4.738	3.953	3.552	14.804	4.346
1123.71	1123.71	453.64	9.455	7.881	5-S2	4.195	5.351	4.530	3.941	15.504	4.612
1310.99	1310.99	455.12	10.942	9.194	5-S2	4.718	5.930	5.083	4.300	16.119	4.848
1487.48	1459.65	456.44	12.265	10.339	5-S2	5.126	6.370	5.512	4.616	16.551	5.047
1685.51	1531.23	457.13	12.952	10.923	5-S2	5.321	6.576	5.715	4.951	16.746	5.250
1872.85	1583.69	457.66	13.478	11.365	5-S2	5.463	6.726	5.862	5.250	16.884	5.426

****

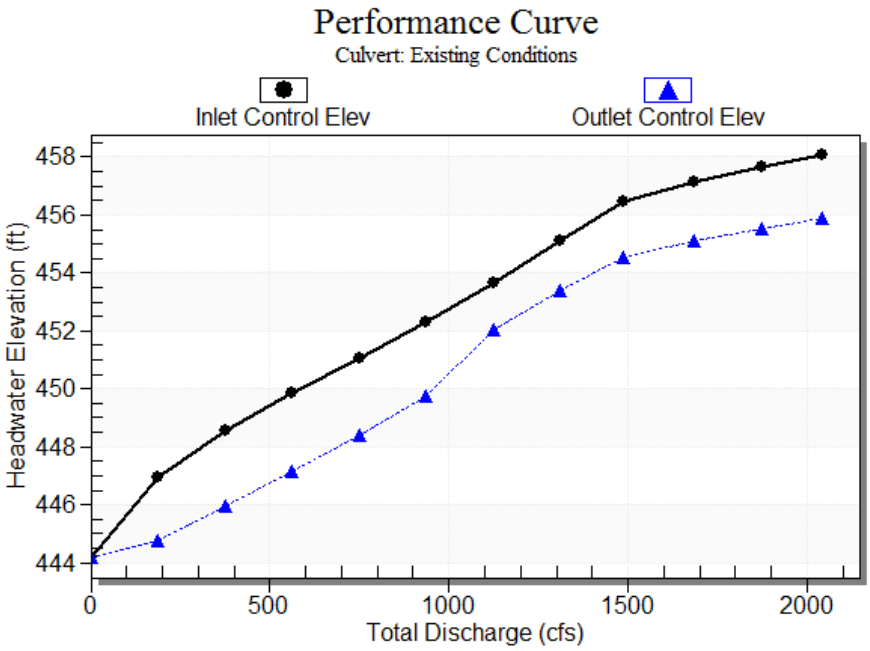
Straight Culvert

Inlet Elevation (invert): 444.18 ft, Outlet Elevation (invert): 443.05 ft

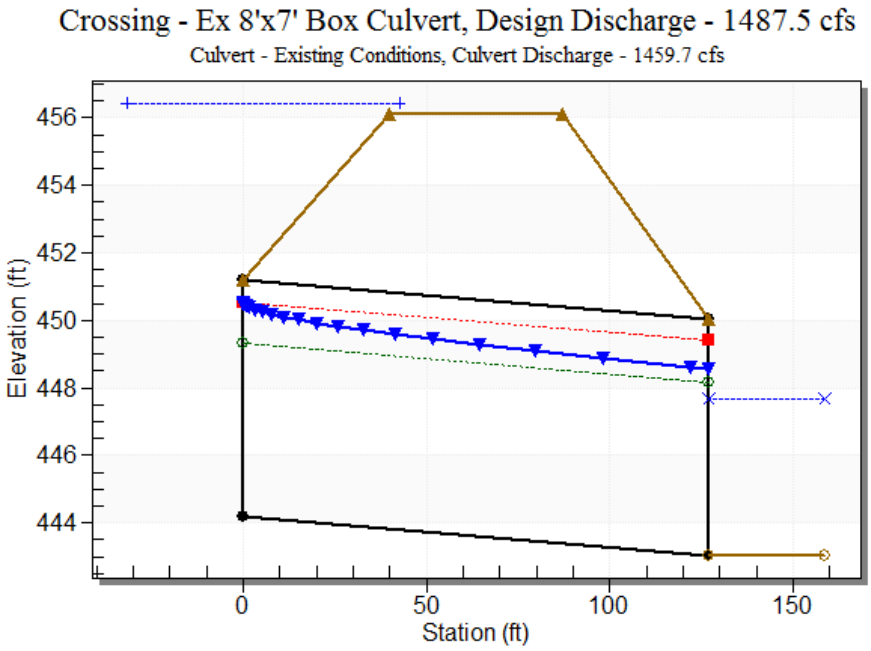
Culvert Length: 127.01 ft, Culvert Slope: 0.0089

****

Culvert Performance Curve Plot: Existing Conditions



Water Surface Profile Plot for Culvert: Existing Conditions



Site Data - Existing Conditions

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 ft
Inlet Elevation: 444.18 ft
Outlet Station: 127.00 ft
Outlet Elevation: 443.05 ft
Number of Barrels: 2

Culvert Data Summary - Existing Conditions

Barrel Shape: Concrete Box
Barrel Span: 8.00 ft
Barrel Rise: 7.00 ft
Barrel Material: Concrete
Embedment: 0.00 in
Barrel Manning's n: 0.0140
Culvert Type: Straight
Inlet Configuration: Square Edge (90º) Headwall
Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: Ex 8'x7' Box Culvert)

Flow (cfs)	Water Surfac Elev (ft)	Depth (ft)	Velocity (ft/s	Shear (psf)	Froude Number
0.00	443.05	0.00	0.00	0.00	0.00
187.29	444.44	1.39	2.48	0.43	0.38
374.57	445.14	2.09	3.18	0.65	0.41
561.86	445.70	2.65	3.66	0.83	0.42
749.14	446.18	3.13	4.04	0.98	0.43
936.42	446.60	3.55	4.35	1.11	0.44
1123.71	446.99	3.94	4.61	1.23	0.45
1310.99	447.35	4.30	4.85	1.34	0.45
1487.48	447.67	4.62	5.05	1.44	0.46
1685.57	448.00	4.95	5.25	1.54	0.46
1872.85	448.30	5.25	5.43	1.64	0.46

Tailwater Channel Data - Ex 8'x7' Box Culvert

Tailwater Channel Option: Trapezoidal Channel
Bottom Width: 50.00 ft
Side Slope (H:V): 3.00 (_:1)
Channel Slope: 0.0050
Channel Manning's n: 0.0500
Channel Invert Elevation: 443.05 ft

Roadway Data for Crossing: Ex 8'x7' Box Culvert

Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 50.00 ft
Crest Elevation: 456.12 ft
Roadway Surface: Paved
Roadway Top Width: 47.00 ft

Appendix F

Howard County Data and Planning

F.3 – Little Patuxent Watershed Plan

MARYLAND DEPARTMENT OF TRANSPORTATION™

STATE HIGHWAY ADMINISTRATION

Little Patuxent River
Watershed Assessment

November 2015

Prepared for:
Howard County,
Department of Public Works,
Stormwater Management Division

clean HOWARD
Howard County Stormwater Solutions

VERSAR

Prepared by:
Versar, Inc.
9200 Rumsey Rd, Suite 1
Columbia, MD 21045

EXECUTIVE SUMMARY

Howard County, Maryland, is required to develop Watershed Assessments to identify specific restoration opportunities to provide greater treatment of stormwater from urban impervious areas and to reduce pollutant loads associated with urban runoff. In 2014-2015, Howard County's Stormwater Management Division sponsored this assessment of the Little Patuxent Watershed within Howard County in order to (1) assess current conditions and (2) recommend watershed restoration opportunities. Employing GIS and field investigations, the project team recommended a suite of opportunities including upgrades to existing stormwater Best Management Practices (BMPs), new BMPs, tree plantings, stream restoration, and stabilization of stormwater outfalls. In all, this assessment yielded 760 potential projects and produced concept plans for 109 of the top-ranked opportunities identified.

The Little Patuxent Watershed in Howard County encompasses an area of 59 square miles. Impervious cover represents about 25.6% of the watershed, a level at which stream degradation is often observed. Residential land use makes up the largest proportion of the watershed area (41.0%), followed by commercial/industrial/institutional use (18.6%) and forest cover (21.1%). Only 4% of sites assessed historically were in Good biological condition and 11% were rated as Fair, with the remainder Poor to Very Poor.

GIS data, including data compiled from studies previously conducted within the Little Patuxent watershed, were used as the first step to identify candidate retrofit and restoration sites for further investigation in the field. Candidates initially selected were reviewed by Howard County staff to finalize the suite of field sites to be visited. In all, 530 sites and 50 stream miles were selected for field investigation, and another 72 sites previously assessed in other studies were slated for desktop assessments.

Field data collection was customized for each of the five site types and focused on assessing current conditions and identifying and describing restoration opportunities. Field data were collected with mobile tablet devices via an ESRI ArcCollector application. Some previously visited sites were evaluated via desktop assessment only, making use of prior data collected. In total, 600 sites and 50.2 stream miles were assessed. More than 800 initial watershed restoration recommendations were proposed based on field and desktop observations.

A standardized method was developed for comparing, ranking, and prioritizing the proposed project opportunities identified. Projects were ranked in two ways. First, each project was ranked against all other projects of the same type. Second, all projects were pooled together and ranked against one another, to enable ranking across project type, and to determine those projects that should be taken to the next design stage.

Ranking criteria were developed within the following categories of factors:

- Permit contribution – how a project will help towards the County meeting the impervious surface treatment requirements and pollutant reduction goals;
- Biological uplift – if a project will provide additional benefits, such as building onto existing green infrastructure or protecting wetlands;

- Programmatic benefit – how project has added value such as visible demonstration projects or public education; and
- Feasibility – estimation of the ease or difficulty of project implementation, including public versus private ownership, site accessibility, or whether a repair is already required at a site.

For the pooled project type ranking, scores were based on permit contribution criteria—specifically, acres of impervious treatment, pollutant load reduction, and cost per acre of impervious treatment—along with a combined score for the remaining three factor categories.

Ranking scores were used to select the 109 highest-ranked projects for concept plan development at this time, out of 760 potential projects. A four-page concept plan was developed for each of the projects, providing location information, description of existing condition (including photos), details of the proposed project (including a design drawing), implementation information (such as utility constraints and other nearby projects), potential impervious treatment credits, and cost estimate. The following numbers of project concepts were developed: 15 BMP Conversions, 10 New BMPs, 19 Tree Plantings, 20 Outfall Stabilizations, and 45 Stream Restorations.

A pollutant load model was created first to quantify nitrogen, phosphorus, and sediment loadings and loading rates to the Little Patuxent River with the watershed's existing and planned BMPs, based on the County's BMP inventory geodatabase as of November 12, 2015. Further, this model was used to calculate the expected nutrient and sediment loading reductions that would occur based on implementation of restoration opportunities identified as part of the watershed assessment. Pollutant load calculations and removals by BMPs were completed for (1) the local TMDL for sediment, and (2) the Chesapeake Bay TMDL for nitrogen, phosphorus, and sediment.

Results included a summary of estimated pollutant load reductions for the implementation of recommended projects, including how reductions were credited, pollutant removal efficiencies, potential load reductions, and units available for restoration. Results for the Bay TMDL indicate that the target load reduction for total phosphorus of 17.2% is easily met with a 54% load reduction; the sediment load reduction target is also met since the phosphorus target is met. These goals are met primarily due to stream restoration and its associated reductions using the interim reduction rates. Actual phosphorus and sediment reduction could be different, depending on the actual design implemented for these projects. The total nitrogen target of 9.4% is not met by the full suite of recommended projects, since there is only a 7.1% reduction achieved if all BMPs are implemented. For the local sediment TMDL, the target goal of 48.1% is achieved with a total reduction achieved of 62% if all BMPs were to be implemented.

The assumed implementation of potential restoration BMPs show how they would approach or exceed the required percent reduction for nitrogen, phosphorus, and sediment loads needed to meet water quality standards for this watershed as specified by the local and Chesapeake Bay TMDLs. Additional reductions may also be achieved through restoration actions not included in this analysis such as street sweeping, erosion and sediment control, and public education and outreach efforts (e.g., watershed trash and recycling campaign, conservation landscaping, pet waste education). These may be added as progress toward TMDL goals is tracked over the next several years.

ACKNOWLEDGEMENTS

The Little Patuxent Watershed Assessment report was prepared by Versar staff: Nancy Roth, Mark Voli, Brenda Morgan, Stephen Schreiner, Allison Brindley, Ben Fertig, Ginny Rogers, and Alexi Boado.

The complete Little Patuxent Watershed Assessment effort was a collaborative effort among the Howard County Stormwater Management Division; Versar, Inc.; KCI Technologies, Inc.; McCormick Taylor; Biohabitats; Stormwater Management and Consulting; and Straughan Environmental, Inc. The following individuals were among those instrumental in providing field assessments and field reports, GIS/technical support, data analysis, quality control, technical review, and preparation of concept plans.

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TABLE OF CONTENTS

Section Page

1 INTRODUCTION 1-1
1.1 Overview 1-1
1.2 Background 1-1
1.3 Regulatory Context 1-3
1.3.1 Water Quality Impairments 1-3
1.3.2 Local Total Maximum Daily Loads 1-4
1.3.3 Chesapeake Bay Total Maximum Daily Load 1-5
1.3.4 Pollutant Load Reduction Targets 1-5
1.3.5 Howard County MS4 Permit 1-5
1.4 Report Structure 1-8

2 ASSESSMENT OF CURRENT WATERSHED CONDITIONS 2-1
2.1 General Information 2-1
2.2 Impervious Surfaces 2-1
2.3 Land Use 2-6
2.4 Soils 2-6
2.5 Stream Condition 2-9
2.6 Previous Assessments Completed in the Study Area 2-12
2.7 Best Management Practices: Opportunities for Retrofit and Restoration 2-14
2.7.1 BMP Conversations 2-16
2.7.2 New BMPs 2-17
2.7.3 Tree Planting 2-18
2.7.4 Stream Restoration 2-19
2.7.5 Outfall Stabilization 2-20

3 DESKTOP ANALYSIS AND FIELD SITE SELECTION 3-1
3.1 Identifying and Assembling GIS Data 3-1
3.2 Conducting Desktop Analysis – Methods 3-1
3.2.1 BMP Conversion Assessment 3-1
3.2.2 New BMP Assessment 3-2
3.2.3 Stream Restoration Assessment 3-3
3.2.4 Tree Planting Assessments 3-4
3.2.5 Outfall Stabilization Assessments 3-5
3.3 Desktop Analysis Summary – Results 3-7

4 FIELD ASSESSMENTS 4-1
4.1 Field Methods and Calibration 4-1
4.1.1 Field Protocols 4-1
4.1.2 Electronic Data Collection 4-3
4.1.3 Calibration of Field Teams 4-3
4.1.4 Landowner Permissions 4-3

4.1.5 Field and Desktop Data Collection 4-4
4.1.6 Field Summary Reports 4-5
4.1.7 Field Data Quality Assurance/Quality Control 4-5
4.2 Summary – Little Patuxent Watershed Field and Desktop Site Assessments 4-5
4.2.1 BMP Conversion Assessments 4-11
4.2.2 New BMP Assessments 4-11
4.2.3 Stream Restoration Assessments 4-11
4.2.4 Tree Planting Assessments 4-11
4.2.5 Outfall Stabilization Assessments 4-11
4.3 Summary – Little Patuxent Watershed Restoration and Retrofit Recommendations 4-12
4.3.1 BMP Conversion Recommendations 4-12
4.3.2 New BMP Recommendations 4-16
4.3.3 Stream Restoration Recommendations 4-16
4.3.4 Tree Planting Recommendations 4-16
4.3.5 Outfall Stabilization Recommendations 4-16
4.4 Public Input and Feedback (Additional Sites) 4-16

5 RESTORATION PROJECT RANKING AND PRIORITIZATION 5-1
5.1 Ranking Methods – Overview 5-1
5.1.1 Impervious Area Credits 5-2
5.2 Ranking and Prioritization Within Project Types 5-3
5.2.1 BMP Conversions and New BMPs 5-3
5.2.2 Tree Plantings 5-4
5.2.3 Outfall Stabilizations 5-5
5.2.4 Stream Restorations 5-6
5.3 Ranking and Prioritization Across All Project Types 5-7
5.4 Concept Plans 5-8

6 POLLUTANT LOAD MODELING 6-1
6.1 Loads and Rates 6-2
6.2 Existing Stormwater Management 6-6
6.3 Stormwater Management Pond Conversions 6-10
6.4 New Stormwater Control Measures 6-13
6.5 Impervious Surface Reduction 6-15
6.6 Urban Tree Plantings 6-15
6.7 Stream Restoration 6-17
6.8 Regenerative Step Pool Storm Conveyance 6-19
6.9 Overall Pollutant Loading Reductions 6-20
6.10 Proposed Implementation Timeframe 6-23

7 REFERENCES 7-1

APPENDICES

A INVENTORY OF GIS DATA COMPILED FOR HOWARD COUNTY WATERSHED ASSESSMENTS JANUARY 2015 ..... A-1

B DESCRIPTION OF BMP TYPES B-1
C FIELD PROTOCOLS: DATA COLLECTION GUIDE C-1
D ELECTRONIC DATA COLLECTION PROTOCOLS D-1
E LANDOWNER NOTIFICATION LETTER E-1
F FIELD REPORTS FROM CONSULTANT FIELD TEAMS F-1
G TABLE LISTING INDIVIDUAL RETROFIT AND RESTORATION OPPORTUNITIES, WITH SCORES AND RANKINGS G-1
H INDIVIDUAL CONCEPT PLANS FOR TOP-RANKED OPPORTUNITIES H-1
I POLLUTANT LOAD REDUCTION CALCULATIONS FOR INDIVIDUAL BMP PROJECTS I-1

LIST OF TABLES

Table Page

1-1. MDE Water Quality Impairment Listings and Status of Local Impairments and TMDLs in the Little Patuxent Watershed in Howard County, not including the overall Chesapeake Bay TMDL 1-4

1-2 Approved TMDLs in Howard County 1-4

1-3 Watershed load reductions required by Chesapeake Bay and Local TMDLs for Little Patuxent Watershed 1-6

3-1 Past studies and GIS data used to identify stream channel problems 3-4

3-2 Past studies and GIS data used to identify candidate outfalls 3-6

3-3 Past studies and GIS data used to exclude candidate outfalls 3-6

3-4 Number of sites selected for field assessments in the Little Patuxent Watershed 3-7

3-5 Number of sites selected for desktop assessments in the Little Patuxent Watershed 3-7

4-1 Number of assessments completed in the Little Patuxent Watershed 4-6

4-2 Summary of recommendations in the Little Patuxent Watershed 4-12

5-1 Impervious acre credits for alternative BMPs 5-2

5-2 Ranking factors, criteria and scoring for BMP conversion and new BMP projects 5-3

5-3 Ranking factors, criteria and scoring for tree planting projects 5-4

5-4 Ranking factors, criteria and scoring for outfall stabilization projects 5-5

5-5 Ranking factors, criteria and scoring for stream restoration projects 5-6

5-6 Ranking factors, criteria and scoping used for ranking all projects and selecting projects for concept plans 5-8

5-7 Number of projects, by type, selected for concept plans in Little Patuxent Watershed 5-9

6-1 MAST land use aggregations for calculating pollutant loading rates for total Nitrogen, Total Phosphorus, and sediment 6-3

6-2a Reclassification of Howard County 2011 land use data groups to MAST land use for Howard County watershed 6-4

6-2b Reclassification of Howard County 2011 land use data and MDP 2010 Land Use/Land Cover to MAST land use for Howard County watersheds 6-4

6-3 Existing Annual Pollutant Loads within Little Patuxent Watershed for the Chesapeake Bay TMDL 6-5

6-4 Existing Annual Pollutant Loads within Little Patuxent Watershed for the local sediment TMDL 6-5

6-5 BMP efficiencies used in MAST for the land use and hydro-geomorphic region applicable to Howard County 6-7

6-6 Existing Stormwater Management Practices in the Little Patuxent Watershed installed after 2009, showing potential pollutant load reductions applicable to the Bay TMDL 6-8

6-7 Existing Stormwater Management Practices in the Little Patuxent Watershed installed after 2004, showing potential pollutant load reductions applicable to the local sediment TMDL 6-9

6-8 Stormwater Management Facility conversions proposed for the Little Patuxent Watershed and potential pollutant load reductions, summarized by MAST category 6-11

6-9 Proposed Stormwater Management facilities for the Little Patuxent Watershed showing potential pollutant load reductions summarized by MAST category type and those with and without concept designs 6-14

6-10 Existing impervious surface reduction projects in the Little Patuxent Watershed showing potential pollutant load reductions 6-15

6-11 Proposed impervious surface reduction projects in the Little Patuxent Watershed showing potential pollutant load reductions 6-15

6-12 Existing urban tree planting in the Little Patuxent Watershed potential pollutant load reductions 6-16

6-13 Urban tree planting in the Little Patuxent Watershed potential pollutant load reductions for sites without concept plans 6-16

6-14 Proposed urban tree planting in the Little Patuxent Watershed potential pollutant load reductions for sites with concept plans 6-16

6-15 Existing Stream Restoration practices in the Little Patuxent Watershed installed after 2009, showing estimated pollutant load reductions applicable to the Bay TMDL 6-17

6-16 Existing Stream Restoration practices in the Little Patuxent Watershed installed after 2004, showing potential pollutant load reductions applicable to the local sediment TMDL 6-18

6-17 Proposed Stream Restoration practices in the Little Patuxent Watershed for sites with concept plans, showing potential pollutant load reductions applicable to the Bay TMDL 6-18

6-18 Proposed Stream Restoration practices in the Little Patuxent Watershed, for sites without concept plans, showing potential pollutant load reductions applicable to the Bay TMDL 6-18

6-19 Proposed Regenerative Step Pool Conveyance projects with concept plans showing potential pollutant load reductions 6-19

6-20 Potential pollutant load reductions for proposed Regenerative Step Pool Storm Conveyance projects without concept plans 6-20

6-21 Summary of potential pollutant load reductions for the Little Patuxent Watershed for existing and proposed stormwater management practices to meet the local sediment TMDL 6-21

6-22 Summary of potential pollutant load reductions for the Little Patuxent Watershed for existing and proposed stormwater management practices to meet the Bay TMDL 6-22

6-23 Pollutant load reduction benchmarks associated with TMDLs and impervious area restoration target, for Little Patuxent Watershed in Howard County 6-23

6-24 Proposed implementation timeline to meet TMDL pollutant reduction and MS4 permit deadlines, for the Little Patuxent Watershed 6-24

LIST OF FIGURES

Figure Page

1-1 Major watersheds of Howard County, Maryland, with Little Patuxent Watershed highlighted 1-2

2-1 Little Patuxent River Watershed in Howard County, Maryland..... 2-2

2-2 Impervious Cover Model 2-3

2-3 Impervious surface in Little Patuxent Watershed..... 2-4

2-4 Treated and untreated impervious surface in Little Patuxent Watershed, along with stormwater BMP locations..... 2-5

2-5 Land use in Little Patuxent Watershed 2-7

2-6 Zoning in Little Patuxent Watershed 2-8

2-7 Soil hydrologic groups in Little Patuxent Watershed 2-10

2-8 Benthic Index of Biotic Integrity ratings, at sites assessed by Howard County, MBSS, and Stream Waders in Little Patuxent Watershed, 1995 – 2013..... 2-11

2-9 Habitat Assessments based on Rapid Bioassessment Protocol for habitat, at sites monitored by Howard County in Little Patuxent Watershed, 2003-2013 2-12

4-1 Study areas for spring 2015 site assessments within the Little Patuxent Watershed..... 4-2

4-2 Typical Dry Pond and Extended Detention Dry Pond evaluated during BMP Conversion Assessments..... 4-6

4-3 Typical untreated impervious surface and a potential location for a new BMP facility observed during New BMP Assessments..... 4-6

4-4 Typical degraded stream channels observed during Stream Restoration Assessments... 4-7

4-5 Typical tree planting opportunities found along stream corridors and adjacent to existing forest..... 4-7

4-6 Typical degraded outfall channels observed during Outfall Stabilization Assessments 4-7

4-7 Location of assessments conducted in the Northern Little Patuxent Study Area 4-8

4-8 Location of assessments conducted in the Southern Little Patuxent Study Area 4-9

4-9 Location of assessments conducted in the Hammond Branch Study Area..... 4-10

4-10. Location of restoration and retrofit opportunities in the Northern Little Patuxent Study Area 4-13

4-11. Location of restoration and retrofit opportunities in the Southern Little Patuxent Study Area 4-14

4-12. Location of Restoration and Retrofit Opportunities in the Hammond Branch Study Area..... 4-15

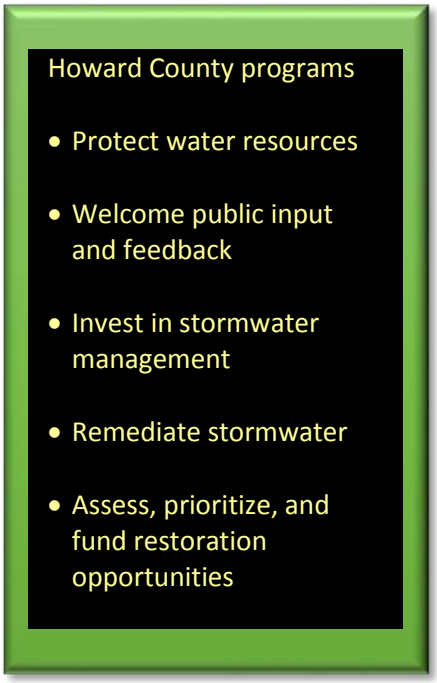
1. INTRODUCTION

1.1 Overview

Howard County, Maryland, is required to develop Watershed Assessments to identify specific restoration opportunities to provide greater treatment of stormwater from urban impervious areas and to reduce pollutant loads associated with urban runoff. In 2014-2015, Howard County's Storm Water Management Division sponsored this assessment of the Little Patuxent River Watershed within Howard County in order to (1) assess current conditions and (2) recommend watershed restoration opportunities. This report documents the Watershed Assessment for Little Patuxent River Watershed, which yielded 760 potential projects and produced concept plans for 102 of the top-ranked opportunities identified. The suite of recommended opportunities includes upgrades to existing Best Management Practices, BMPs, new BMPs, tree plantings, stream restoration opportunities, and stabilization of stormwater outfalls.

1.2 Background

Howard County continues to implement significant controls on stormwater discharges under its National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Permit (MDE 2014a) and other Clean Water Act requirements. In addition, the County conducts programs supporting watershed restoration and environmental sustainability that include (1) protection of water resources, (2) public outreach, (3) new investment in stormwater management, (4) development of a Watershed Protection and Remediation Fee, (5) development of a Countywide Implementation Strategy for addressing pollutant reductions and (6) preparation of assessments for individual watersheds.



As Howard County continues to increase its watershed planning efforts to comply with its MS4 permit and meet other water resource goals, detailed watershed plans will be developed for the entire county. While previous watershed assessments have been completed for many areas of the county, the current round of assessments and plans incorporate a focus on addressing MS4 permit requirements. Plans include development of a detailed inventory of projects that can be undertaken to restore impervious surface area that has not already been restored to the maximum extent practicable (MEP) and to reduce nutrients and sediment in stormwater runoff. In addition, the expected pollutant load reductions of proposed projects are modeled, and the amounts of impervious surface area equivalent acres restored are calculated.

The Little Patuxent Watershed is located in the center of Howard County (Figure 1-1). The MS4 area under the jurisdiction of Howard County includes the majority of the County, with the exception of state and federal lands, as shown, and other properties which have industrial stormwater discharge NPDES permits, not visible at this map scale.

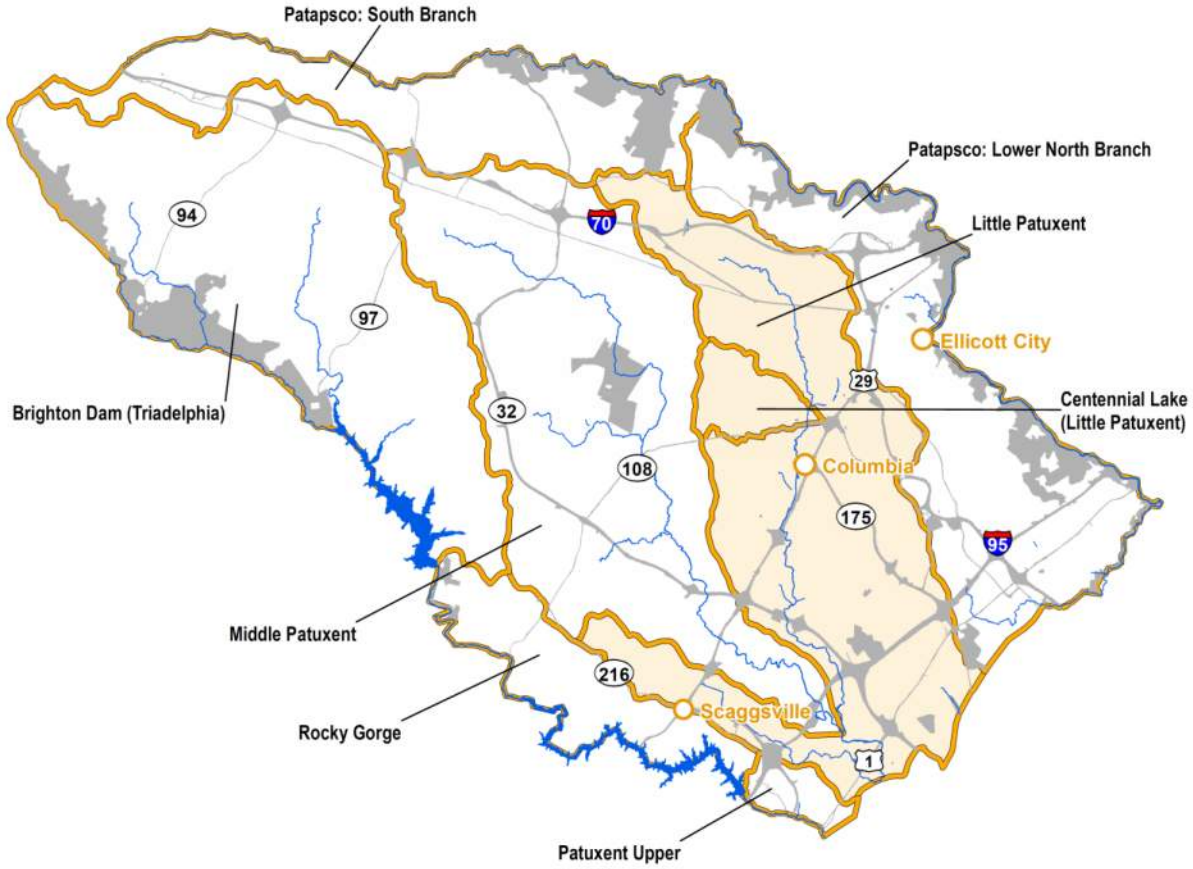


Figure 1-1. Major watersheds of Howard County, Maryland, with Little Patuxent Watershed highlighted. The MS4 permit for Howard County includes the entire county with the exception of areas under other jurisdictions. On this map, federal lands, state highway lands, and other state lands are shown in gray; other properties which have industrial stormwater discharge NPDES permits are also not within the County MS4 but are not visible at this map scale.

Previously, Howard County prepared the following assessments and plans within the Little Patuxent Watershed. Results and recommendations from these projects were incorporated into the present study.

- General Watershed Restoration Assessments and Strategy (WRAS) and Stream Corridor Assessments (SCAs) for
  - Little Patuxent (Howard County 2002; Maryland Department of Natural Resources 2001)
  - Dorsey Run and Hammond Branch 2003 SCAs
  - Upper Little Patuxent SCA (USACE 2008)

- Specific watershed plans with restoration projects
  - Centennial Lake and Wilde Lake (Center for Watershed Protection and Tetra Tech 2005)
  - Downtown Columbia (Howard County 2010)
  - Columbia Watershed Management Plan / Lake Elkhorn (Versar 2009)
  - Upper Little Patuxent (KCI Technologies, Inc. 2009)
  - Countywide Dry Pond and Extended Detention Pond Retrofit study (Versar 2013a)
  - Countywide identification of Low Impact Development (LID) Retrofit and Tree Planting opportunities on County properties (Versar 2013b)

Citizen complaints also provided a source of potential restoration projects and were included in the current study.

1.3 Regulatory Context

Howard County has several watersheds where pollutant loading limits have been established by the State of Maryland and approved by the U.S. Environmental Protection Agency (EPA), through quantitative assessment studies under the Clean Water Act.

1.3.1 Water Quality Impairments

Section 303(d) of the 1972 Clean Water Act requires states to develop and periodically update a list of impaired waters that fail to meet applicable state water quality standards, which are defined by their designated uses. States must also establish priority rankings and develop Total Maximum Daily Loads (TMDLs) for waters on the impaired waters 303(d) list. According to EPA, a TMDL is a calculation of the maximum amount of a pollutant that a water body can receive and still safely meet state water quality standards. TMDLs can be developed for a single pollutant or group of pollutants of concern which generally include nutrients, sediment, bacteria, metals, and pesticides. To meet TMDL targets, pollutant loads from point and nonpoint sources must be reduced by implementing a variety of control measures.

Several watersheds in Howard County are listed as impaired for various pollutants in the Maryland 2014 Integrated Report (formerly known as the 303(d) list of impaired waters) prepared by the Maryland Department of the Environment (MDE 2014b, http://www.mde .maryland.gov/programs/Water/TMDL/Integrated303dReports/Pages/2014IR.aspx). Impairment listings reflect the inability to meet water quality standards for the designated uses for a water body. Impairment in tidal receiving waters is related to pollutants coming from entire watersheds; therefore, TMDLs developed for these segments will require watershed pollutant load reductions. Water Quality Assessments (WQAs) are performed to determine if the pollutant of concern is actually impairing the waters. If it is determined that the pollutant of concern is not contributing to water impairment, a report documenting the findings is submitted to EPA for concurrence.
Based on these listings, there are a number of water body segments in the Little Patuxent Watershed that MDE has identified as potentially impaired (Table 1-1). Of these, two have had water quality assessments performed, showing that they are not impaired; one is impaired and

will need a TMDL in the future; and three have completed TMDLs, all for phosphorus or sediment.

Table 1-1. MDE Water Quality Impairment Listings and Status of Local Impairments and TMDLs in the Little Patuxent Watershed in Howard County, not including the overall Chesapeake Bay TMDL

Impairment	Applicable Segment	Status	Approval Date
Chlorides	Little Patuxent	WQA - Impaired	
Eutrophication	Little Patuxent	WQA – Not Impaired	March 2010
Cadmium	Little Patuxent	WQA – Not Impaired	July 2009
Sediment	**Little Patuxent**	**TMDL completed**	**September 2011**
Sediment	**Little Patuxent-Centennial**	**TMDL completed**	**April 2002**
Phosphorus	**Little Patuxent-Centennial**	**TMDL completed**	**April 2002**

1.3.2 Local Total Maximum Daily Loads (TMDLs)

Nitrogen, phosphorus and sediment reductions are driven by federal and state regulations under the Clean Water Act. Overall, Howard County must address seven approved local TMDLs in six of its watersheds, as well as the Chesapeake Bay Watershed TMDL (Table 1-2). The present watershed study addresses both local and Chesapeake Bay TMDL targets for the Little Patuxent Watershed. The watershed of Centennial Lake is within Little Patuxent; however, MDE's Stormwater WLA list for Howard County does not include a separate WLA for Centennial Lake, so it is not modeled separately here (see wlat.mde.state.md.us/ByMS4.aspx). The present project addressed the local sediment TMDL for Little Patuxent and the nitrogen, phosphorus, and sediment Chesapeake Bay TMDLs in the Howard County portion of the Little Patuxent River Watershed.

Table 1-2. Approved TMDLs in Howard County (as of September 8, 2015). Those affecting the Little Patuxent Watershed are shown in bold text.

Watershed	TMDL Constituent
Patapsco Lower North Branch	Fecal coliform (Dec. 2009) Sediment (Sept. 2011)
Baltimore Harbor* (assumed superseded by Bay TMDL)	Nitrogen/Phosphorus (Dec. 2007)
Little Patuxent	**Sediment (Sept. 2011)**
Little Patuxent – Centennial Lake	**Sediment (Apr. 2002)** **Phosphorus (Apr. 2002)**
Patuxent River Upper	Sediment (Sept. 2011)
Patuxent River Upper – Brighton	Phosphorus (Nov. 2008) Sediment (Nov. 2008)
Patuxent River Upper – Rocky Gorge	Phosphorus (Nov. 2008) Sediment (Nov. 2008)
Chesapeake Bay	**Nitrogen (Dec. 2010)** **Phosphorus (Dec. 2010)** **Sediment (Dec. 2010)**

1.3.3 Chesapeake Bay Total Maximum Daily Load (TMDL)

The Chesapeake Bay TMDL, established by the EPA in 2010, sets pollution limits for nitrogen, phosphorus, and sediment in the Chesapeake Bay Watershed. These bay-wide pollution limits are a response to the slow progress by states within the watershed to limit their pollutants to levels which meet water quality standards in the Bay and its tidal tributaries. Total limits set in the Bay TMDL for the states of Delaware, Maryland, New York, Pennsylvania, Virginia, West Virginia, and the District of Columbia are "185.9 million pounds of nitrogen, 12.5 million pounds of phosphorus and 6.45 billion pounds of sediment per year—a 25% reduction in nitrogen, 24% reduction in phosphorus and 20% reduction in sediment" (EPA 2010). The TMDL also sets "rigorous accountability measures" for state compliance.

When EPA established the Chesapeake Bay TMDL, a historic and comprehensive "pollution diet" for nutrients and sediment, it set forth rigorous accountability measures to initiate sweeping actions to restore clean water in the Chesapeake Bay and the region's streams, creeks, and rivers (EPA 2010). Concurrent with the development of the Bay TMDL, EPA charged the Bay watershed states and the District of Columbia with developing watershed implementation plans (WIPs) to provide adequate "reasonable assurance" that the jurisdictions can and will achieve the nutrient and sediment reductions necessary to implement the TMDL within their respective boundaries. Maryland's Phase 2-WIP provided a series of proposed strategies that will collectively meet the 2017 target (60% of the total nutrient and sediment reductions needed to meet final 2025 goals).

Stormwater runoff is a primary contributor of nutrients and sediment from watersheds in Howard County. Substantial nitrogen, phosphorus, and sediment reductions from stormwater runoff will be required to meet local and Chesapeake Bay TMDLs for these watersheds. (TMDLs for other pollutants will be addressed later.) The Chesapeake Bay TMDL analysis determined that a roughly 15% reduction in nitrogen and phosphorus loads from urban stormwater discharges in Howard County is necessary to meet Bay water quality standards. A roughly 20% reduction in sediment is needed from the urban portions of the watersheds to meet water quality standards in the local streams and rivers.

1.3.4 Pollutant Load Reduction Targets

Within Little Patuxent Watershed, the load reductions in sediment and nutrients needed within the urban portion of the watershed to achieve the reduction targets in the Chesapeake Bay and Local TMDLS are summarized in Table 1-3.

1.3.5 Howard County MS4 Permit

Howard County is one of five medium and five large municipalities in Maryland that are regulated by a Phase I MS4 permit (Section 402(p) of the Water Quality Act of 1987 and NPDES Permit Application Regulations for Storm Water Discharges of November 16, 1990). The Maryland State Highway Administration also is under an NPDES MS4 permit. Howard County's first permit went into effect on April 17, 1995.

Table 1-3. Watershed load reductions required by Chesapeake Bay and Local TMDLs for Little Patuxent Watershed (from wlat.mde.state.md.us/ByMS4.aspx)

River Basin/TMDL name	% Reduction	Baseline Year
Little Patuxent		
Bay Total Nitrogen	9.4	2009
Bay Total Phosphorus	17.2	2009
Bay Sediment	**	2009
Local Sediment	48.1	2005

** Bay sediment TMDL assumed met if TP target is met

Under Howard County's current MS4 permit (Permit Number 11-DP-3318, MD0068322, issued December 18, 2014), the County is required to develop Watershed Assessments and Restoration Plans to identify specific restoration opportunities to address pollutant reductions in approved TMDLs. One condition of the County's MS4 permit is implementation of TMDL load reduction allocations in the County's watersheds. This applies to all current local TMDLs, as well as any new TMDLs approved by EPA. Such new TMDLs could be developed for any watersheds in the County that have listed water quality impairments.

Specifically, the 2014 MS4 permit for Howard County (MDE 2014a) states:

> *Howard County shall annually provide watershed assessments, restoration plans, opportunities for public participation, and TMDL compliance status to MDE. A systematic assessment shall be conducted and a detailed restoration plan developed for all watersheds within Howard County. … watershed assessments and restoration plans shall include a thorough water quality analysis, identification of water quality improvement opportunities, and a schedule for BMP and programmatic implementation to meet stormwater WLAs included in EPA approved TMDLs.*

In concert with these efforts, the County has developed a Countywide Implementation Strategy (CIS). The CIS evaluates potential management recommendations and anticipated pollutant reduction strategies and is being updated concurrently with this watershed assessment. As described previously, several past watershed-specific plans have recommended restoration projects that have already been completed, while other restoration projects are currently being implemented.

These past and ongoing efforts contributed to the preparation of the current Watershed Assessment for the Little Patuxent Watershed, which was tailored to address the latest MS4 requirements. This assessment and plan were specifically designed to assess current water quality conditions and identify the most effective management measures to reduce stormwater pollutant loads to address both the Chesapeake Bay TMDL and local sediment TMDL in Little Patuxent Watershed. The assessment and plan have been developed in accordance with the new permit requirements and provides Howard County with a list of projects where restoration of impervious surface area can be achieved.

Howard County's MS4 permit, PART IV.E.1, includes the following provisions regarding watershed assessments:

a. *By the end of the permit term, Howard County shall complete detailed watershed assessments for the entire County. Watershed assessments conducted during previous permit cycles may be used to comply with this requirement, provided the assessments include all of the items listed in PART IV.E.1.b below. Assessments shall be performed at an appropriate watershed scale (e.g., Maryland's hierarchical eight or twelve-digit sub-basins) and be based on MDE's TMDL analysis or an equivalent and comparable County water quality analysis.*

b. *Watershed assessments by the County shall:*

   i. *Determine current water quality conditions;*

   ii. *Include the results of a visual watershed inspection;*

   iii. *Identify and rank water quality problems;*

   iv. *Prioritize all structural and nonstructural water quality improvement projects; and*

   v. *Specify pollutant load reduction benchmarks and deadlines that demonstrate progress toward meeting all applicable stormwater WLAs.*

The permit also requires an impervious area assessment, prepared by the County, which sets the target for treatment of 20% of the County's impervious area that has not been treated to the Maximum Extent Practicable (MEP). This target was considered in development of the watershed plan, such that the benefits of implementing individual projects were computed in terms of impervious acres treated, or equivalent acres treated, as per MDE guidance (MDE 2014c), and the suite of recommended projects is able to be evaluated against the 20% goal.

In the permit, PART IV.E.2.b includes the following specifications for restoration plans:

b. *Within one year of permit issuance, Howard County shall submit to MDE for approval a restoration plan for each stormwater WLA approved by EPA prior to the effective date of the permit. The County shall submit restoration plans for subsequent TMDL WLAs within one year of EPA approval. Upon approval by MDE, these restoration plans will be enforceable under this permit. As part of the restoration plans, Howard County shall:*

   i. *Include the final date for meeting applicable WLAs and a detailed schedule for implementing all structural and nonstructural water quality improvement projects, enhanced stormwater management programs, and alternative stormwater control initiatives necessary for meeting applicable WLAs;*

   ii. *Provide detailed cost estimates for individual projects, programs, controls, and plan implementation;*

   iii. *Evaluate and track the implementation of restoration plans through monitoring or modeling to document the progress toward meeting established benchmarks, deadlines, and stormwater WLAs; and*

iv. *Develop an ongoing, iterative process that continuously implements structural and nonstructural restoration projects, program enhancements, new and additional programs, and alternative BMPs where EPA approved TMDL stormwater WLAs are not being met according to the benchmarks and deadlines established as part of the County's watershed assessments.*

This report provides details on the methods and results of a comprehensive process for identifying, assessing, and prioritizing existing and new restoration opportunities in the Howard County portion of the Little Patuxent Watershed.

The CIS described previously in this section will serve to meet the requirement for a restoration plan.

1.4 Report Structure

This report documents the process employed for identifying, assessing, and prioritizing existing and new restoration opportunities in the Howard County portions of the Little Patuxent Watershed. The report is organized into seven chapters along with four appendices, each highlighting an aspect of the overall project.

Chapter 1: Introduction provides context for the project and describes the regulatory drivers for watershed assessment and pollutant reduction planning, as well as the overall structure of this report.

Chapter 2: Assessment of current watershed condition highlights key information regarding the condition of the Little Patuxent Watershed. This condition includes information about physical characteristics such as impervious cover, existing stormwater BMPs, and assessments of stream biota and habitat, e.g., the Benthic Index of Biotic Integrity (BIBI) and Rapid Bioassessment Protocol (RBP) habitat assessments. This chapter also provides background information about the Little Patuxent Watershed and brief summary information from previous assessments completed in the study area. Finally, it describes the five types of potential restoration opportunities considered in this study for assessment, ranking, prioritization, and estimated pollutant load reduction. These restoration opportunity types are (1) BMP conversion, (2) proposed new BMPs, (3) tree planting, (4) stream restoration, (5) outfall stabilization.

Chapter 3: Desktop analysis explains the process used to synthesize and analyze past data in order to select sites for field investigation. It also describes the creation of a geodatabase to be populated by consultant teams in the field.

Chapter 4: Field assessments delves into the field work methodology, calibration, and QA/QC employed by consultant teams conducting the fieldwork within the geographic scope of this study. Assessment data, including the desktop revisits of previously assessed sites and public

input/feedback, are reported for each of the five types of potential restoration opportunities in the Little Patuxent Watershed, and are depicted spatially and in tabular form.

Chapter 5: Restoration project ranking and prioritization sequences the steps and results of scoring and ranking individual potential restoration opportunities among all the individual opportunities of that type (e.g., BMP conversions, new BMPs, etc.). Further, this chapter details the scoring and comparative ranking of individual opportunities across all five types of potential restoration for prioritization. By identifying the high priority opportunities, this process produced a more limited set of candidates for development of Concept Plans, which are included as four-page summaries in Appendix H.

Chapter 6: Pollutant load modeling reports the calculations of potential pollutant loading reductions. Pollutant loads for nitrogen, phosphorus, and sediment were modeled at the planning level for the Little Patuxent Watershed. Anticipated pollutant load reductions for the Little Patuxent Watershed were modeled for both the Chesapeake Bay TMDL and the local TMDL for sediment.

Chapter 7: References documents other works cited throughout the report.

Appendices: Additional details are provided in nine appendices. These include:

A. Inventory of GIS Data
B. Descriptions of BMP Types
C. Field Protocols and Data Collection Guide
D. Electronic Data Collection Protocols
E. Landowner Notification Letter
F. Field Reports from Consultant Field Teams
G. Tables Listing Individual Retrofit and Restoration Opportunities, with Scores and Rankings
H. Individual Concept Plans for Top-ranked Opportunities
I. Stormwater BMP Conversions and New Stormwater BMPs Proposed for the Little Patuxent Watershed and Potential Pollutant Load Reductions, for Individual Sites

2. ASSESSMENT OF CURRENT WATERSHED CONDITIONS

This chapter describes the current conditions in the Little Patuxent Watershed, including information from geographic information system (GIS) data and existing stream monitoring efforts. GIS data were compiled from Howard County and other sources for use throughout the watershed assessment and planning process; see Appendix A for an inventory of GIS data gathered. The initial watershed characterization and desktop assessment step is described in this chapter. Subsequent chapters detail the remaining steps of the project, for which GIS was integral: GIS screening analysis to select sites for field visits, planning and conducting field investigations, prioritization of restoration opportunities identified, and development of concept plans.

2.1 General Information

Little Patuxent Watershed in Howard County (Figure 2-1) encompasses an area of 59 square miles (37,727 acres). The watershed includes 9,688 impervious acres, 9,043 acres of woods, and 190 miles of streams.

2.2 Impervious Surfaces

Studies have shown a correlation between the amount of impervious surface within a watershed and stream quality (e.g., Schueler et al. 2009). Impervious surfaces, including roads, parking areas, roofs, and other paved surfaces, prevent precipitation from naturally infiltrating the ground. This prohibits the natural filtration of pollutants and conveys concentrated, accelerated stormwater runoff directly to the stream system. Consequently, stormwater runoff from impervious surfaces can cause stream erosion and habitat degradation from the high energy flow. Furthermore, such runoff is likely more polluted than runoff generated from pervious areas.

Percent impervious cover is the most commonly used single measure of urban impacts to streams. Schueler (2008) defines the following general categories, using the Impervious Cover Model (Figure 2-2, adapted from Schueler et al. 2009) describing the general relationship between the amount of impervious cover in a watershed and stream quality:

- Sensitive Streams: 2 - 10% impervious cover
- Impacted: 10 - 24%
- Damaged (Non-Supporting): 25 - 59%
- Severely Damaged (Urban Drainage): 60% or more

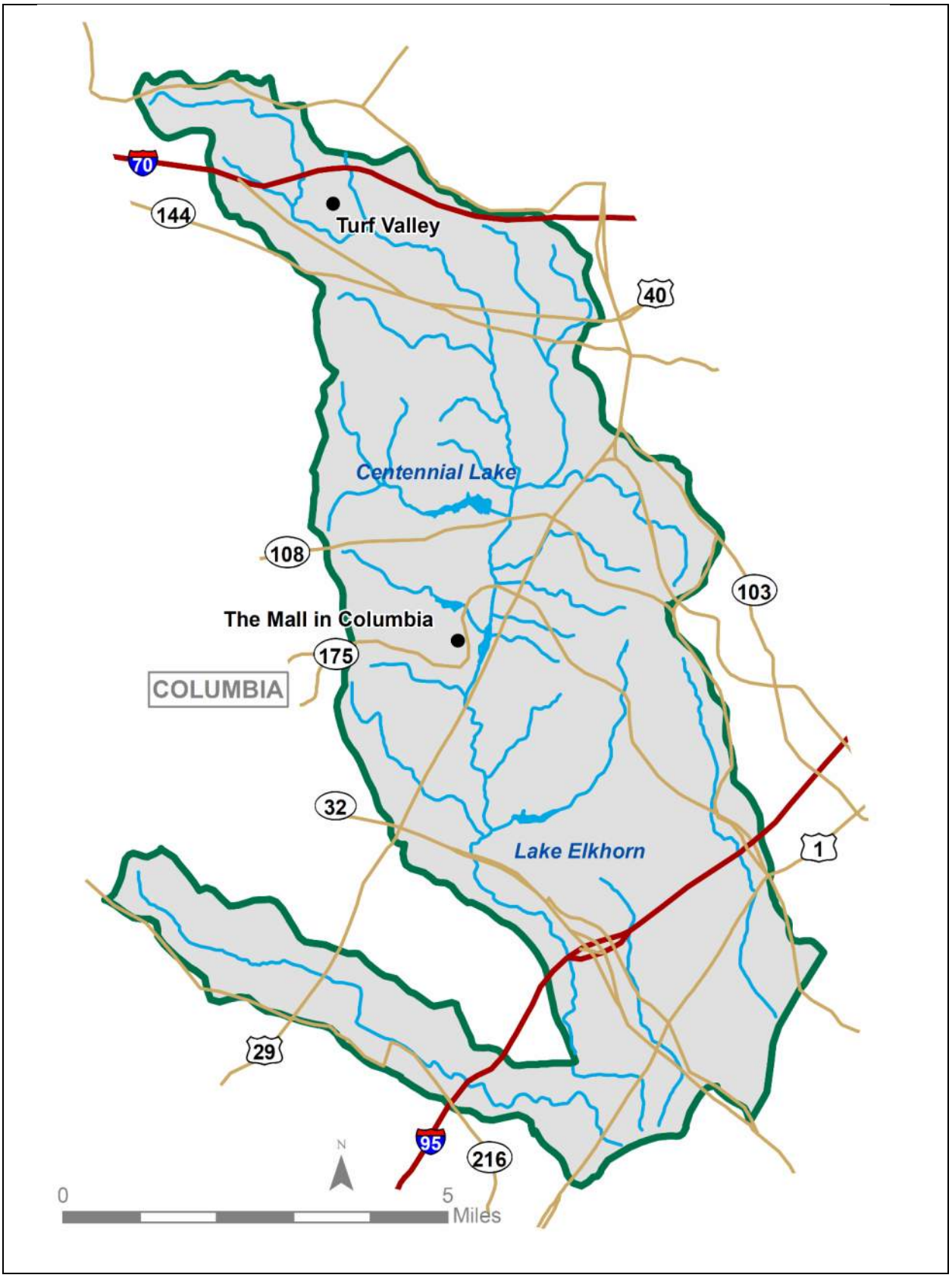


Figure 2-1. Little Patuxent River Watershed in Howard County, Maryland

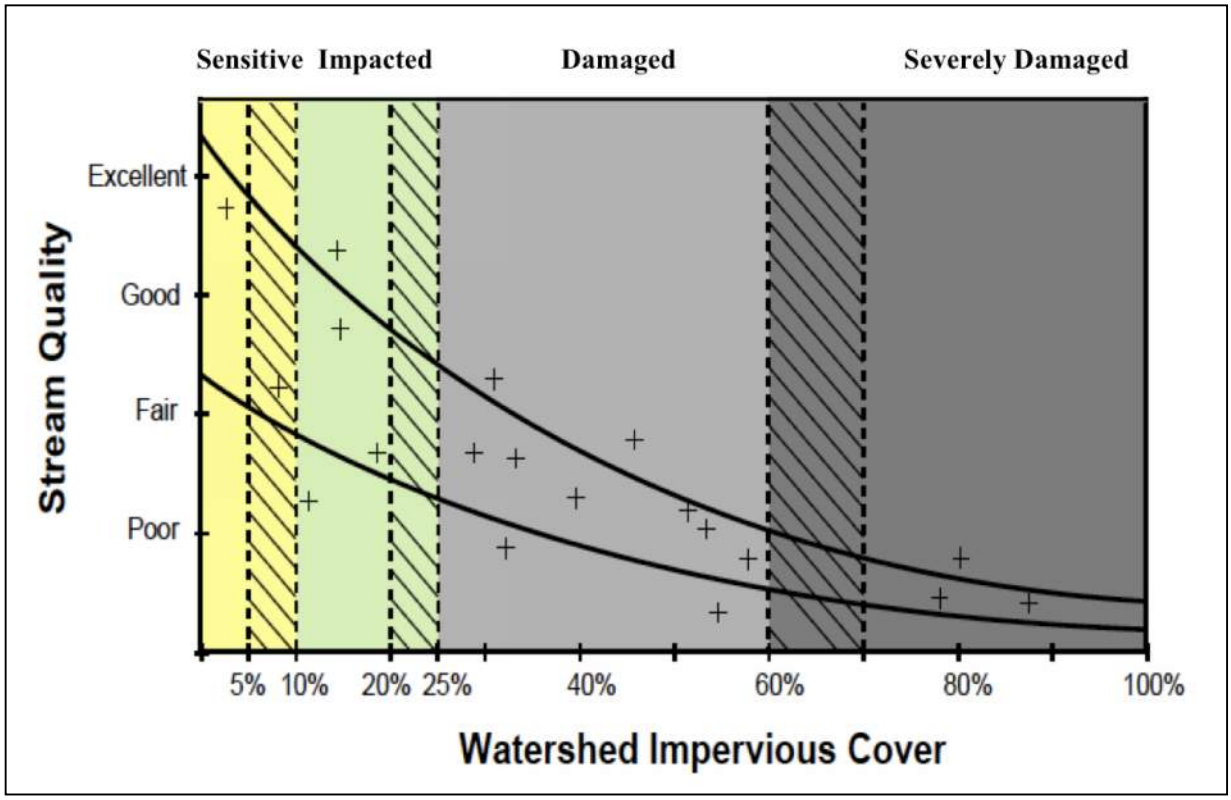


Figure 2-2. Impervious Cover Model (adapted from Schueler et al. 2009)

Howard County's impervious cover data were used to map and quantify impervious cover within the Little Patuxent Watershed (Figure 2-3). The 2014 impervious layer, based on 2013 planimetric data, includes roads, parking lots, driveways, major buildings, bridge decks, sidewalks, pathways, and swimming pools. In all, impervious cover represents about 25.6% of the Little Patuxent Watershed.

While the Impervious Cover Model provides a general indication of stream conditions under varying degrees of impervious cover, it does not explicitly account for the effectiveness of BMPs that are in place to treat runoff from those impervious areas. Existing BMPs provide treatment of water quantity and/or quality for much of the developed, impervious area in Little Patuxent. According to recent Howard County data, there are 1,746 stormwater BMPs treating approximately 47% of the impervious area in Little Patuxent Watershed. Figure 2-4 shows impervious cover and areas treated by existing BMPs (based on BMP drainage areas available in Howard County's database, as of June 2015).

Howard County's current MS4 permit requires restoration of an additional 20% of impervious cover, countywide, not already restored to the MEP. Following MDE guidance (MDE 2014c), impervious cover not restored to the MEP can be defined, in practice, as any impervious acres not draining to BMPs constructed after 2001. After 2002, Maryland regulations and local ordinances began requiring BMPs to address a specific suite of volumes equivalent to providing water quality treatment to the MEP.

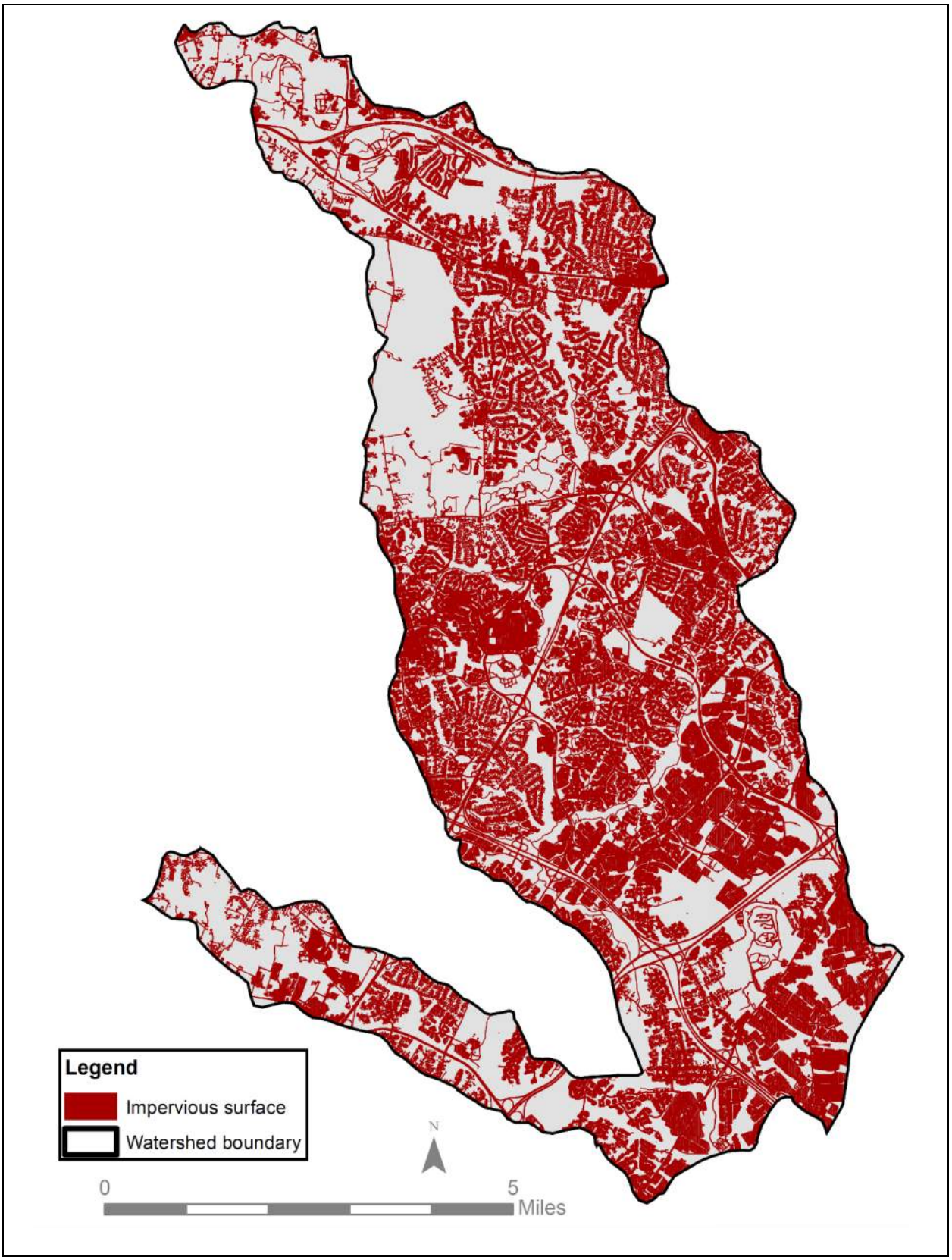


Figure 2-3. Impervious surface in Little Patuxent Watershed (Howard County 2014 impervious data)

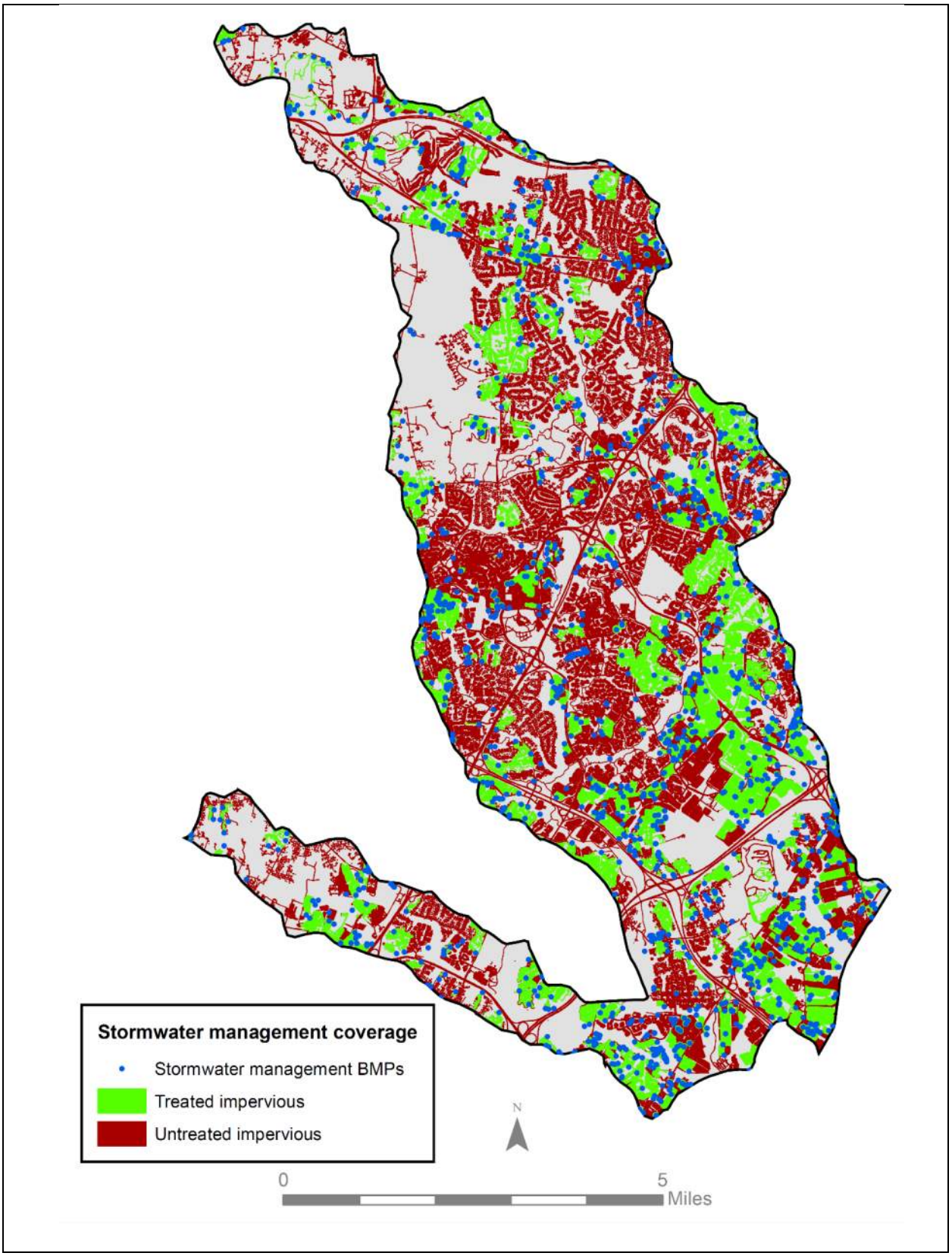


Figure 2-4. Treated and untreated impervious surface in Little Patuxent Watershed, along with stormwater BMP locations

2.3 Land Use

Land use within Little Patuxent Watershed was derived from Maryland Department of Planning, 2010 data (Figure 2-5). Residential land use makes up the largest proportion of area (41.0%), followed by commercial/industrial/institutional use (18.6%), primarily in the southern half of the watershed. Forest cover makes up 21.1% of the watershed area, much of that along stream corridors and the Little Patuxent mainstem.

Future land use will be influenced by zoning (Figure 2-6). The area is largely planned for development, including a predominance of residential and commercial uses, as well as the New Town designation for the planned community of Columbia in the central part of the watershed. Some areas in the northern part of the Little Patuxent Watershed and the upper part of Hammond Branch are designated as Rural Residential.

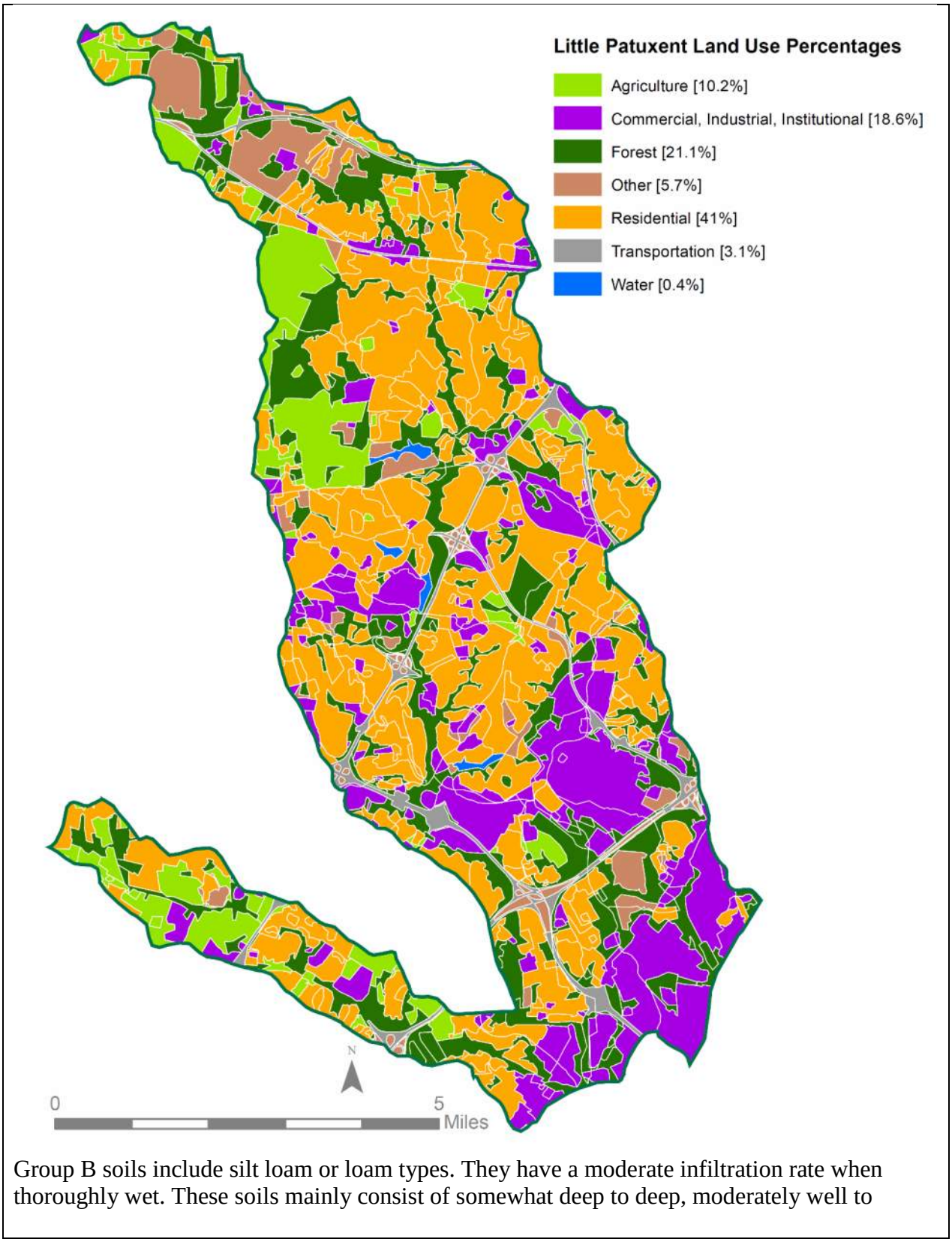
2.4 Soils

Soil conditions are important when evaluating how a watershed affects water quantity and quality in streams and rivers. Soil type and moisture conditions impact how land may be used and its potential for infiltration or various types of plants. Howard County's GIS soils layer was used for the soils data analysis and is a representation of the Howard County Soil Survey.

The Natural Resource Conservation Service (NRCS) classifies soils into four hydrologic soil groups based on runoff potential. Runoff potential refers to the tendency of soils to produce surface runoff; it is the opposite of infiltration capacity (i.e., the ability for the soil to absorb precipitation). Soils with high infiltration capacity will have low runoff potential, and vice versa. Infiltration rates are highly variable among soil types and are also influenced by disturbances to the soil profile (e.g., land development activities). For example, urbanization in watersheds with high infiltration rates (e.g., sands and gravels) will have a greater impact than urbanization in watersheds consisting mostly of silts and clays, which have low infiltration rates. Factors that affect infiltration rate include soil permeability (influenced mostly by texture and structure), slope, degree of soil saturation, and percentage of leaf litter cover. The four hydrologic soil groups are A, B, C, and D, where group A soils generally have the lowest runoff potential and Group D soils have the greatest.

Brief descriptions of each hydrologic soil group are provided as follows. Further explanation of each can be found in the U.S. Department of Agriculture (USDA)/NRCS publication, Urban Hydrology for Small Watersheds, also called Technical Release 55 (USDA 1986).

- Group A soils include sand, loamy sand, or sandy loam types. These soils have a high infiltration rate and low runoff potential even when thoroughly wet. These consist mainly of deep, well to excessively drained sands or gravel. These soils have a high rate of water transmission.



Group B soils include silt loam or loam types. They have a moderate infiltration rate when thoroughly wet. These soils mainly consist of somewhat deep to deep, moderately well to

Figure 2-5. Land use in Little Patuxent Watershed

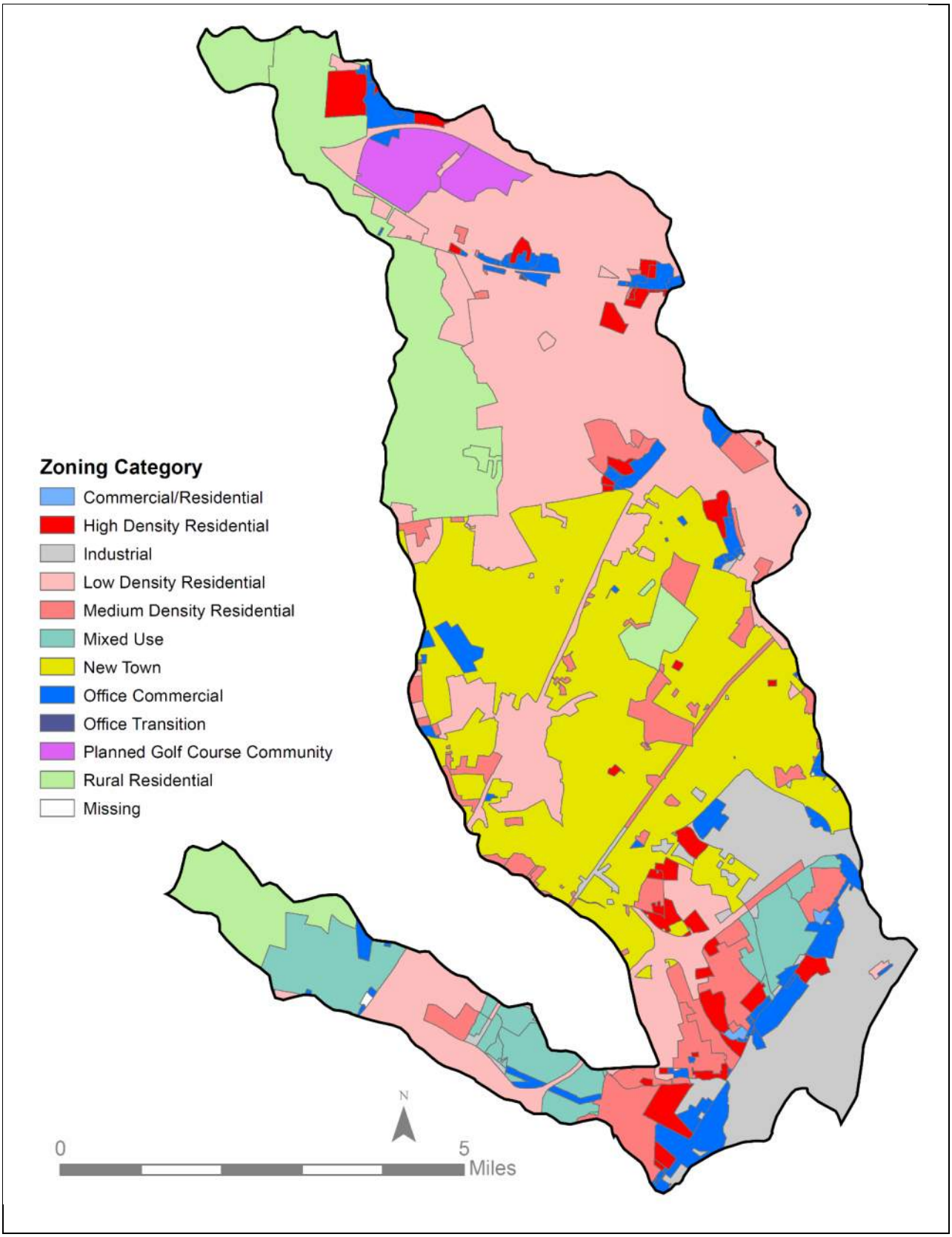


Figure 2-6. Zoning in Little Patuxent Watershed

well drained soils with moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

- Group C soils are sandy clay loam. These soils have a low infiltration rate when thoroughly wet. These types of soils typically have a layer that hinders downward movement of water and soils with moderately fine or fine texture. These soils have a low rate of water transmission.
- Group D soils include clay loam, silty clay loam, sandy clay, silty clay, or clay types. These soils have a very low infiltration rate and high runoff potential when thoroughly wet. These consist mainly of clays with high swell potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission.

As shown in Figure 2-7, the majority of area in the Little Patuxent Watershed falls into soil groups with higher runoff potential, in hydrologic groups C and D. The low infiltration rates of these soils mean that they are more susceptible to flooding and provide a poor porous medium for stormwater ponds and Environmental Site Design (ESD) opportunities, so opportunities should be considered carefully, using local-scale information. Some parts of the Upper Little Patuxent and the upper part of Hammond Branch have a predominance of better drained, B soils.

2.5 Stream Condition

Howard County conducts biological monitoring at randomly selected stations in its Countywide monitoring program which began in 2001. The Little Patuxent Watershed consists of the Lower Little Patuxent, Middle Little Patuxent, Upper Little Patuxent subwatersheds, as well as Dorsey Run and Hammond Branch. With the exception of Hammond Branch and Dorsey Run, which were last sampled in 2009, the watershed was sampled most recently in 2013. In addition, the Maryland Department of Natural Resources (DNR) Maryland Biological Stream Survey (MBSS) has performed stream monitoring statewide since 1995, using similar monitoring methods as the County. Since 2000, the DNR Stream Waders volunteer program has performed benthic macroinvertebrate monitoring throughout the County. The results of all of these assessments are shown in Figure 2-8.

Of the 281 sites in Little Patuxent Watershed, only 10 (4% of sites) were in Good condition, 31 (11%) were rated Fair, 79 (28%) were rated Poor, and 160 (57%) rated Very Poor. Some good sites were found in the Upper Little Patuxent subwatershed and upper reaches of Hammond Branch. However, most sites in Lower Little Patuxent subwatershed and Dorsey Run were in poor to very poor condition.

Stream habitat condition was also evaluated by Howard County using EPA's Rapid Bioassessment Protocol (RBP) for habitat assessment. Of the 124 sites assessed (Figure 2-9), only one site (less than 1% of sites) was rated as comparable to reference condition (the highest scoring category). Seventeen (14%) sites were rated as supporting, 48 (39%) as partially supporting, and 58 (47%) as not supporting (the lowest scoring category), indicating that many streams in the Little Patuxent Watershed show evidence of habitat degradation.

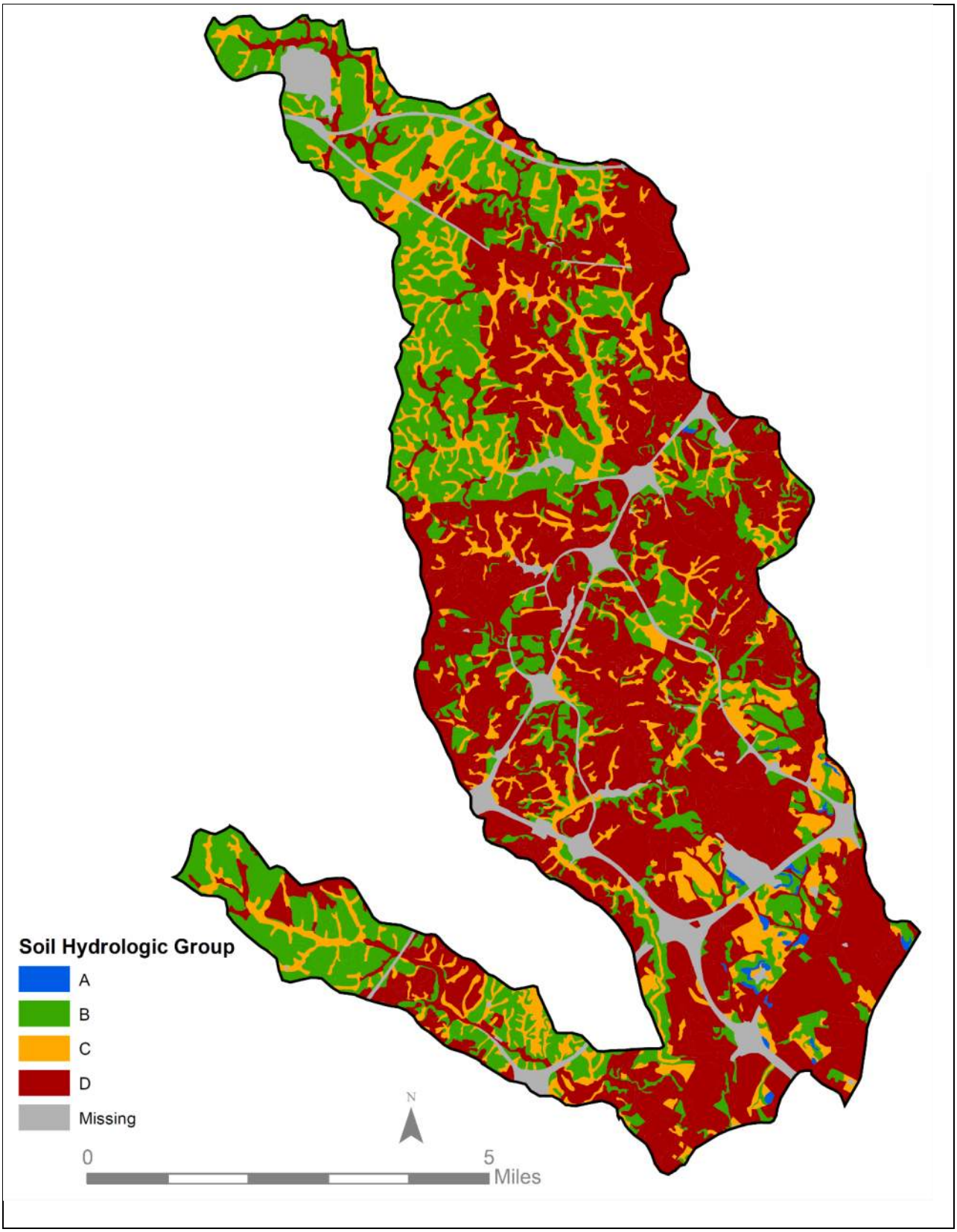


Figure 2-7. Soil hydrologic groups in Little Patuxent Watershed

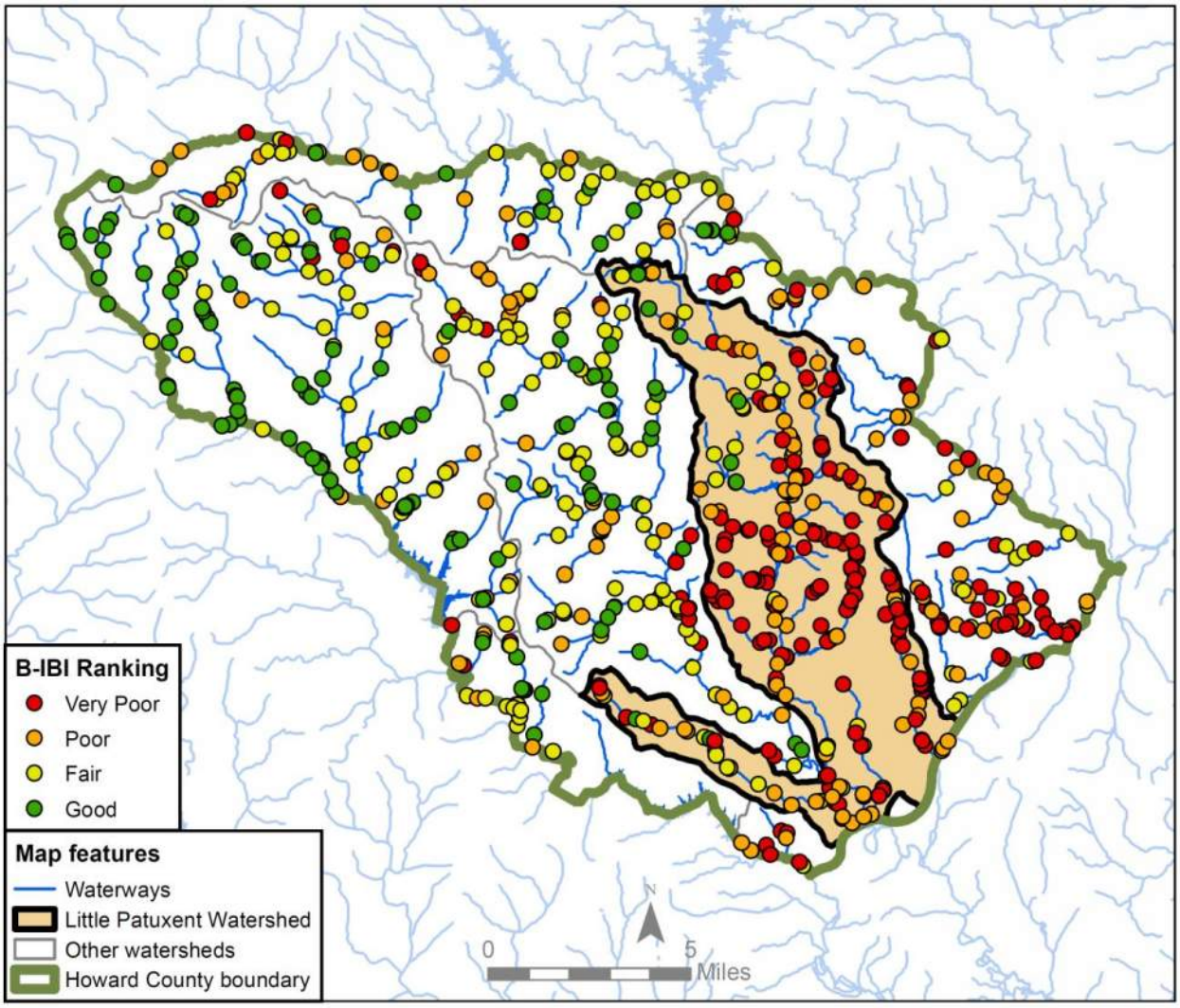


Figure 2-8. Benthic Index of Biotic Integrity ratings, at sites assessed by Howard County, MBSS, and Stream Waders in Little Patuxent Watershed, 1995 - 2013

While stream conditions vary across the county, degradation is more prevalent in the heavily developed urban areas. This reflects the history of urban and suburban development prior to effective stormwater management regulations. Watershed condition is generally better in the more rural parts of the county, but stream degradation still occurs in these areas as a result of large lot development and agricultural impacts. By reducing the adverse effects of stormwater runoff throughout the county, the process of watershed assessment, restoration planning, and implementation of prioritized BMPs should improve the water quality condition in Little Patuxent Watershed over time.

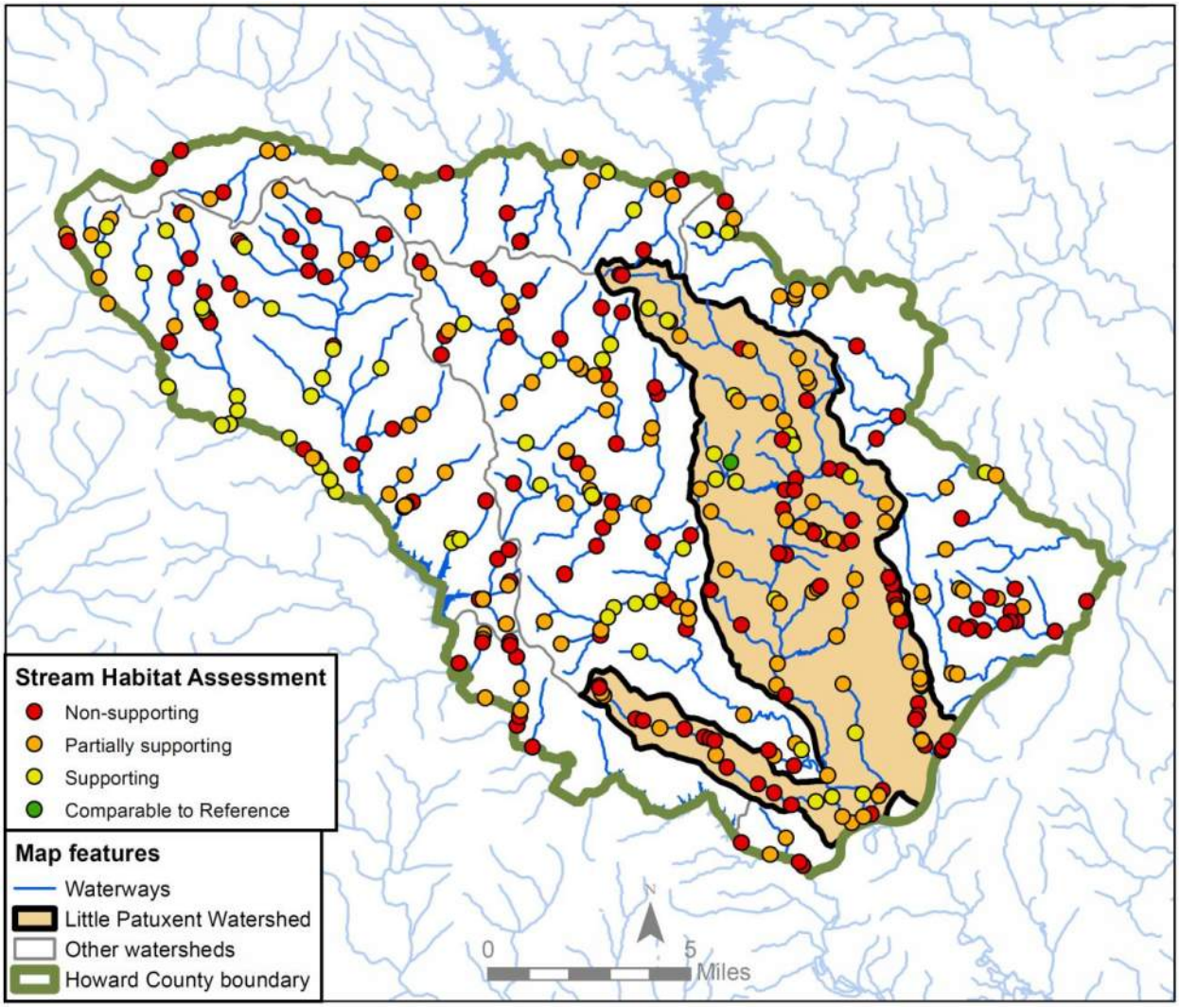


Figure 2-9. Habitat Assessments based on Rapid Bioassessment Protocol for habitat, at sites monitored by Howard County in Little Patuxent Watershed, 2003-2013

2.6 Previous Assessments Completed in the Study Area

As previously described, Howard County has been developing inventories of restoration projects since 1999. These include individual projects, some of which have already been completed, and others identified in the following watershed plans that covered portions of the Little Patuxent Watershed:

Stream Corridor Assessment (SCA) of the Little Patuxent River (Maryland DNR 2001)

A SCA was conducted as part of an overall assessment of the condition of the Little Patuxent Watershed and the streams within it. The assessment identified 1,090 environmental problems within the watershed, which included pipe outfalls, tree blockages, inadequate buffers, erosion sites, fish blockages, channel alterations, exposed pipes, unusual conditions, trash dumping, and

in/near stream construction. A total of 229 ponds and 89 representative habitat sites were also documented during the assessments. This study excluded the Dorsey Run and Hammond Branch subwatersheds, but similar SCA studies were conducted in these subwatersheds in 2003 and documented 126 and 195 environmental problems, 56 and 31 pond sites, and 15 and 25 representative habitat sites, respectively. GIS data for all environmental problems, ponds, and representative sites were available for the desktop analysis portion of this Little Patuxent Watershed assessment study.

Centennial Lake and Wilde Lake in Little Patuxent (CWP/TetraTech 2005)

A watershed management plan was developed for the Centennial Lake and Wilde Lake Watersheds in 2005 as a result of a watershed prioritization study conducted under Howard County's June 2000 to June 2005 NPDES permit term. A combination of field reconnaissance and public input resulted in specific restoration and protection efforts being recommended for each of the watersheds. For the Centennial Lake Watershed, the final proposed restoration projects included over 1 mile of forested stream restoration through two floodplain reconnection projects, and a series of stream buffer restoration projects, the creation of 10 to 12 acres of forested wetlands, the creation of 0.5 acre of meadow buffer restored around the lake, and the implementation of 8 stormwater retrofits to treat approximately 18 acres of untreated impervious area. For the Wilde Lake Watershed, the final proposed projects included approximately 0.5 mile of stream restoration/rehabilitation, and the implementation of 15 to 20 priority stormwater retrofits for 40 to 50 acres of untreated or poorly treated impervious area. GIS data for features collected during field assessments and the final project recommendations were available for the desktop analysis portion of this Little Patuxent Watershed assessment study.

Downtown Columbia (Biohabitats 2008, for General Growth Properties,)

Watershed assessments were conducted in the Symphony Stream and Lake Kittamaqundi Watersheds in 2008 in order to identify stormwater retrofit and riparian corridor restoration opportunities. Assessments were conducted on more than 60 stormwater retrofit sites throughout the two watersheds, which resulted in 49 BMP conversion and new BMP recommendations. Additionally, more than two miles of stream assessments were conducted throughout the two watersheds, which resulted in 10 riparian corridor restoration recommendations. GIS data for the final retrofit and restoration sites were available for the desktop analysis portion of this Little Patuxent watershed assessment study.

Lake Elkhorn in Little Patuxent (Versar 2009, for Columbia Association)

During 2008 and 2009 a watershed assessment was conducted in the Lake Elkhorn Watershed in conjunction with the Columbia Association (CA) Columbia Watershed Management Plan. RRI assessments were conducted at 24 sites within the Lake Elkhorn Watershed and resulted in the development of 18 concept plans. Concept plans consisted of BMP conversion, new BMP, and stream restoration sites. Approximately 30 reforestation sites on CA and public land were also identified during the study. GIS data for all sites investigated during the course of the study were available for the desktop analysis portion of this Little Patuxent Watershed assessment study.

Upper Little Patuxent (KCI 2009)

A watershed management plan was developed for the Upper Little Patuxent Watershed in 2009 as a result of impervious area restoration requirements outlined in Howard County's June 2005 NPDES permit. RRI assessments and desktop analysis of reforestation sites identified 184 candidate project sites, which included a combination of BMP conversions, new BMPs, stream restorations, outfall stabilizations, and reforestation plantings. Concept plans were developed for high priority sites, which included 17 pond conversions, 17 new bioretention areas, 7 new ponds/shallow marshes, 15 stream restoration/outfall stabilization projects, and 22 reforestation projects. GIS data for all sites investigated during the course of the study, including SCA data collected by the U.S. Army Corps of Engineers, were available for the desktop analysis portion of the Little Patuxent Watershed assessment.

In 2013, Howard County completed the following two countywide surveys for potential restoration projects:

Howard County LID Retrofits and Tree Planting Study (Versar 2013a)

In 2012 and 2013 Howard County conducted a study to identify Low Impact Development (LID) opportunities on Howard County-owned properties, including Board of Education land, in order to meet NPDES permit and Chesapeake TMDL impervious area treatment and pollutant load reduction obligations. RRI assessments were conducted at 80 sites throughout the County. Concept plans were developed for 34 unique LID (or micro-BMP) opportunities on 22 different parcels. These LID projects would treat 73 acres, including 42 acres of impervious cover. In addition to the LID projects, 32 tree sites were selected for tree planting projects. GIS data for all sites investigated during the course of the study were available for the desktop analysis portion of this Little Patuxent Watershed assessment study.

Howard County Dry Pond and Extended Detention Pond Retrofits Study (Versar 2013b)

In 2012 and 2013 Howard County conducted a study to identify existing private and public flood control dry-ponds and existing extended detention flood control ponds that could be upgraded to provide or enhance water quality control, in order to meet NPDES permit and Chesapeake TMDL impervious area treatment and pollutant load reduction obligations. RRI assessments were conducted at 140 ponds throughout the County. Concept plans were developed for 52 ponds, which treat 1,184 acres, including 343 acres of impervious cover. GIS data for all sites investigated during the course of the study were available for the desktop analysis portion of this Little Patuxent Watershed assessment study.

2.7 Best Management Practices: Opportunities for Retrofit and Restoration

There were five types of retrofit and restoration opportunities considered for the current watershed assessment: (1) upgrading or retrofitting existing BMPs, (2) proposing new BMPs, (3) planting trees, (4) restoring streams, and (5) stabilizing storm drain outfalls. Howard County

has implemented BMPs and other watershed management practices since the 1980s. The initial focus of stormwater management was detention of large flows to reduce flooding. Subsequent designs addressed water quality treatment and stream channel protection in accordance with revised State and County design criteria. Most recently, "green" BMPs known as ESD or green stormwater infrastructure are being encouraged for new development and to facilitate restoration of watersheds. Maryland stormwater regulations for new and re-development will require that stormwater management provide for control of water quantity and quality using the latest guidelines.

The following categories of stormwater and watershed management practices were considered in this watershed assessment study as the major strategies to address Howard County's local and Chesapeake Bay TMDL goals and NPDES MS4 impervious surface area restoration requirements. Each has the potential to yield quantifiable benefits in stormwater quality and in quantity control for channel protection and flooding.

1. Conversion of dry ponds and extended detention dry ponds to modern facilities with greater pollutant removal efficiencies, which include:

    - Extended detention dry ponds (if dry pond is present and no other viable option is available)
    - Extended detention wet ponds / wetlands (ED, WP), shallow wetlands
    - Bioretention
    - Non-bioretention filtering practices
    - Infiltration practices
    - Swales
    - Addition of pre-treatment or post-treatment BMPs within existing dry or wet pond boundaries
    - New BMP retrofits outside of existing dry or wet pond boundaries but which would drain into an existing pond or capture and treat stormwater just outside of the existing pond (e.g. step pool conveyance).

2. Retrofitting untreated impervious with new stormwater BMP facilities, which include:

    - Extended detention dry ponds
    - Extended detention wet ponds / wetlands (ED, WP), shallow wetlands
    - Bioretention
    - Non-bioretention filtering practices
    - Infiltration practices
    - Swales
    - Green roofs
    - Replacement of impervious cover with pervious pavement
    - Impervious cover removal

- Rain barrels
- Rain gardens
- Rooftop disconnection

3. Reforestation of stream buffers and upland areas
4. Restoring degraded stream channels for erosion control and enhanced nutrient processing
5. Restoring degraded ephemeral and intermittent outfall channels through stabilization techniques which include:
    - Rip Rap stabilization
    - Step Pool Stormwater Conveyance (SPSC) / Regenerative Stormwater Conveyance (RSC) stabilization
    - Installing a drop structure or other stabilization of the outfall channel

2.7.1 BMP Conversions

Stormwater pond conversions can include the following general options for the re-design of existing stormwater ponds to provide additional water quantity control or water quality treatment:

- Increasing storage capacity by additional excavation.
- Providing water quality treatment features at facilities that currently have only water quantity control, if the space is available. Examples include: micropools, sediment forebays, or constructed stormwater wetlands.
- Modifying or replacing existing outlet controls to reduce the discharge rate from the stormwater management facility.
- Where soil types are appropriate, adding infiltration (sometime referred to as exfiltration) features to promote groundwater recharge and improve pollutant removal.
- Where water quality flows can be split or separated from larger events, vegetated areas with engineered soils and underdrain, referred to as bioretention, can sometimes be retrofit into an existing pond as pretreatment or post treatment and yield a significant increase in pollutant removal efficiency.
- Installing proprietary settling, filtering or hydrodynamic devices in parking lots or other areas with a large percentage of impervious area to trap sediments, trash and petroleum products before they flow into a pond. These tend to have low pollutant removal efficiencies but can be good options in the highly urban context, particularly where subterranean treatment is the only option.

Specifically, the following types of conversions are recommended.

- ***Conversion of Dry Stormwater Management Detention Ponds*** to extended detention dry ponds or extended detention wet pond/wetlands or conversion to ponds with infiltration capability, where soils permit. These BMPs typically treat the largest area of impervious

cover because they have the largest drainage areas and were originally built as a low cost option for flood control, channel protection and/or water quality control. Conversion of these existing devices is among the most cost effective of pollutant reduction measures because the existing ponds do not require acquisition of new property, the pipe infrastructure is already in place, most of the excavation is already complete, maintenance responsibilities and easements have already been established and because stormwater flows already concentrate at these devices. Pollution reduction credits may depend on specific design characteristics affecting both runoff time and treatment. Possible constraints regarding these options include acceptance by local residents and pond owners of the proposed pond's aesthetics, the revised maintenance, and the costs.

- Dry and Wet Extended Detention (ED) Basins are depressions that temporarily store ("detain") runoff and release it at a prescribed rate via surface flow or groundwater infiltration following storms. Dry ED basins are designed to dry out between storm events, in contrast with wet ED ponds, which contain standing water permanently. As such, they (ED type) are similar in construction and function to simple dry or wet detention basins which are primarily for flood control or channel protection, except that the duration of detention of stormwater is designed to be longer, theoretically improving treatment effectiveness by increasing residence time of pollutants which encourages settling of sediments and allows more time for biological and physical processing of nutrients.
- Urban Infiltration Practices are depressions created to allow the collection and infiltration of stormwater in order to trap sediments and nutrients in soil media and simultaneously recharge groundwater aquifers. No underdrains are associated with infiltration basins and trenches, because by definition these systems provide complete infiltration. Infiltration basins and trenches cannot be constructed on poor soils, such as C and D soil types. These urban infiltration practices may include vegetation and sand which increases the removal of phosphorus by 5% on average compared to infiltration practices without sand or vegetation.

2.7.2 New BMPs

New stormwater management features involve placing new stormwater management ponds, including extended detention dry ponds, urban infiltration ponds, and constructed wetlands and wet ponds at locations that currently have no stormwater quantity or quality controls or where existing BMPs are inadequate and where space is available for a new BMP. Ponds are the traditional method of controlling stormwater flows and the opportunity to retrofit new SWM ponds is not common in the developed environment. However, the resulting benefits to flow volume, velocity control, and water quality improvement can be significant. Benefits may vary depending on the specific design features of the individual ponds.

Micro-BMPs (LID) include the use of innovative practices designed to mimic natural flows by reducing the volume of stormwater runoff at the source. Distributed Micro-BMPs features are a series of smaller landscape features that function as retention/detention areas integrated with developed areas. Micro-BMPs include bioretention areas and rain gardens created by excavating a depression and backfilling with engineered media, mulch, and vegetation. These planted

shallow basins temporarily pond stormwater runoff, filter it through the bed components and treat it through biological and biochemical reactions within the soil matrix and root zones of the plants. Micro-BMPs are suitable for stormwater runoff control for new development and re-development projects, which strive to mimic "woods in good condition" and are often paired with ponds in order to meet flood control and channel protection objectives. Practices in this category are variously called ***green stormwater infrastructure***, ***ESD***, or ***LID***. These also include such practices as bioswales or wet swales which both treat and convey stormwater.

The suite of available ESD practices is diverse and many are advocating for a more expansive use of lower-cost vegetation and tree-based practices, especially near outfalls, within existing conveyances, adjacent to parking lots, and as green streets. In general, ESD practices most conducive to residential landscapes include rain gardens (typically in front yards), permeable pavement (typically for driveways), rainbarrels or cisterns, turf conversion or sustainable landscaping, dry wells, green roofs, tree canopy, soil decompaction, and pavement removal. ESD opportunities in rights-of-way may include bioretention (in medians, cul-de-sac islands, street bump outs, adjacent open space, as well as behind curbs or sidewalks), permeable pavement (in parking or bike lanes, sidewalks), turf conversion or sustainable landscaping, street trees (including tree pits), and step-pool stormwater conveyances in roadside channels.

Impervious cover removal may be an option in areas where existing parking surfaces or other paved surface are not currently needed. In some cases, large parking surfaces were previously built in commercial and institutional developments for events that occur very infrequently. Potentially, these areas could be converted to turf, thus reducing overall impervious cover and thereby reducing runoff. Pervious concrete or asphalt surfaces are another option that can be employed where appropriate.

2.7.3 Tree Planting

Reforestation consists of the following two types of tree planting, both of which provide ancillary benefits of enhancing wildlife and amenity values. Planting trees reduces runoff through interception and uptake/transpiration of precipitation, while also providing soil stability, heat island reduction and wildlife habitat benefits.

- Riparian Forest Buffers are areas of trees, shrubs, and other vegetation adjacent to a body of water. The riparian area, typically at least 35 feet wide (on each side of a stream), is managed to maintain the integrity of stream channels, and to reduce the impacts of upland sources of pollution by trapping, filtering, and converting sediment, nutrients, and other chemicals. Planting trees and enhancing existing streamside vegetation with native varieties of trees, shrubs, and wildflowers restores many of the water quality, wildlife, and aesthetic benefits associated with riparian buffers. Vegetation filters sediments and other pollutants from stormwater runoff, moderates water temperatures in streams, and provides shelter and food to both terrestrial and stream organisms. This BMP converts urban or agricultural land to forest land and provides a nitrogen, phosphorus, and sediment reduction benefit proportional to the amount of land converted.

- Upland Tree Planting is planting trees on currently urban or other open pervious areas at a rate that would produce a forest-like condition over time. Benefits include reductions in nutrient and sediment runoff as well as improvements in wildlife habitat and aesthetics.

2.7.4 Stream Restoration

Stream restoration is used to improve the ecosystem condition in degraded streams by restoring the natural hydrology and landscape of a stream and by enhancing habitat and water quality. Streams damaged by erosive flows, excess sedimentation, and disruptive human activities are often not capable of re-establishing a stable form. Preferred techniques to repair these damaged or degraded streams are based on mimicking natural stream channels and the range of natural variability exhibited by nearby stable streams. Termed ***natural stream channel design***, such repairs focus on establishing natural stream channel shape, size, and habitat features. Restoration can range from minor repairs to restore bank stability to complete reconstruction of the stream channel. Stream restoration also provides significant ancillary benefits through habitat enhancement and improved ecosystem services.

Incised stream channels are often targeted for stream restoration projects due to the accelerated stream bank erosion and loss of aquatic habitat caused by the instability of incised channels. Rosgen (1997) proposes four priority channel design options for restoring incised stream channels, where Priority 1 is the most preferred, and Priority 4 is the least preferred:

- **Priority 1.** Re-establish the stream channel on the historic floodplain.
- **Priority 2.** Establish a lower floodplain elevation and a new stream channel at the existing channel-bed elevation.
- **Priority 3.** Widen the floodplain at the existing bankfull stage elevation by excavating a new floodplain bench on one or both sides of the existing incised channel
- **Priority 4.** Stabilize the existing stream bed and banks in place using typical stabilization structures and methods.

Credits may vary depending on the type of stream restoration undertaken. According to MDE's accounting guidance for impervious area credits (MDE 2014c), stream restoration is credited at a rate of 1 acre impervious equivalent per 100 linear feet of stream restored. Nutrient and sediment load reductions associated with stream restoration may be estimated using rates derived from regional studies. The Chesapeake Bay Program's Expert Panel to Define Removal Rates for Individual Stream Restoration Projects (Schueler and Stack 2014) has defined these rates, which are acceptable for watershed planning purposes (for further details, see Section 6.7). However, recognizing that every stream restoration project is unique with respect to its design, stream order, landscape position and function, the Panel developed four protocols for determining

pollutant reduction credits for individual projects, once site-specific design details are known. These protocols are as follows (from Schueler and Stack 2014):

- ***Protocol 1: Credit for Prevented Sediment during Storm Flow.*** *This protocol provides an annual mass nutrient and sediment reduction credit for qualifying stream restoration practices that prevent channel or bank erosion that would otherwise be delivered downstream from an actively enlarging or incising urban stream.*

- ***Protocol 2: Credit for Instream and Riparian Nutrient Processing during Base Flow.*** *This protocol provides an annual mass nitrogen reduction credit for qualifying projects that include design features to promote denitrification during base flow within the stream channel through hyporheic exchange within the riparian corridor.*

- ***Protocol 3: Credit for Floodplain Reconnection Volume.*** *This protocol provides an annual mass sediment and nutrient reduction credit for qualifying projects that reconnect stream channels to their floodplain over a wide range of storm events.*

- ***Protocol 4: Credit for Dry Channel Regenerative Stormwater Conveyance (RSC) as an Upland Stormwater Retrofit****. This protocol provides an annual nutrient and sediment reduction rate for the contributing drainage area to a qualifying dry channel RSC project. The rate is determined by the degree of stormwater treatment provided in the upland area using the retrofit rate adjustor curves developed by the Stormwater Retrofit Expert Panel.*

An individual stream restoration project may qualify for credit under one or more of the protocols, depending on its design and overall restoration approach.

2.7.5 Outfall Stabilization

Step Pool Stormwater Conveyances / Regenerative Stormwater Conveyances are open-channel conveyance systems that convert surface stormwater flow to shallow ground water flow through surface pools and subsurface sand seepage filters (Anne Arundel County 2012). These practices can be used to stabilize degraded ephemeral and intermittent channels while also providing water quality treatment for the contributing drainage area, allowing for pollutant removal opportunities that do not exist with traditional outfall stabilization techniques. Specific site conditions will dictate whether these practices are appropriate. Pollutant reductions for regenerative stormwater conveyances will be credited using the Expert Panel's Protocol 4, as described previously.

Other Stabilization Practices. Where step pool conveyances are not feasible, simpler outfall channelization practices such as riprap or drop structures may be implemented to reduce erosion.

3. DESKTOP ANALYSIS AND FIELD SITE SELECTION

3.1 Identifying and Assembling GIS Data

A suite of GIS data, including data compiled from studies previously conducted within the Little Patuxent Watershed, was used to identify and select candidate retrofit and restoration sites for further investigation in the field. Section 2.6 contains a list of those prior studies along with a description of the types of GIS data that were available to be used in this desktop analysis, while Appendix A lists GIS data compiled from Howard County and other sources.

3.2 Conducting Desktop Analysis - Methods

3.2.1 BMP Conversion Assessment

Howard County GIS data were used to identify BMPs that could be converted to a design with increased pollutant removal efficiencies. Recent improvements to the County's stormwater BMP facility database were available, including BMP drainage area polygons, indicators of conversion status, and other updates that had been completed by Howard County in 2014 and early 2015. This desktop analysis was conducted with the most complete BMP database update available at the time, in early January 2015.

Age of BMPs was a key factor in selection of facilities with conversion potential. MDE's Impervious Accounting guidance (MDE 2014c) reflects the stormwater design guidelines instituted with the Maryland 2000 Stormwater Manual:

> *The baseline year for the impervious area assessment shall be 2002, which is the year that the Manual was fully implemented. BMPs designed in compliance with the water quality volume (WQv) treatment criteria found in the Manual are considered to provide quality treatment to the MEP. Therefore, the impervious area draining to BMPs designed and approved in accordance with the Manual is considered treated and does not need to be counted toward restoration requirements.*

Therefore, as an initial step, all dry pond and extended detention dry ponds in the County's stormwater BMP facility database with pre-2002 built dates qualified as BMP conversion candidate sites. To further narrow down the pool of remaining BMP conversion candidates, all BMPs located in parcels with plan year dates of 2002 or later—i.e., as noted on the County's Site Development Plan (SDP) and Final Plan for public roads (FPlan)—were eliminated from consideration. Of the remaining BMPs, those with a conversion status in the County's project database of planned, selected for concept, under construction, or complete were removed, which reduced the total number of BMP conversion candidates.

During a two day review of all sites selected via the GIS desktop analysis, Howard County Stormwater Management staff had a chance to remove sites where conditions were known to be not conducive for a project. The County also had a chance to add sites that citizens had brought to the County's attention. In the end, a total of 133 sites in Little Patuxent were selected for BMP Conversion assessment field visits, and 61 sites were selected for BMP Conversion desktop assessments. Desktop assessments were reserved for sites of interest that had been previously visited during three recent County studies conducted to identify retrofit and restoration opportunities: Upper Little Patuxent Watershed Management Plan (KCI 2009), Howard County Low Impact Development (LID) and Tree Planting Summary Report (Versar 2013a), and Howard County Dry Pond and Extended Detention Pond Retrofits Summary Report (Versar 2013b). These desktop assessments were included to put all previously studied sites into the same frame of reference, so that previously identified opportunities could be ranked and evaluated alongside the new opportunities identified during this Watershed Assessment.

3.2.2 New BMP Assessment

Prior to 1982, when the State's first Stormwater Management law was passed, there were no requirements for quantity or quality control of urban runoff. This means that when land development occurred before this law's enactment, there were very few BMPs built to control the runoff from new impervious surfaces. Controlling runoff from impervious surfaces in areas of older development presents unique challenges – there must be adequate open space available for a new BMP and the open space must be in the correct landscape location for receiving impervious runoff (or costly changes need to be made to site grading or stormwater infrastructure to re-direct runoff to the available open space). Because of this, when selecting assessment sites for new BMPs, efforts were made to limit assessments to areas where implementation of new practices would allow for treatment of significant areas of impervious surface.

The County's latest planimetric GIS layers (including buildings, parking lots, driveways and major sidewalks) were combined to identify where there were contiguous blocks of impervious surface. These blocks of impervious were then overlaid with the drainage areas treated by current or planned BMPs; the potential pool of candidates was limited to those areas not treated by an existing or planned BMP, as per the County's BMP and Water Quality Improvement Projects data. A list and geodatabase of candidate sites were prepared for presentation to Howard County staff during a site-by-site review of opportunities selected by the GIS desktop analysis.

After initial site identification, in an effort to identify candidate sites distributed across the study area, different size thresholds for candidate sites were considered (ranging from 0.5 to 2 acres). These thresholds corresponded to the variations in age of development across the study area, i.e., areas with more recent development had fewer and smaller blocks of uncontrolled impervious cover and therefore a smaller size threshold would be required to generate a number of candidate sites comparable to other areas. In the end, during the desktop site review, it was decided to set a universal threshold of greater than one acre for candidate impervious block size, in order to concentrate new BMP implementation to where it would be most beneficial and cost effective.

Initially, County-owned secondary roads and minor highways with a 50 foot pervious buffer were considered for the candidate pool. Per discussions with Howard County during the GIS

desktop review, road site candidates would be limited to those with median strips wide enough for BMP installation. Upon further review, the determination was made to not include road sites as candidates for assessment in this study, because of the anticipated difficulties in identifying large enough impervious areas and finding sufficient space for water quality treatment.

The final selection of candidate new BMP sites yielded 188 sites in Little Patuxent Watershed for field investigation.

3.2.3 Stream Restoration Assessment

Howard County GIS data were used to isolate stream segments within the Little Patuxent Watershed where environmental problems are known to exist. First, Howard County's stream centerline layer was used to select stream segments for restoration consideration. A stream segment was defined as a stream polyline that is uninterrupted by junctions or confluences with other stream polylines, whether it be a lower order stream flowing into the segment of interest, or this segment flowing into a higher order stream. A total of 860 stream segments were identified within the Little Patuxent Watershed using this method.

Specific GIS data were used to identify stream segments containing known problems, particularly where erosion had been observed, such that sites would be good candidates for further investigation of restoration potential. Past data that were used as the first step to flag potential sites included: erosion and channel alteration points from past stream corridor assessment (SCA) studies, bank stability scores collected during annual Countywide biological monitoring surveys conducted every spring (years 2001-2014), and open pervious areas within 35 foot riparian buffers contained within the County's MS4 area. A complete list of GIS layers used in this analysis, including the corresponding study if applicable, is presented in Table 3-1.

The presence of one or more SCA erosion, SCA channel alteration, or Countywide biological sites within a stream segment that met the scoring criteria noted in Table 3-1 qualified the associated stream segment as a stream restoration assessment candidate site. A total of 196 segments extending approximately 66 miles were identified as candidates using these criteria. Stream segments that lacked a forested riparian buffer were also considered for the final pool of stream restoration assessment candidate sites. The acreage of open pervious area within the 35 foot riparian buffer was calculated for each stream segment within the study areas. This value, normalized by dividing by stream length, was assigned as one indicator of the stream segments' potential for restoration. Stream segments that had an open pervious acreage to stream segment length (miles) ratio of 6 or greater were retained as candidate sites. In addition to the segments already identified for erosion and alteration issues, a total of 66 segments extending approximately 6 miles were retained as candidates for their lack of forested riparian area.

During a two-day review of sites selected by the GIS desktop analysis, staff from Howard County's Stormwater Management Division had a chance to remove sites where stream restoration work was already completed or planned, or sites where conditions were known to be not conducive for a restoration project. The County staff also had a chance to add sites that citizens had brought to the County's attention that had not made the initial list of candidates. In

the end, a total of 190 sites within the Little Patuxent Watershed extending approximately 50 miles were selected for stream restoration assessment field visits.

Table 3-1. Past studies and GIS data used to identify stream channel problems

Study Name	GIS Data Used	Criteria for Problem Sites
Upper Little Patuxent Watershed Management Plan (SCA) - 2009	Layer of points collected during Stream Corridor Assessment (SCA)	Erosion points with Severity of 1, 2 or 3 Channel Alteration points with Severity of 1, 2 or 3
Dorsey Run SCA	Layer of erosion and channel alteration points collected during SCA	Erosion points with Severity of 1, 2 or 3 Channel Alteration points with Severity of 1, 2 or 3
Little Patuxent SCA	Layer of erosion and channel alteration points collected during SCA	Erosion points with Severity of 1, 2 or 3 Channel Alteration points with Severity of 1, 2 or 3
Hammond Branch SCA	Layer of erosion and channel alteration points collected during SCA	Erosion points with Severity of 1, 2 or 3 Channel Alteration points with Severity of 1, 2 or 3
Countywide Biological Monitoring	Layers of sites visited as part of the County's biological monitoring program	Bank Stability score of 1-5 for either the right or left bank.
County Open Pervious Land Cover	Layer of open pervious area within Howard County	Open pervious area occurring within the 35 foot riparian buffer contained within the County's MS4 area.

3.2.4 Tree Planting Assessments

Howard County GIS data were used to identify parcels that are good candidates for tree planting projects. The Countywide property layer was used to select all public and County-owned property within the Little Patuxent Watershed that also fall within the County's MS4 area. Of the public and County-owned properties, those that had one or more of the following characteristics were selected:

- Parcels containing large open pervious area(s), particularly adjacent to existing forest. This was noted via visual inspection of aerial photographs
- Properties that had been visited in previous tree planting studies or efforts, but did not have a project status of proposed, concept, or completed

- Parcels containing a point representing an inadequate buffer in the County's SCA data sets
- Parcels containing a wetland of palustrine forested, shrub/scrub, or emergent types, as identified within MD DNR's wetland GIS data layer
- Parcels containing an open pervious streamside area of significant length or connectivity to existing forest. This was noted via visual inspection of aerial photography and through analyzing 35-foot stream buffers in the MDP GIS data for Agriculture or Urban pervious areas.

During a comprehensive review of sites selected by the GIS desktop analysis, Howard County Stormwater Management Division staff had a chance to remove sites where conditions were known to be not conducive for a tree planting project. As an additional step following this meeting, staff of the Howard County Recreation and Parks department were also provided with maps and given the opportunity to review the candidate sites and remove/add sites based on their local knowledge of sites and proximity to known Forest Conservation Areas (FCAs). Parcels with FCAs were not necessarily excluded, since in many cases the FCA made up a portion of the property, while potential opportunities for additional tree planting were located elsewhere on the parcel. In the end, a total of 29 sites within the Little Patuxent Watershed were selected for Tree Planting assessment field visits, and 5 sites that had been visited in previous studies were also selected for Tree Planting desktop assessments.

3.2.5 Outfall Stabilization Assessments

GIS data from previous watershed studies, BMP inspections, and Illicit Discharge Detection and Elimination (IDDE) investigations were used to identify an initial pool of outfall stabilization candidates. The GIS data were used to select outfalls that had been previously identified as having an erosion issue. Table 3-2 provides a list of the studies and their associated GIS data used to obtain an initial pool of 194 candidate outfalls within the Little Patuxent Watershed. Outfalls were removed from the initial pool of candidates if they were associated with an outfall stabilization project identified in a previous study or were within Howard County's Water Quality Improvement Project database as a planned or completed project. Table 3-3 provides a list of past studies and their associated GIS data used to remove candidate outfalls from the initial pool. The stream restoration projects listed in Howard County's Water Quality Improvement Project database were also considered as projects that may narrow down the pool of candidates. Howard County Stormwater Management staff determined that additional outfalls were to be excluded from the pool of candidate sites due to their proximity to planned stream restoration projects, which further narrowed down the candidate pool.

Several of the candidate outfalls were close enough to another candidate outfall that it was possible that they were the same outfall surveyed during multiple studies or over multiple IDDE investigations. All obvious duplicate outfalls were removed prior to the merging of candidate outfall GIS layers from previous studies, but the duplication of several proximate outfalls could not be verified due to a lack of a unique identifier and inconsistencies with surveyed outfalls matching the location of outfalls and pipes contained within the County's stormwater infrastructure GIS layers. In order to get a sense of which outfalls might be duplicates, a 25-foot buffer was created around each candidate outfall. A count of the number of candidate outfalls

that fell within each 25-foot buffer was calculated, and buffers with a count of greater than one resulted in the removal of the assumed duplicate outfall points. In the end, a total of 180 outfalls within the Little Patuxent Watershed were selected for Outfall Stabilization Assessments.

Table 3-2. Past studies and GIS data used to identify candidate outfalls

Study Name	GIS Data Used	Criteria for Problem Sites
2000, 2002-2014 IDDE*	IDDE Outfalls Geodatabases	Erosion = Moderate or Severe
BMP Inspections*	Howard County BMP inspection spreadsheet	Candidate = 3 or 4 on a 4 point scale
Upper Little Patuxent Watershed Management Plan (SCA) - 2009	Layer of points collected during Stream Corridor Assessment (SCA)	Erosion Cause = Pipe Outfall
Dorsey Run SCA	Layer of erosion points collected during SCA	Erosion Cause = Pipe Outfall
Little Patuxent SCA	Layer of erosion points collected during SCA	Erosion Cause = Pipe Outfall
Centennial Lake Unified Stream Assessment (USA) – 2005	Layer of points collected during USA	All outfall issues noted during the assessments
Wilde Lake USA – 2005	Layer of points collected during USA	All outfall stabilization sites noted during assessments
Wilde Lake Retrofits - 2005	Proposed Retrofit Projects Layer	TYPE = Outfall Stabilization OR Plunge/Step pool
Columbia Association (CA) Watershed Management Plan – 2008/2009	Project Site Points Layer	Tier = 2 Report was reviewed to determine which Tier 2 projects had outfall stabilization recommended
Dry Pond Study –2013*	Layers of ponds visited during Task 1 and Task 2 of Dry Pond Study	Ponds that fell within the Little Patuxent Watershed that had outfall channel issues noted during the assessments

* Study identified additional outfalls that fell outside of the study areas. Results were clipped to the study area.

Table 3-3. Past studies and GIS data used to exclude candidate outfalls

Study Name	GIS Data Used	Criteria
Howard County Water Quality Improvement Projects	BMP point layer in Howard County Projects Database	BMP Type = SPSC OR Outfall
General Growth Properties (GGP) Downtown Columbia Study - 2008	GGP Retrofits Layer	Type = Wooded Wetlands and Regenerative Stormwater Conveyance
CA Watershed Management Plan – 2008/2009	Project Site Points Layer	Tier = 1 Note: Report was reviewed to determine which Tier 1 projects had outfall stabilization recommended
Upper Little Patuxent Watershed Management Plan - 2009	Restoration Sites Point Layer	Type = Stream Restoration/Outfall Stabilization OR Stream, Bank, Outfall Stabilization OR Outfall Stabilization/Restoration AND Concept Plan = Yes

3.3 Desktop Analysis Summary - Results

Tables 3-4 and 3-5 show the final breakdown of sites selected for field and desktop assessments. The final number of sites that were actually assessed, which are presented in Chapter 4, do not match the numbers shown in these tables for two reasons. First, in addition to the sites selected through the desktop analysis, field teams had the ability to add new sites that they found in the field, increasing the number of assessed sites. Second, some of the sites selected through the desktop analysis were not able to be visited due to issues such as property owner constraints and sites not being found, decreasing the number of assessed sites. Explanations of why sites could not be assessed can be found in the consultant field reports located in Appendix A.

Table 3-4. Number of sites selected for field assessments in the Little Patuxent Watershed

Assessment Type	Number of Sites (or Stream Miles)
BMP Conversions (# of BMP facilities)	133
New BMPs for untreated impervious (# of sites)	188
Stream Restorations (# of stream miles)	50
Tree Planting (# of sites)	29
Outfall Stabilization (# of outfalls)	180
Total	**530 sites + 50 stream miles**

Table 3-5. Number of sites selected for desktop assessments in the Little Patuxent Watershed

Assessment Type	Total Number of Sites
BMPs Conversion	61
New BMP	6*
Tree Planting	5
Total	**72**

*One site ultimately evaluated in the field

4. FIELD ASSESSMENTS

Field assessments were conducted in early 2015 to gather data on existing conditions in the Little Patuxent Watershed and to recommend sites with potential restoration and stormwater retrofit opportunities. Teams from four consultant groups were assigned portions of the Little Patuxent Watershed to assess (Figure 4-1). Northern Little Patuxent was assessed by KCI Technologies, Southern Little Patuxent by Versar, Hammond Branch by Biohabitats, and Dorsey Run by McCormick Taylor. Additional desktop assessments were performed by Versar and KCI.

4.1 Field Methods and Calibration

4.1.1 Field Protocols

Howard County Watershed Assessment field protocols were developed by Versar, in consultation with Howard County Stormwater Management Division and the other three consultant teams. Data collection was customized for each of the five site types and focused on (1) assessing current conditions and (2) identifying and describing restoration opportunities.

Specific protocols for each type in many instances drew from existing methodologies, but with customization to ensure that data collected in the field met the needs for this project. Custom data collection protocols were developed to document the following types of assessments and recommendations.

- **Conversion of existing stormwater BMPs** - methods were derived from the Center for Watershed Protection's Retrofit Reconnaissance Investigation (RRI) protocol, from the Urban Subwatershed Restoration Manual 3 (CWP 2007);
- **Establishment of new stormwater BMPs for impervious surfaces not currently treated** - also from RRI (CWP 2007);
- **Tree planting** - methods were drawn from Pervious Area Assessments (PAA), Unified Subwatershed and Site Reconnaissance, Manual 11 (CWP 2005) and Urban Reforestation Site Assessment (URSA), Urban Watershed Forestry Manual, Part 3: Urban Tree Planting Guide (CWP 2006);
- **Stream restoration** - methods were a combination of Stream Corridor Assessment (SCA, Yetman 2001) for characterizing erosion and other stream features, EPA's Rapid Bioassessment Protocol (RBP, Barbour et al. 1999) for habitat assessment, Rosgen (1996, 2001) methods for Bank Erosion Hazard Index (BEHI) and other geomorphic indicators; and
- **Outfall stabilization** - methods were primarily derived from the SCA protocols.

A complete field packet was distributed to each of the consultant teams to ensure that assessments were being conducted in a consistent manner. The packet included guidance on naming sites added in the field, a list of sites with special notes that field crews were to read prior to assessing the sites, a field assessment decision flow chart, field names and domains for field

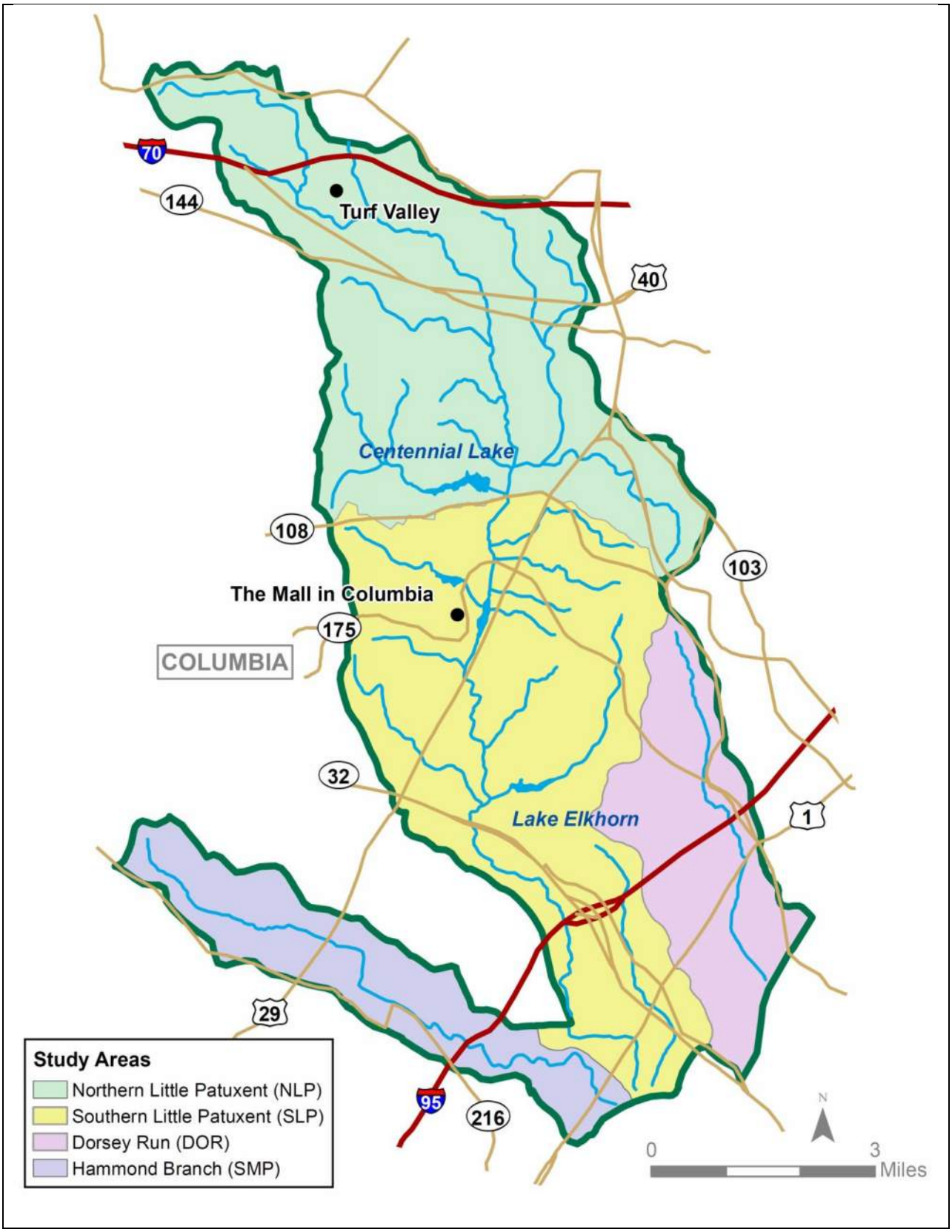


Figure 4-1. Study areas for spring 2015 site assessments within the Little Patuxent Watershed

assessment layers, Rapid Bioassessment Protocol habitat scoring sheets, and Bank Erosion Hazard Index (BEHI) diagrams. A complete copy of the packet can be found in Appendix C.

4.1.2 Electronic Data Collection

Field assessment data were collected with mobile tablet devices through the ESRI ArcCollector application. Digital photographs were taken at each assessment site and appended to the database. The electronic collection of data allowed for data to be entered directly into a geodatabase in the field and removed the step of having to manually enter data from paper datasheets in the office. ESRI Web Maps that were linked to the field assessment geodatabases were accessed from desktop computers to complete desktop assessment data entries, and to edit the field data. An ArcCollector Field Data Collection Instructions packet was developed and distributed to each of the consultant teams to be used as a reference guide while working with the geodatabases and the associated background data layers. A complete copy of the packet can be found in Appendix D.

4.1.3 Calibration of Field Teams

Prior to beginning data collection, two field assessment calibration days were held to ensure that field personnel from each of the consultant teams were familiar with the methods being used to collect field data and to create a consistent perspective among all consultant personnel for recording field observations. The first calibration day covered BMP Conversion, New BMP, and Tree Planting field assessment protocols, and was held on January 22, 2015. The second calibration day covered Stream Restoration and Outfall Stabilization field assessment protocols, and was held on January 29, 2015. Each of the calibration days consisted of a review, discussion, and revisions to field assessment protocols in the morning, followed by a review of data download, collection, and upload procedures with the tablets and the ArcCollector application in the afternoon. Brief visits to representative field sites for each of the five assessment types were also conducted.

4.1.4 Landowner Permissions

Once the complete list of field sites was created (see Section 3.3), an Excel file was created listing all properties containing field sites, along with property ownership data derived from county tax assessment data. The parcel address was used to identify the owner or local resident who would be contacted via a notification letter. The following steps were taken to refine the mailing list:

- For public property (e.g., county-owned parklands, schools), County staff confirmed that sites were accessible and no letter was sent.
- School system personnel were contacted separately, through the Howard County Public Schools Assistant Manager for Grounds. Field staff were also instructed to visit the school office, upon arrival at each school site, in order to present identification and sign in.
- Parcels containing more than one site were reduced to a single entry, to avoid duplicate mailings.

- For multiple-tenant commercial properties, a single letter was sent for the whole unit.
- Multi-owner or publicly accessible facilities (e.g., a commercial complex that would be readily accessible from a parking lot) were removed from the mailing list.
- Howard County staff reviewed the list and removed a small number of properties that would not be amenable to site visits. These parcels were clearly noted for the field crews' information, within the ArcCollector application.
- Howard County staff developed an umbrella agreement with Columbia Association, providing blanket permission for all sites on Columbia Association properties.
- Sites on agricultural properties were reviewed by the Soil Conservation District staff, who helped identify appropriate sites to visit, prior to letters being sent.
- In a few cases, County staff made direct contact with managers of larger properties (e.g., Turf Valley golf course, Alpha Ridge landfill) to coordinate permission and access to those sites.
- Parcels without address information were removed from the mailing list.

Howard County Stormwater Management Division staff developed a letter to send to property owners (see Appendix E). All letters sent, or the landowner review process performed by the County, were tracked in an Excel table for all sites and parcels. County staff sent out letters and field staff were instructed to wait an initial period of two weeks after letters were sent before beginning field work on private properties, to allow time for responses to be received by the County.

A web-based map was developed by the project team for County staff to use in recording permission responses and kept up-to-date as responses were received. Data fields were added to the data for each parcel to capture permission status (Granted, Notify Prior to Accessing, or Denied), comments, and contact name, address, and phone/email information. The map was color-coded to reflect parcel permission status. All information was readily available to field crews through the web map and ArcCollector application.

4.1.5 Field and Desktop Data Collection

The four field teams collected data during the period of March through May 2015. Teams communicated with Versar and County staff as needed to answer questions that arose about BMP data, site access, or other issues. Data were collected using field tablets, by working locally (with daily backups) or by collecting data live, on-line, and saving directly to the server.

In addition to the field assessments, two of the consultant teams (Versar and KCI) conducted desktop reviews of sites that were visited during the Upper Little Patuxent Watershed Management Plan study (KCI) and the Howard County Dry Pond study (Versar). Desktop assessments consisted of BMP Conversion, New BMP, and Tree Planting sites for KCI, and BMP Conversion sites for Versar. All of the KCI desktop assessment sites were located within the Northern Little Patuxent study area, whereas the Versar desktop assessment sites were located throughout both Little Patuxent study areas. Data for desktop assessment sites were

entered using the same data system along with field data, based on information available from prior studies and, in a few cases, a brief field visit.

4.1.6 Field Summary Reports

At the conclusion of the field visits, the consultant teams were asked to prepare a field summary report, summarizing field and desktop assessments completed, including the following information:

- Summary of the number of field assessments completed, by type;
- If there were sites that could not be assessed in the field, a summary of primary reasons;
- Comments about data or assumptions made;
- Summary of the number of recommendations made at field sites, with initial field rating of restoration potential (high, medium, or low);
- General comments about the types of recommendations made;
- List of sites reported to Howard County for follow-up because of suspected illicit discharges, safety concerns, or other reasons;
- Other comments/explanations related to data collected; and
- Summary of sites evaluated via desktop assessments.

Consultant team Field Summary Reports are included in Appendix F.

4.1.7 Field Data Quality Assurance/Quality Control

At the completion of the field and desktop assessments, all of the data for a given area were copied from the ESRI ArcGIS Server and sent to each of the consultant teams in the form of a file geodatabase. Each team had an opportunity to make any additions or edits to the geodatabases before they were sent to Versar for Quality Assurance/Quality Control (QA/QC). Once the file geodatabases were received, Versar went through each and checked for logical data (e.g., checking for stream bed particle size distributions that do not sum to 100%), use of correct site IDs, matching assessment and recommendation data, and overall completeness. Once the QA/QC process was complete, all of the file geodatabases were merged into a single personal geodatabase that could be used for the prioritization analysis.

4.2 Summary - Little Patuxent Watershed Field and Desktop Site Assessments

Table 4-1 provides a tally of the assessments conducted in Little Patuxent Watershed, for each of the five assessment types. Examples of field conditions observed are shown in the photographs in Figures 4-2 to 4-6. Locations of BMP Conversion, New BMP, Stream Restoration, Tree Planting, and Outfall Stabilization Assessment sites are shown in Figures 4-7 to 4-9. All field and desktop assessment site locations are shown in these maps.

Table 4-1. Number of assessments completed in the Little Patuxent Watershed

Type	Number of Sites (or miles) Assessed
BMP Conversion Field Assessments	129
New BMP Field Assessments	177
Stream Restoration Field Assessments	50.2
Tree Planting Field Assessments	44
Outfall Stabilization Field Assessments	191
Total Field Assessments	**541 sites + 50.2 stream miles**
BMP Conversion Desktop Assessments	51
New BMP Desktop Assessments	4
Tree Planting Desktop Assessments	4
Total Desktop Assessments	**59 sites**
Total Assessments	**600 sites + 50.2 stream miles**

Figure 4-2. Typical Dry Pond (left) and Extended Detention Dry Pond (right) evaluated during BMP Conversion Assessments

Figure 4-3. Typical untreated impervious surface (left) and a potential location for a new BMP facility (right) observed during New BMP Assessments

Figure 4-4. Typical degraded stream channels observed during Stream Restoration Assessments

Figure 4-5. Typical tree planting opportunities found along stream corridors (left) and adjacent to existing forest (right)

Figure 4-6. Typical degraded outfall channels observed during Outfall Stabilization Assessments

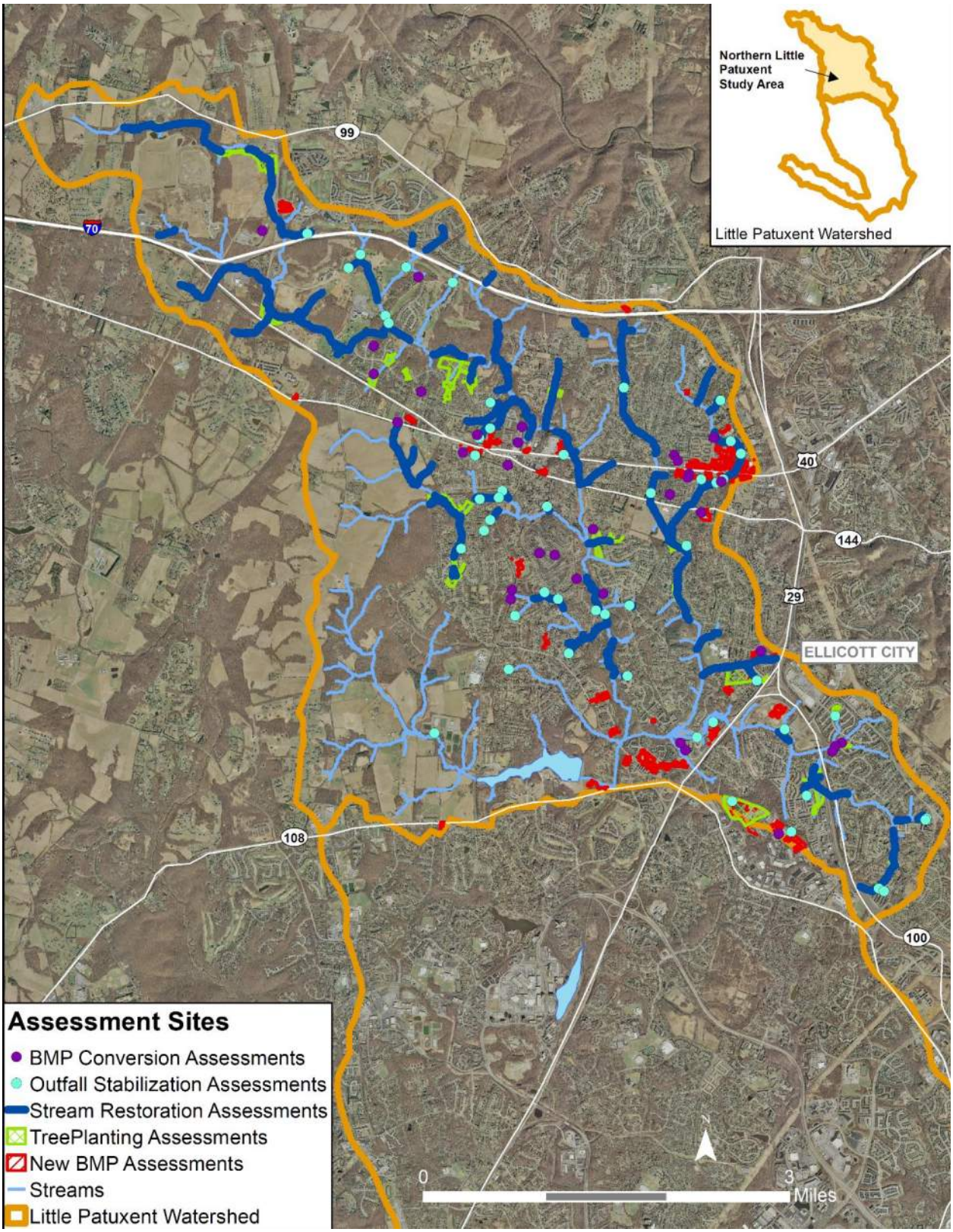


Figure 4-7. Location of assessments conducted in the Northern Little Patuxent Study Area

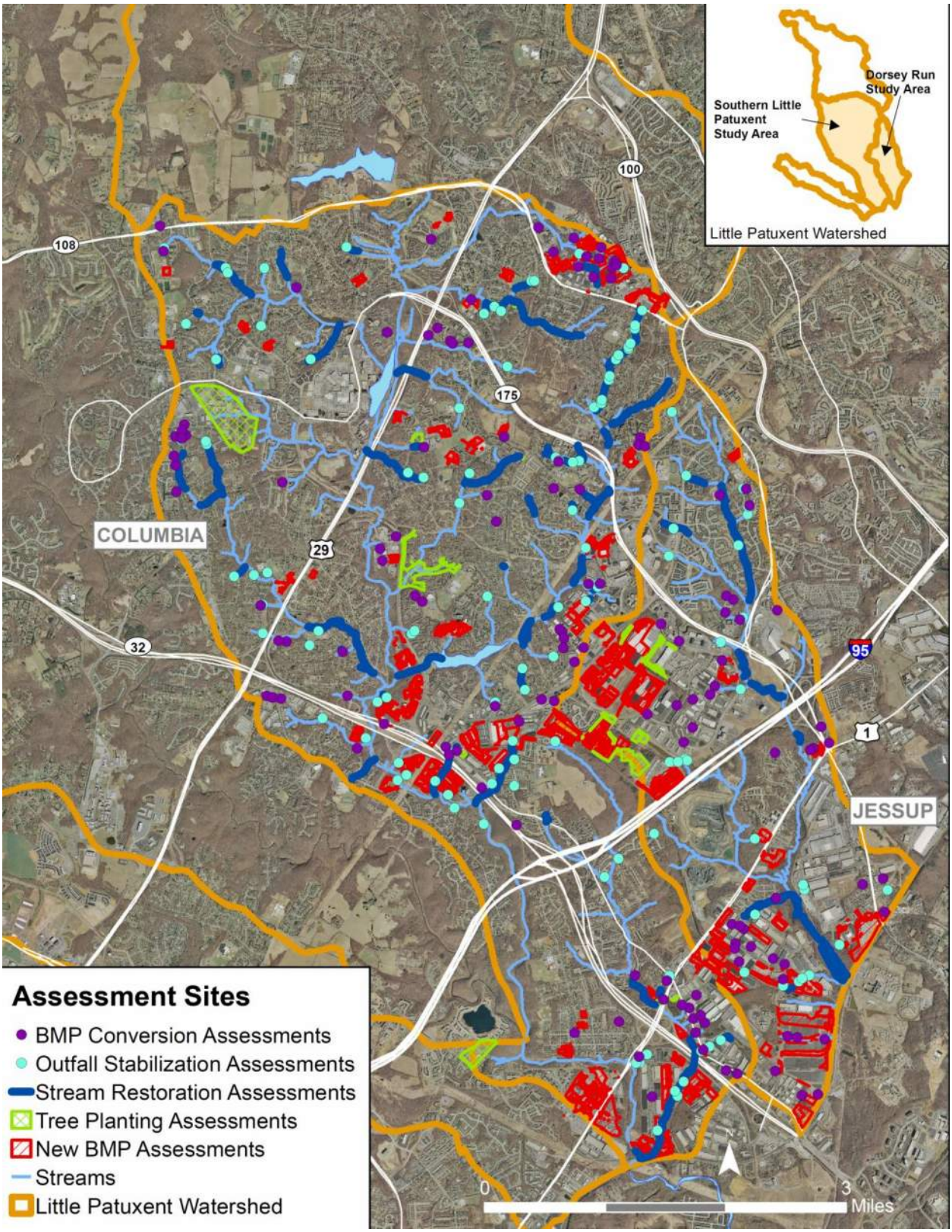


Figure 4-8. Location of assessments conducted in the Southern Little Patuxent Study Area, including Dorsey Run

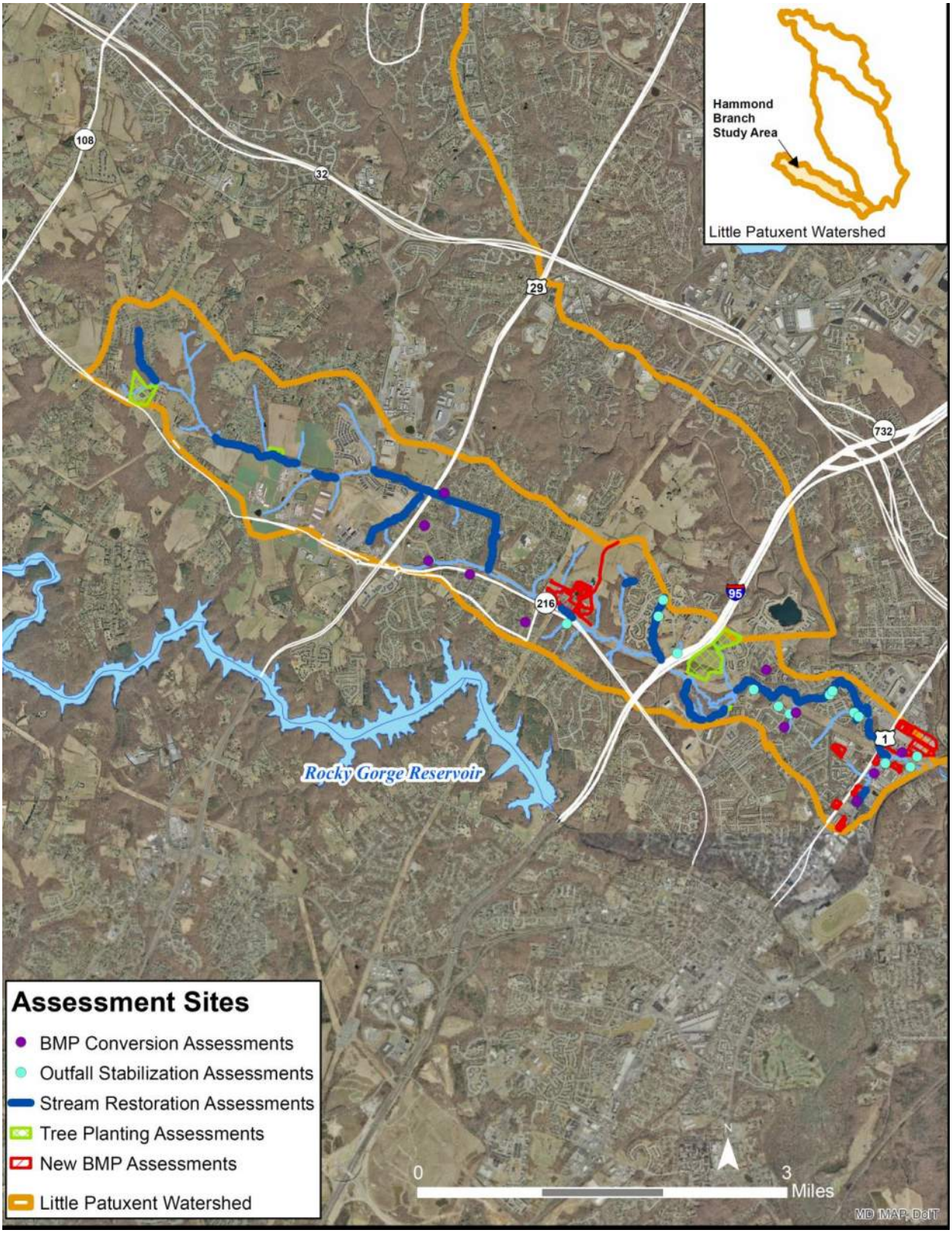


Figure 4-9. Location of assessments conducted in the Hammond Branch Study Area

4.2.1 BMP Conversion Assessments

A total of 129 BMP Conversion Assessments were conducted in the field, and an additional 51 BMP Conversion Assessments were conducted as desktop assessments. All BMP facilities evaluated for conversion potential were existing dry ponds (Figure 4-2, left) or extended detention dry ponds (Figure 4-2, right), with the exception of one wet pond. Types of BMP conversion options proposed during field and desktop assessments are discussed in Section 2.7. The majority of BMP Conversion Assessment sites were located in the Southern Little Patuxent study area due to its higher density of impervious surfaces.

4.2.2 New BMP Assessments

A total of 177 New BMP Assessments were conducted in the field, and an additional 4 New BMP Assessments were conducted as desktop assessments. The majority of areas evaluated for BMP retrofits consisted of business parks with large buildings surrounded by parking and driving surfaces for employees, customers, and deliveries. Other types of sites evaluated included schools, community centers, and apartment buildings. Representative photos of New BMP Assessment sites are shown in Figure 4-3. Similar to BMP conversion Assessment sites, the majority of New BMP Assessment sites were located in the Southern Little Patuxent study area due to its high density of untreated impervious surfaces.

4.2.3 Stream Restoration Assessments

A total of 50.2 miles of Stream Restoration Assessments were conducted in the field. The majority of stream channels evaluated consisted of degraded 1st and 2nd order perennial streams (Figure 4-4). Several intermittent and ephemeral channels were also evaluated, as well as a short section of the mainstem of the Little Patuxent River.

4.2.4 Tree Planting Assessments

A total of 44 Tree Planting Assessments were conducted in the field, and an additional 4 Tree Planting Assessments were conducted as desktop assessments. Tree Planting Assessments conducted for sites selected during the desktop analysis primarily consisted of open pervious space located on County-owned land (Figure 4-5, right). Several Tree Planting Assessments were conducted in riparian open pervious areas (Figure 4-5, left) that were noted while conducting Stream Restoration Assessments; these riparian sites added were primarily on private property.

4.2.5 Outfall Stabilization Assessments

A total of 191 Outfall Stabilization Assessments were conducted in the field. The assessed outfalls ranged in size from 4 to 120 inches in diameter, though over 50% of outfalls fell in the 18-36 inch size range. Photos of representative outfalls assessed during the study are shown in Figure 4-6. The majority of the outfalls assessed during the study were located in the Southern Little Patuxent due to its higher density of impervious surfaces and stormwater infrastructure.

4.3 Summary - Little Patuxent Watershed Restoration and Retrofit Recommendations

Locations of recommendations for BMP Conversion, New BMPs, Stream Restoration, Tree Planting, and Outfall Stabilization made based on field and desktop assessments are shown in Figures 4-10, 4-11, and 4-12. For all recommendations made, field crews assigned an initial assessment of restoration potential, rating the recommendation as High, Medium, or Low potential, based on field findings and other available information and observations. Table 4-2 summarizes the total numbers and restoration potential ratings for all recommendations made within the Little Patuxent Watershed.

Table 4-2. Summary of recommendations in the Little Patuxent Watershed

Type	Number of Recommendations	High Potential Sites	Medium Potential Sites	Low Potential Sites
BMP Conversion Field Recommendations	117	65	43	9
New BMP Field Recommendations	388	128	164	96
Stream Restoration Field Recommendations	147	65	64	18
Tree Planting Field Recommendations	58	33	13	12
Outfall Stabilization Field Recommendations	86	39	38	9
Total Field Recommendations	**796**	**330**	**322**	**144**
BMP Conversion Desktop Recommendations	48	32	14	2
New BMP Desktop Recommendations	4	3	1	0
Tree Planting Desktop Recommendations	6	3	3	0
Total Desktop Recommendations	**58**	**38**	**18**	**2**
Total Recommendations	**854**	**368**	**340**	**146**

4.3.1 BMP Conversion Recommendations

A total of 117 BMPs were recommended for conversion in the field, and an additional 48 BMPs were recommended for conversion during the desktop assessments. The majority of the proposed BMP conversion options consisted of wet ponds, wetlands, extended detention, bioretention, and non-bioretention filtering practices. Multiple conversion options were identified at the majority of the assessed sites.

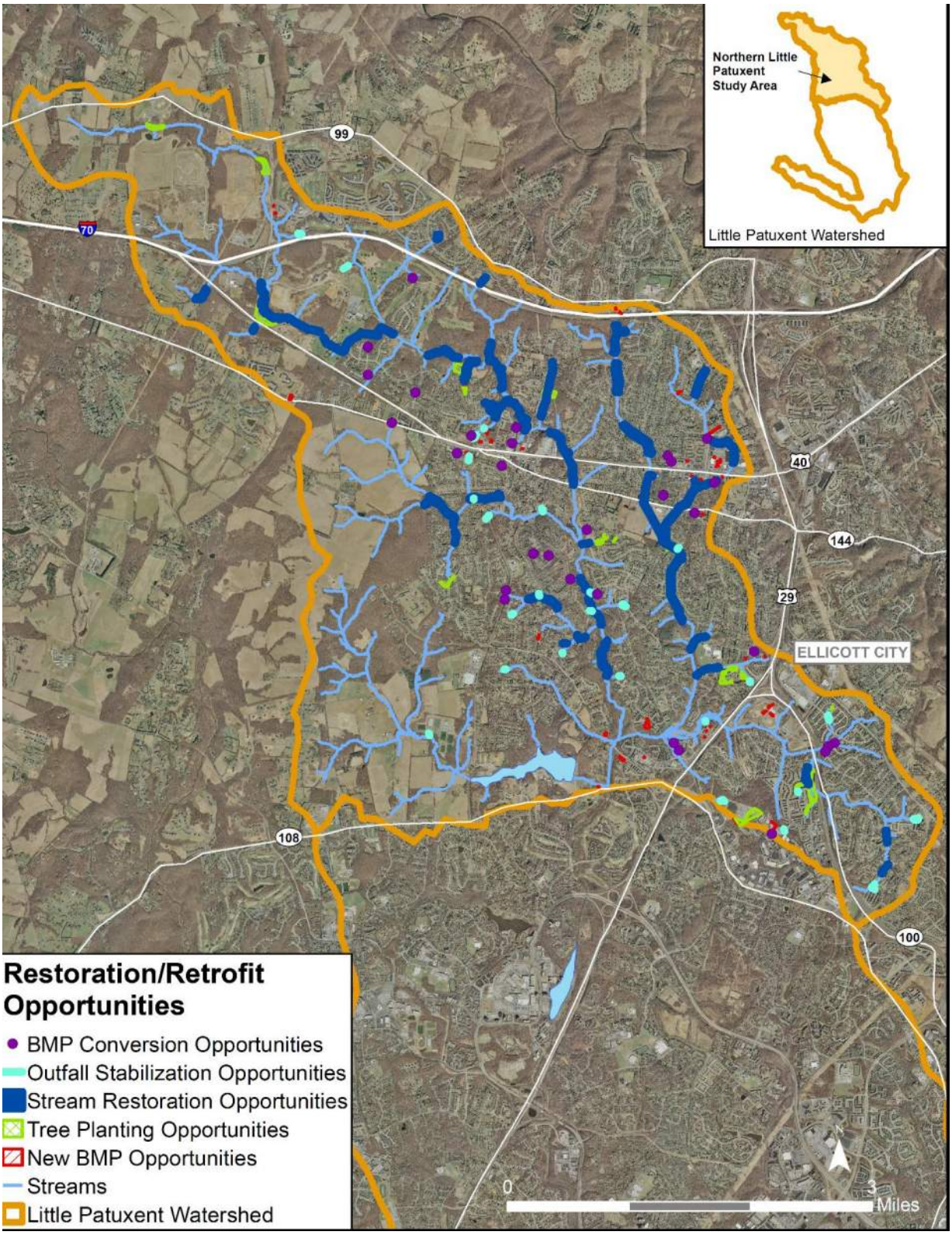


Figure 4-10. Location of restoration and retrofit opportunities in the Northern Little Patuxent Study Area

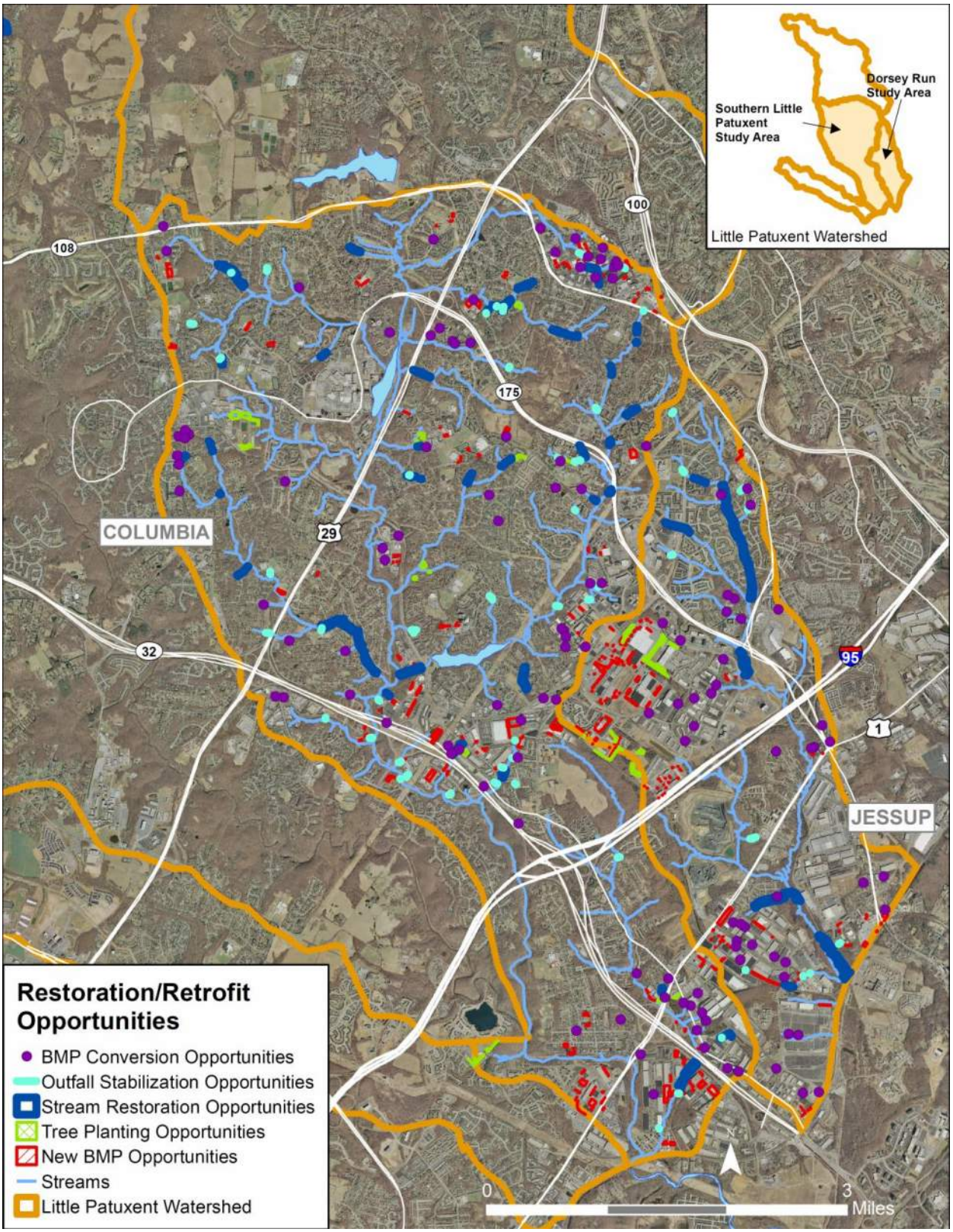


Figure 4-11. Location of restoration and retrofit opportunities in the Southern Little Patuxent Study Area, including Dorsey Run

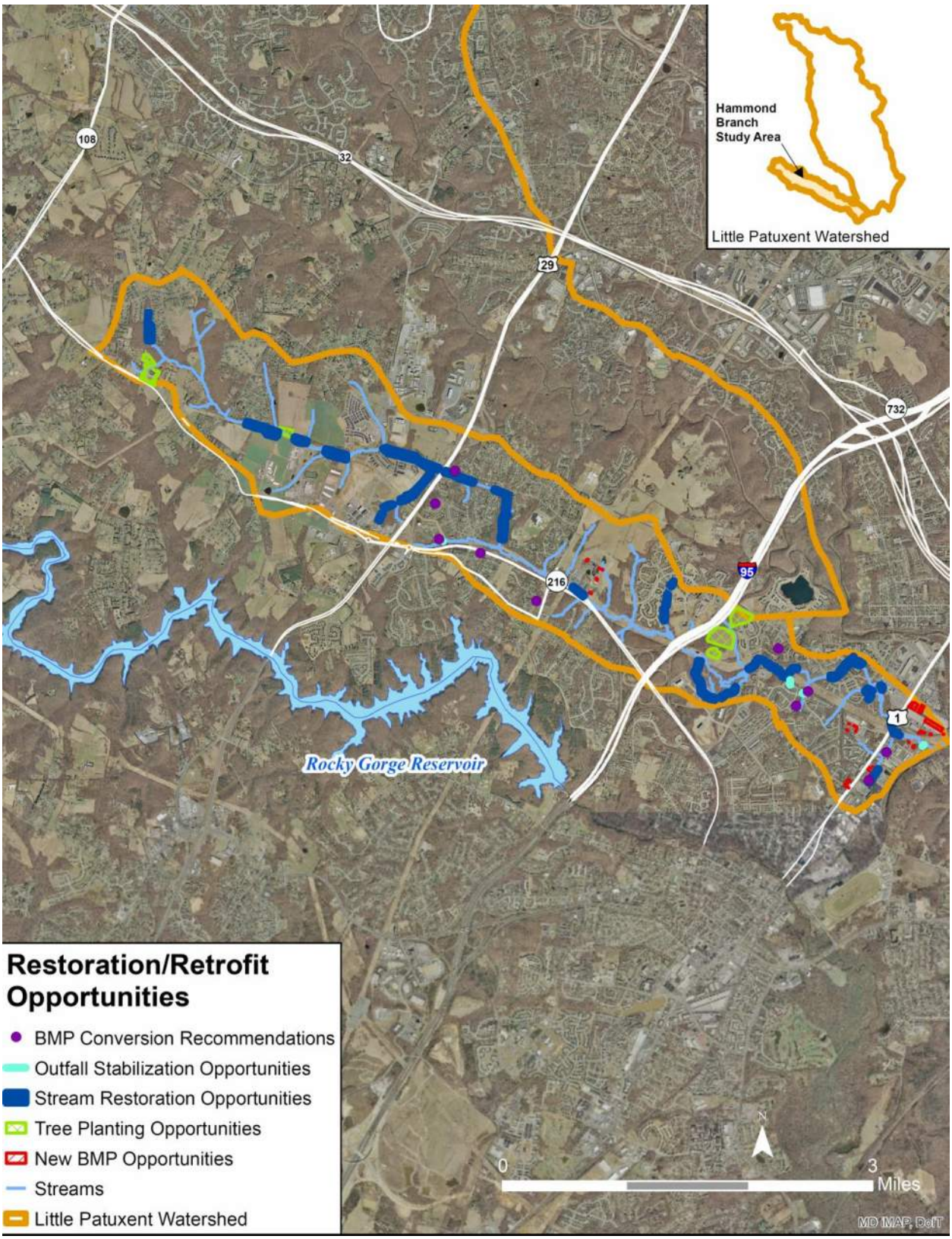


Figure 4-12. Location of Restoration and Retrofit Opportunities in the Hammond Branch Study Area

4.3.2 New BMP Recommendations

A total of 388 New BMP Recommendations were proposed in the field, and an additional 4 New BMP Recommendations were proposed for desktop sites. The majority of the proposed BMP facilities consisted of bioretention and non-bioretention filtering practices. Multiple New BMP facilities were recommended at most of the assessed sites.

4.3.3 Stream Restoration Recommendations

A total of 147 Stream Restoration Recommendations were proposed in the field. The total length of the proposed projects is approximately 25 miles. In general, stream reaches recommended for restoration contained either one (or multiple) instance(s) of severe bank erosion, or consistent minor to moderate bank erosion along with unsuitable instream habitat and threatened infrastructure (e.g., exposed utility pipes, power line poles located in the stream channel, etc.). In addition, several concrete channels were recommended for removal.

4.3.4 Tree Planting Recommendations

A total of 58 Tree Planting Recommendations were proposed in the field, and an additional 6 Tree Planting Recommendations were proposed for desktop sites. Tree planting areas ranged in size from approximately 0.25 acres to 20 acres. The majority of the Tree Planting Recommendations were between 1 and 5 acres in planting area, and the total area of all proposed tree planting projects is approximately 117 acres.

4.3.5 Outfall Stabilization Recommendations

A total of 86 Outfall Stabilization Recommendations were proposed in the field. The majority of the proposed outfall stabilization projects consisted of regenerative stormwater conveyances and were located in areas with high amounts of impervious cover.

4.4 Public Input and Feedback (Additional Sites)

Field assessment results were presented during a set of public meetings that were held by Howard County Stormwater Management Division in June 2015. During the meetings, citizens had the opportunity to review assessment findings and recommendations developed to date, and to bring issues to the attention of the County that could be investigated as additional BMP Conversion, New BMP, Stream Restoration, Tree Planting, or Outfall Stabilization Assessment sites. Meetings included a County presentation of background information, an overview of the watershed assessment process, and highlights of findings to date. During an interactive discussion period, County and consultant team staff were available to talk with participants about particular sites or concerns. Large map display posters and data tablets were available for viewing field assessment data and recommendations. As a result of the citizen input, one additional site was assessed, though it was not recommended as a potential project location.

5. RESTORATION PROJECT RANKING AND PRIORITIZATION

5.1 Ranking Methods - Overview

During the various field assessments, crews determined which locations were best suited for potential projects, as reported in Chapter 4. In all, 760 potential projects were identified. The large list of possible projects they generated, as well as the multiple goals this watershed assessment aims to address (e.g., impervious surface treatment, pollutant reductions, etc.), makes it challenging to select the best projects for implementation. To address this challenge, an automated, standardized method was developed for comparing, ranking, and prioritizing the projects. This method relied on a combination of data collected in the field, the known costs and benefits of various BMP types, and GIS analyses. The method was applied to select a set of projects for which concept designs were developed; it can be used in the future to choose additional project for design, as needed.

Projects were ranked in two different ways, the details of which will be discussed in more detail in the next sections. First, each project was ranked against all other projects of the same type. This will allow Howard County, for example, to target grant funding that must be applied to forest canopy improvement to the areas in the watershed that were identified as having the best tree planting opportunities. This type of ranking also allows for the incorporation of more specialized ranking factors. For example, the length and severity of erosion at an outfall is a useful way to compare stabilization projects, but would not apply to rankings that also include tree planting sites or locations for new BMP installations.

Second, all projects were pooled together and every potential project was ranked against each other. In this way, the County can compare the relative costs and benefits of the complete project list. This list can help to determine those projects which have the highest potential value and should be taken to the next design stage, as well as aid in modeling scenarios to determine which combination of projects will help to meet TMDL and other goals, and at what cost.

Ranking factors included the amount of impervious area restoration that would be achieved by the project (Table 5-1) and other benefits and constraints. There were some factors that were generally applicable across all project types (see details noted as level “A” in Tables 5-2 through 5-5). Level “A” factors were divided into four main categories:

- Permit contribution – how a project will help towards the County meeting the impervious surface restoration requirements in its NPDES MS4 permit, as well as its TMDL goals
- Biological uplift – if a project will provide additional benefits, such as building onto existing green infrastructure or protecting wetlands
- Programmatic benefit – if a project has value beyond its primary functional purpose, such as visible demonstration projects or public education

- Feasibility – estimation of the ease or difficulty of project implementation, including public versus private ownership, site accessibility, or whether a repair is already required at a site providing an opportunity to minimize costs by upgrading the facility during the course of other required construction activities

Each factor was scored according to various criteria (see Tables in Section 5.2 and 5.3). The sum of all the factor scores was used to rank each project, with higher total scores representing higher priority projects. A table of all projects, with scores, is found in Appendix G.

5.1.1 Impervious Area Credits

For all opportunities identified, the potential benefits in terms of impervious area restoration credit were calculated in accordance with MDE's accounting guidance (MDE 2014c). For stormwater BMPs, according to MDE criteria the target is treatment of the water quality volume (WQv), typically associated with the 1-inch rainfall event. When the practice is able to provide treatment for the full WQv, full impervious area credit is given based the total impervious area within the BMP drainage area. When less than 1 inch of rainfall is treated, impervious area treatment credit is based on the proportion of the full WQv treated. For alternative BMPs such as tree plantings and stream restoration, impervious acre equivalents were calculated based on factors provided by MDE (2014c), as summarized in Table 5-1. Impervious acre credits (and impervious acre equivalents, for alternative BMPs) are used to plan for and estimate progress toward meeting the 20% impervious area restoration requirement in Howard County's MS4 Permit (MDE 2014a).

Table 5-1. Impervious acre credits for alternative BMPs (from MDE 2014c)

BMP	Notes	Impervious Acre Equivalent
Reforestation on Pervious Urban	Survival rate of 100 trees/acre or greater; at least 50% of trees have two-inch diameter or greater (4.5 feet above ground).	0.38 acre credit / acre reforested
Impervious Urban to Pervious	Remove pavement and provide vegetative cover for 95% of area.	0.75 acre credit / acre revegetated
Impervious Urban to Forest	Survival rate of 100 trees/acre or greater; at least 50% of trees have two-inch diameter or greater (4.5 feet above ground).	1.00 acre credit / acre reforested
Regenerative Step Pool Storm Conveyance (SPSC)	Located in dry or ephemeral channels; impervious area credit is based on runoff depth treated. When less than 1 inch of rainfall is treated, a proportion of credit is taken.	1.00 acre credit / impervious acre treated, based on treating 1 inch of rainfall.
Stream Restoration	Planning level estimate	0.01 acre credit / linear foot restored
Outfall Stabilization	Stabilization or repair of localized areas of erosion below a storm drain outfall; max credit is two acres per project.	0.01 acre credit / linear foot restored

5.2 Ranking and Prioritization Within Project Types

5.2.1 BMP Conversions and New BMPs

The similar nature of these two project categories led to them sharing a set of ranking criteria (Table 5-2), though they were ranked separately. Prior to scoring and ranking, some projects were eliminated from the candidate pool. Pond conversion candidates that seemed to be naturally converting to a wetland facility were not included in the ranking, as it was unlikely that the County would want to disturb an area that was already providing additional water quality benefits. Howard County intends to focus on projects that would have larger-scale benefits, and so new BMP projects that were determined to address less than 2 acres of impervious surface were also removed from the ranking.

Table 5-2. Ranking factors, criteria and scoring for BMP conversion and new BMP projects

	Factor	Criteria	Score
A. Factors for all site types			
1. Permit contribution			
1.a	Acres of impervious treatment	> 10 acres	20
		5 - 10 acres	15
		1 - 5 acres	10
		< 1 acre	5
1.b	Pollutant load reduction factor (Sum of % load reductions for TN, TP, and sediment)	181 - 260	10
		101 - 180	6
		0 - 100	3
1.c	Cost per acre of impervious treatment	< $50,000	10
		$50,000 - $100,000	8
		$100,000 - $200,000	5
		> $200,000	2
2. Biological uplift			
2.a	BMP in a subwatershed with 45-65% of sites with IBI scores below degradation threshold	Yes	5
		No	0
2.b	BMP is within 500 feet of Green Infrastructure Network or Tier II waters	Yes	5
		No	0
3. Programmatic benefit			
3.a	Site has educational value and/or is visible for public demonstration	Yes	2
3.b	Site is near 2 or more other potential projects allowing for easier monitoring and demonstration of benefit	Yes	3
4. Feasibility			
4.a	Ease of access	Easy	10
		Moderate	6
		Difficult	3
4.b	Conflicts with infrastructure or other site constraints	None	10
		Some	6
		Many	3
4.c	Adverse impacts to nearby trees	Minimal	10
		Moderate	6
		Significant	3

Table 5-2. (Continued)

	Factor	Criteria	Score
4.d	Ownership – public vs. private	Public	10
		Private, other	0
4.e	Pond/infrastructure already in need of repair	Yes	15
4.f	Field assessment – high potential for restoration/retrofit	Yes	5

5.2.2 Tree Plantings

In the case of tree plantings, there were a few minor variations from the standard factor scoring. In the case of structural and pond BMPs, there are many different types, allowing for a wide range of pollutant reduction efficiencies per drainage acre and costs per unit treatment across different projects. In the case of tree planting projects, these values would be the same across all projects; for this reason factors 1.b and 1.c were not scored (Table 5-3). Additionally, for tree planting projects, where the impact to surrounding trees would not be a concern, the level of site preparation required for planting was substituted as a factor (see 4.c in Table 5-3).

Table 5-3. Ranking factors, criteria and scoring for tree planting projects

	Factor	Criteria	Score
A.	**Factors for all site types**		
	1. Permit contribution		
1.a	Acres of impervious treatment	> 2 acres	20
		0.75 - 2 acres	15
		0.38 - 0.75 acres	10
		< 0.38 acres	5
1.b	Pollutant load reduction factor (Sum of % load reductions for TN, TP, and sediment)	N/A – same for all sites	
1.c	Cost per acre of impervious treatment	N/A – same for all sites	
	2. Biological uplift		
2.a	Planting in a subwatershed with 45-65% of sites with IBI scores below degradation threshold	Yes	5
		No	0
2.b	Planting is within 500 feet of Green Infrastructure Network or Tier II waters	Yes	10
		No	0
2.c	Planting is within 100 feet of wetlands	Yes	5
		No	0
	3. Programmatic benefit		
3.a	Site has educational value/visible for public demonstration	Yes	2
3.b	Site is near 2 or more other potential projects allowing for easier monitoring and demonstration of benefit	Yes	3
	4. Feasibility		
4.a	Ease of access	Easy	10
		Moderate	6
		Difficult	3
4.b	Conflicts with infrastructure or other site constraints	None	10
		Some	6
		Many	3

Table 5-3. (Continued)

	Factor	Criteria	Score
4.c	Site preparation required before planting	None	10
		Minimal	8
		Moderate	5
		Extensive	2
4.d	Ownership – public vs. private	Public	10
		Private, other	0
4.e	Infrastructure in need of repair	N/A	
4.f	Field assessment – high potential for restoration/retrofit	Yes	5

5.2.3 Outfall Stabilizations

Outfall stabilization projects, for the purposes of ranking, were divided into broad categories: traditional stabilizations (e.g., riprap) and step pool stormwater conveyances (SPSC, or regenerative stormwater conveyances, RSC). These two methods of stabilization vary greatly from one another in both cost and benefit and were thus used to help differentiate the projects in scoring (Table 5-4). Beyond the standard level "A" ranking factors, an additional level "B" factor was included, in order to characterize the length and severity of erosion each project would address.

Table 5-4. Ranking factors, criteria and scoring for outfall stabilization projects

	Factor	Criteria	Score
A.	**Factors for all site types**		
	1. Permit contribution		
1.a	Acres of impervious treatment	1.5 - 2 acres	20
		1 - 1.5 acres	15
		0.5 - 1 acres	10
		< 0.5 acres	5
1.b	Pollutant load reduction factor (Note: standard outfall stabilizations receive no pollution reduction credits)	SPSC	10
		All other types	0
1.c	Cost per acre of impervious treatment (Note: Riprap is the less expensive option and receives more points)	Riprap	10
		SPSC	3
		All other types	0
	2. Biological uplift		
2.a	Stabilization in a subwatershed with 45-65% of sites with IBI scores below degradation threshold	Yes	5
		No	0
2.b	Stabilization is within 500 feet of Green Infrastructure Network or Tier II waters	Yes	5
		No	0
2.c	Stabilization is within 100 feet of wetlands	Yes	5
		No	0
	3. Programmatic benefit		
3.a	Site has educational value/visible for public demonstration	Yes	2
3.b	Site is near 2 or more other potential projects allowing for easier monitoring and demonstration of benefit	Yes	3

Table 5-4. (Continued)

	Factor	Criteria	Score
	4. Feasibility		
4.a	Ease of access	Easy	10
		Moderate	6
		Difficult	3
4.b	Conflicts with infrastructure or other site constraints	None	10
		Some	6
		Many	3
4.c	Adverse impacts to nearby trees	Minimal	10
		Moderate	6
		Significant	3
4.d	Ownership – public vs. private	Public	10
		Private, other	0
4.e	Outfall/infrastructure already in need of repair	Yes	15
4.f	Field assessment – high potential for restoration/retrofit	Yes	5
B.	**Erosion factor**		
1	Length and severity of erosion (Length of erosion in feet x erosion severity rating)	> 1,000	15
		500 – 1,000	10
		< 500	5

5.2.4 Stream Restorations

As noted for the tree planting project ranking discussed in Section 5.2.1, pollutant reduction efficiencies and costs per unit treatment are the same among all stream restoration projects, and therefore 1.b and 1.c were not scored (Table 5-5). Beyond the standard level "A" ranking factors, two additional levels of factors were incorporated into the stream restoration prioritization. A level "B" factor was included, similar to that used for the outfall stabilization ranking, which characterizes the length and severity of erosion each project would be able to address. Three level "C" factors were also included, which address factors unique to streams, such as habitat quality and other problems identified during stream corridor assessments.

Table 5-5. Ranking factors, criteria and scoring for stream restoration projects

	Factor	Criteria	Score
A.	**Factors for all site types**		
	1. Permit contribution		
1.a	Acres of impervious treatment	> 9 acres	20
		6 – 9 acres	15
		3 – 6 acres	10
		< 3 acres	5
1.b	Pollutant load reduction factor (Sum of % load reductions for TN, TP, and sediment)	N/A – same for all sites	
1.c	Cost per acre of impervious treatment	N/A – same for all sites	
	2. Biological uplift		
2.a	Restoration in a subwatershed with 45-65% of sites with IBI scores below degradation threshold	Yes	5
		No	0

Table 5-5. (Continued)

	Factor	Criteria	Score
2.b	Restoration is within 500 feet of Green Infrastructure Network or Tier II waters	Yes	5
		No	0
2.c	Restoration is within 100 feet of wetlands	Yes	5
		No	0
	3. Programmatic benefit		
3.a	Site has educational value/visible for public demonstration	Yes	2
3.b	Site is near 2 or more other potential projects allowing for easier monitoring and demonstration of benefit	Yes	3
	4. Feasibility		
4.a	Ease of access	Easy	10
		Moderate	6
		Difficult	3
4.b	Conflicts with infrastructure or other site constraints	None	5
		Some	3
		Many	1
4.c	Adverse impacts to nearby trees	Minimal	10
		Moderate	6
		Significant	3
4.d	Ownership – public vs. private	Public	10
		Private, other	0
4.e	Already in need of repair	N/A	
4.f	Field assessment – high potential for restoration/retrofit	Yes	5
	B. Erosion factor		
1	Length and severity of erosion (Length of bank erosion in feet x erosion severity rating)	> 300	15
		100 - 300	10
		< 100	5
	C. Stream condition factors		
1	Average BEHI score (length-weighted) along reach	46 - 50	10
		40 - 45	8
		30 - 39	6
		20 - 29	4
		< 20	2
2	Average Habitat Assessment score (length-weighted) within a reach rated site as non-supporting or only partially supporting aquatic biota	Yes	5
3	Number of other problems along reach (exposed pipes, pipe outfalls, unusual conditions, etc.)	Other problems > 2	10

5.3 Ranking and Prioritization Across All Project Types

In order for a fair comparison of all projects, factors were limited to those that were common to all project types (level "A"), as shown in Table 5-6. Due to minor variations in the number of factors used for the different project types (e.g., factor 4.e, which determines if repairs are already recommended at an existing facility, only applied to outfalls and BMP conversions) the sum of individual scores for categories 2 through 4 were converted to a proportion so that each

project was judged based on highest possible score for its own project type. After looking at the final ranked list of all projects, the County determined a cut-off score, above which all projects would be considered for concept plans.

Table 5-6. Ranking factors, criteria and scoring used for ranking all projects and selecting projects for concept plans

	Factor	Criteria	Score
A. Factors for all site types			
	1. Permit contribution		
1.a	Acres of impervious treatment	> 10 acres	10
		5 – 10 acres	8
		3 – 5 acres	5
		1 – 3 acres	4
		< 1 acre	2
1.b	Pollutant load reduction factor (Sum of % load reductions for TN, TP, and sediment)	201 - 260	10
		151 - 200	6
		1 - 150	3
		0	0
1.c	Cost per acre of impervious treatment	< $50,000	10
		$50,000 - $100,000	8
		$100,000 - $200,000	5
		> $200,000	2
	2. Biological uplift ***3. Programmatic benefit*** ***4. Feasibility***		
2.a – c 3.a – c 4.a – f	Sum of scores, as a proportion of total possible points (Note: Total possible points is dependent of type of site)	> 0.8	10
		0.6 - 0.8	8
		0.4 - 0.6	6
		0.2 - 0.4	4
		0.01 - 0.2	2
		0	0

5.4 Concept Plans

After the County approved the results of the ranking (Table 5-7), a four-page concept plan was developed for each of the highest ranked projects. These concept plans included:

- Location information (including a site locator map),
- Existing site conditions (including photos),
- Details of the proposed project (including a concept design drawing),
- Implementation information, such as utility constraints and other nearby projects,
- Potential impervious treatment and pollutant reduction credits, and
- Cost estimate.

Each concept plan provides a complete picture of the potential project, including costs and benefits. They may be used by the County to communicate with the public about a particular

project, to apply for a grant for funds to move forward with project implementation, or to aid in the allocation of funds during the County's budget process. The complete set of concept plans is available in Appendix H.

Table 5-7. Number of projects, by type, selected for concept plans in Little Patuxent Watershed

Project Type	Number of Concept Plans Developed
BMP Conversions	15
New BMPs	10
Tree Plantings	19
Outfall Stabilizations	20
Stream Restorations	45
Total	109

6. POLLUTANT LOAD MODELING

Howard County has implemented stormwater BMPs since the 1980s. The initial focus of stormwater management was retention and detention of large flows to reduce flooding. Subsequent designs have addressed water quality treatment, infiltration, and stream channel protection. Here, calculations are presented of the nitrogen, phosphorus, and sediment loadings and loading rates to the Little Patuxent River with the existing and planned BMPs, based on the County's BMP database as of November 12, 2015. Existing BMPs are those that have already been installed while planned BMPs are those indicated as "planned" in the database but have not yet been built. Further, calculations are presented of the nutrient and sediment loading reductions that would occur based on implementation of restoration opportunities that were identified as part of the watershed assessment presented herein (see Chapters 1-5).

Existing pollutant loads and projected reductions in loads were calculated for the application of various BMPs. The pollutant load model is spreadsheet-based and is comparable to the Maryland Assessment Scenario Tool (MAST) for calculating annual pollutant loads. The models account for the reductions by a suite of BMPs. As the first step, the model calculated existing pollutant loads using MAST loading rates at the scale of the Maryland-designated 8-digit watershed (i.e., Little Patuxent), combined with the latest county watershed land use (explained in detail below), followed by treatment with existing and planned stormwater management practices. In the second step, the model subtracted the reductions expected from future practices from the remaining existing loads using the pollutant reduction values provided in MAST, derived from the Chesapeake Bay Watershed Model. Each future practice type was compared to the pollution load reduction targets to estimate implementation effectiveness.

The pollutant load calculations and removals by BMPs were completed for the watershed for the Bay TMDL and separately for the local TMDLs. Note that Howard County land use was used in conjunction with the MAST model loading rates to calculate the loads of nitrogen, phosphorus, and sediment for the Little Patuxent Watershed. This included both a local TMDL for sediment and the Chesapeake Bay TMDL for nitrogen, phosphorus, and sediment.

For each pollutant, the model was run under existing conditions with existing and planned BMPs to determine the baseline load. While the baseline period for the Bay TMDL is 2010, the local TMDL baseline starts at 2005 for the Little Patuxent. Each BMP installed as of the baseline year was assumed to be operating as intended and included in the baseline based on the "as-built date". Next, model runs were conducted for each restoration practice and its associated pollutant load reductions. For simplicity, the restoration options for each TMDL target are shown in tables with the incremental and cumulative reductions associated with the following BMPs:

- Baseline of projects completed or planned after the TMDL baselines
- Proposed conversion of dry ponds to various upgraded practices
- Proposed conversion of extended detention ponds to various upgraded practices
- Proposed New Structural BMPs
- Proposed Tree Plantings

- Proposed Stream Restoration
- Proposed Outfall Stabilization

Using these models, provisional sets of the BMPs most likely to be feasible and cost-effective are included for the watershed. The selected combination of BMPs are thus evaluated against all TMDL targets in the watershed. The sections that follow describe this process in detail, but the basic steps are listed as follows:

1. MAST output of watershed-specific and land use-specific pollutant loadings were used to calculate baseline loading rates in pounds per acre for pervious and impervious urban areas (combined County MS4 and non-regulated urban categories for these areas). Federal, State Highway Administration (SHA), other State lands, agriculture, and water areas were included for comparison, but only forested area rates were applied where needed for some of the calculations.

2. A custom modeling spreadsheet was prepared to present the baseline calculations with watershed-specific loading rates as described above.

3. For the Bay TMDL baseline, the benefit was estimated for BMPs installed or planned for installation since the Bay TMDL model run, based on the county database of BMPs from 2010 to present.

4. For the local TMDL baseline, the benefit was estimated for BMPs installed or planned for installation since the applicable TMDL was developed, based on the county database for the year applicable to each local TMDL.

5. To estimate future load reductions, the benefits were calculated for proposed new BMPs, dry pond and extended detention pond conversions, tree plantings, stream restoration, and outfall stabilization (regenerative stormwater conveyances).

6.1 Loads and Rates (Model Tab T0)

Pollutant loading analyses for Maryland-designated 8-digit watersheds located entirely or in part within Howard County (e.g., Little Patuxent Watershed) are intended to assess the impacts of current development on water quality. To support these analyses, watershed-specific pollutant loading rates were derived for nitrogen, phosphorus, and sediment based on MAST for Howard County (www.mastonline.org). MAST results from the 2010 Progress scenario were used to develop current loadings rates for all land uses. Land use types were aggregated as listed in Table 6-1.

Table 6-1. MAST (Devereaux, 2011) land use aggregations for calculating pollutant loading rates for total Nitrogen, Total Phosphorus, and sediment

MAST Land Use Name	Aggregated Land Use Group
Alfalfa	Agriculture
Animal feeding operations	Agriculture
County Phase I/II MS4 impervious*	Impervious
County Phase I/II MS4 pervious*	Pervious
Degraded riparian pasture	Agriculture
Federal impervious	Impervious
Federal pervious	Pervious
Forest*	Forest
Harvested forest	Forest
Hay with nutrients	Agriculture
Hay without nutrients	Agriculture
Hightill with manure	Agriculture
Hightill without manure	Agriculture
Nonregulated extractive	Impervious
Nonregulated impervious developed*	Impervious
Nonregulated pervious developed*	Pervious
Nursery	Agriculture
Pasture	Agriculture
Regulated construction	Impervious
Regulated extractive	Impervious
Regulated industrial facility impervious	Impervious
Regulated industrial facility pervious	Pervious
SHA Phase I/II MS4 impervious	Impervious
SHA Phase I/II MS4 pervious	Pervious
State Phase II MS4 impervious	Impervious
State Phase II MS4 pervious	Pervious
Water	Water

* These land uses were used for estimating the loading rates for BMP benefit estimation

Detailed land use information for the Howard County watersheds was derived from a combination of Howard County's land use (received from Howard County Department of Planning and Zoning in June 2011), forest cover, and larger waterways and water body data sets; and the MDP's 2010 Land Use/Land Cover data set. For areas where the County land use data set was missing information, or identified parcels as undeveloped, for urban and agricultural types, the associated MDP data were used to complete the data coverage. Approximately 30% of the parcels with MDP land use classifications were confirmed with comparisons to aerial photography of the same time period before accepting the data set elements as replacements for the missing County data. For the purposes of watershed-scale pollutant loading analyses, a consolidated version of land use classifications was used, since loading rates do not differ significantly between certain land use classes (e.g., various forest types). The land use/land cover categories present in the study-area-wide data set and the corresponding MAST land use classes used for the pollutant loading analyses are summarized in Tables 6-2a and 6-2b.

Table 6-2a. Reclassification of Howard County 2011 land use data groups to MAST land use for Howard County watersheds

Howard County Land Use Groups	MAST Land Use Type
11, 12, 13, 14, 15, 16, 17, 18, 19 Residential	Urban*
21 Commercial	Urban*
31 Industrial	Urban*
32 Manufacturing	Urban*
33 Transportation, communication, and utilities	Urban*
41 Government	Urban*
42, 43 Institutional	Urban*
44 Recreation, parks, courses, and clubs	Urban*
45 Institutions, hospitals, churches, and cemeteries	Urban*
51-1 Farmland	Agriculture
51-2 Woodland	Forest and wetlands
61 Miscellaneous	Urban*
10, 20, 30, 40 Undeveloped	N/A

* These categories were split into pervious urban and impervious urban areas using Howard County's impervious cover (roads and buildings, parking lots, driveways, sidewalks, paved paths, etc.) GIS layers.

Table 6-2b. Reclassification of Howard County 2011 land use data and MDP 2010 Land Use/Land Cover to MAST land use for Howard County watersheds

MDP Land Use/Land Cover Classification	MAST Land Use Type
191 Very low density residential (agriculture)	Urban*
192 Very low density residential (forest)	Urban*
11 Low density residential	Urban*
12 Medium density residential	Urban*
13 High density residential	Urban*
14 Commercial	Urban*
15 Industrial	Urban*
16 Institutional	Urban*
17 Extractive	Urban*
18 Open urban land	Urban*
21 Cropland	Agriculture
22 Pasture	Agriculture
41 Deciduous forest	Forest and wetlands
43 Mixed forest	Forest and wetlands
44 Brush	Forest and wetlands
50 Water	Water
60 Wetlands	Forest and wetlands
73 Bare ground	Urban*
80 Transportation	Urban*

* These categories were split into pervious urban and impervious urban areas using Howard County's impervious cover (roads and buildings, parking lots, driveways, sidewalks, paved paths, etc.) GIS layers.

Consolidated land uses were used to determine the total acreage for each land use category in the watershed. These were multiplied by the corresponding loading rates derived from MAST. Resulting annual pollutant loads for total nitrogen, total phosphorus, and sediment from the watershed are summarized by land use. Estimates provide baseline nutrient loads before implementation of restoration projects and will allow a better assessment of both progress made to date and further progress needed to meet TMDL goals for urban stormwater runoff pollutant reduction. Annual nutrient and sediment loads for the Little Patuxent Watershed Bay TMDL are summarized in Table 6-3 and for the local TMDL in Table 6-4. These tables also include nitrogen, phosphorus, and sediment loading rates (lbs/ac/yr). The total pollutant load estimate will be used to estimate necessary reductions to meet local and Chesapeake Bay TMDL goals.

Table 6-3. Existing (2010) Annual Pollutant Loads within Little Patuxent Watershed (02131105) for the Chesapeake Bay TMDL

Land Use	County Area (acres)	Nitrogen		Phosphorus		Sediment	
		Rate (lbs/ac/yr)	Load (lbs/yr)	Rate (lbs/ac/yr)	Load (lbs/yr)	Rate (lbs/ac/yr)	Load (lbs/yr)
Urban Impervious	8,002	15.62	124,974	1.99	15,930	2,013.7	16,113,753
Urban Pervious	16,152	9.93	160,351	0.29	4,714	286.2	4,622,235
Agricultural	1,853	7.81	14,468	0.97	1,790	720.9	1,335,588
Forest	9,468	3.49	33,029	0.08	740	194.4	1,840,996
Water	425	9.37	3,980	0.61	260	0.0	0
Totals	35,900		336,802		23,434		23,912,572
Total Urban	24,155		285,325		20,644		20,735,988

Table 6-4. Existing (2010) Annual Pollutant Loads within Little Patuxent Watershed (02131105) for the local sediment TMDL

Land Use	MAST 2005 Area (acres)	Nitrogen		Phosphorus		Sediment	
		Rate (lbs/ac/yr)	Load (lbs/yr)	Rate (lbs/ac/yr)	Load (lbs/yr)	Rate (lbs/ac/yr)	Load (lbs/yr)
Urban Impervious	6,620	16.11	106,683	1.66	11,010	1,551.5	10,271,289
Urban Pervious	18,189	9.65	175,585	0.34	6,249	239.6	4,358,188
Agriculture	2,077	16.56	34,387	1.65	3,430	1,008.3	2,094,074
Forest	8,101	3.64	29,509	0.08	635	184.9	1,498,031
Water	79	13.11	1,038	0.61	48	0.0	0
Totals	35,067		347,203		21,372		18,221,582
Total Urban	24,810		282,269		17,259		14,629,477

6.2 Existing Stormwater Management (Model Tab T1)

The following sections present a quantitative analysis of pollutant removal capabilities of existing and potential BMPs to estimate reduction in nutrient loads from urban runoff in this watershed. The removal efficiencies used to estimate pollutant reductions are based on the August 5, 2015 version of MAST (www.mastonline.org). Table 6-5 presents the removal efficiency rates used in this analysis for structural BMPs except as noted elsewhere in the text; where there are multiple rates for a BMP type based on soil group and the soil group is not known, the removal rate used was for the soil group most likely to be proposed for that BMP type. Also note that the calculations and estimates presented in the following subsections represent maximum potential pollutant reduction capabilities. A summary of overall pollutant load reduction estimates is presented at the end of this section.

Howard County has implemented many capital improvement projects in the county's various watersheds including stream restoration, stormwater facility conversions, and retrofits (new BMPs in drainage areas where none were previously installed). Pollutant loads were estimated based on the contributing drainage area (DA) and the corresponding project type's land use-specific pollutant loading rates. Load reduction is calculated as the product of the pollutant load and removal efficiency. For existing and planned BMPs, pollutant removals are shown in Table 6-5. For stream restoration projects, nutrient reduction credits are based on the length of stream restored. Existing SWM facilities in the county's watersheds include dry ponds, infiltration and filtration practices, extended detention, proprietary BMPs, and other types of SWM facilities (e.g., underground detention). For local TMDLs, some of which were developed based on data collected more than 10 years ago, existing and planned BMPs that were added to the county database since development of that TMDL were included in the calculations. Here, "planned" BMPs refers to those listed in Howard County's BMP database as planned, but that are not yet built. This does not include newer recommendations, such as those BMPs proposed as a result of the current watershed assessment. The work done to create the Bay TMDL takes into account all BMPs implemented through 2009; this was the most recent year that there was BMP implementation data at the time that the Bay TMDL was published. All BMPs on the ground at that time were credited toward the allocations. Any BMPs added after 2009 are included in the calculations presented here (Table 6-6). The Little Patuxent Watershed has a local TMDL for sediment, with a baseline year of 2005. Thus, any BMPs added after 2004 are included in Table 6-7.

Pollutant reductions for existing and planned BMPs were calculated based on the approximate pollutant load received from the DA and removal efficiencies (RE) used in MAST for the various types of SWM faculties. The equation used to estimate nutrient and sediment load reductions for a particular type of SWM facility is expressed as

[#(lbs/ac/yr)*DA (acres)]*RE (%)

Table 6-5. BMP efficiencies used in MAST for the land use and hydro-geomorphic region applicable to Howard County (County MS4). From http://www.mastonline.org/Documentation.aspx.

BMP	BMP Short Name	Nitrogen Effectiveness (%)	Phosphorus Effectiveness (%)	Sediment Effectiveness (%)
Bioretention/raingardens - A/B soils, no underdrain	BioRetNoUDAB	80	85	90
Bioretention/raingardens - A/B soils, underdrain	BioRetUDAB	70	75	80
Bioretention/raingardens - C/D soils, underdrain	BioRetUDCD	25	45	55
Bioswale	BioSwale	70	75	80
Dry Detention Ponds and Hydrodynamic Structures	DryPonds	5	10	10
Dry Extended Detention Ponds	ExtDryPonds	20	20	60
MS4 Permit-Required Stormwater Retrofit	RetroSWM	25	35	65
Permeable Pavement w/ Sand, Veg. - A/B soils, no underdrain	PermPavSVNoUDAB	80	80	85
Permeable Pavement w/ Sand, Veg. - A/B soils, underdrain	PermPavSVUDAB	50	50	70
Permeable Pavement w/ Sand, Veg. - C/D soils, underdrain	PermPavSVUDCD	20	20	55
Permeable Pavement w/o Sand, Veg. - A/B soils, no underdrain	PermPavNoSVNoUDAB	75	80	85
Permeable Pavement w/o Sand, Veg. - A/B soils, underdrain	PermPavNoSVUDAB	45	50	70
Permeable Pavement w/o Sand, Veg. - C/D soils, underdrain	PermPavNoSVUDCD	10	20	55
Stormwater Management by Era 1985 to 2002 MD	SWMEra8502	17	30	40
Stormwater Management by Era 2002 to 2010 MD	SWMEra0210	30	40	80
Stormwater to the Maximum Extent Practicable (SW to the MEP)	E3SWMNew	50	60	90
Street Sweeping 26 times a year-acres (formerly called Street Sweeping Mechanical Monthly)	StreetSweep	3	3	9
Urban Filtering Practices	Filter	40	60	80
Urban Forest Buffers	ForestBufUrban	25	50	50
Urban Infiltration Practices w/ Sand, Veg. - A/B soils, no underdrain	InfiltWithSV	85	85	95
Urban Infiltration Practices w/o Sand, Veg. - A/B soils, no underdrain	Infiltration	80	85	95
Vegetated Open Channels - A/B soils, no underdrain	VegOpChanNoUDAB	45	45	70
Vegetated Open Channels - C/D soils, no underdrain	VegOpChanNoUDCD	10	10	50
Wet Ponds and Wetlands	WetPondWetland	20	45	60

The pollutant load received from the drainage area contributing to the SWM facility is denoted by the first expression in brackets in the previous equation. The pollutant loading rates shown for Total Nitrogen, Total Phosphorus, and Sediment, each expressed as number of lbs/ac/yr, represent the impervious and pervious urban rates used in the pollutant loading analysis for each watershed (Tables 6-3 and 6-4) since this represents the likely sources of runoff being treated. Note that impervious and pervious urban loading rates are based on MAST. The percent pollutant removal efficiency depends on the type of facility and is based on the values shown in Table 6-5. The total pollutant load reduction expected from existing and planned BMPs is a sum of the removal capacities of the individual facilities. A summary of existing SWM load reduction calculations and results are shown in the Tables that follow.

Table 6-6. Existing Stormwater Management Practices in the Little Patuxent Watershed installed after 2009, showing potential pollutant load reductions applicable to the Bay TMDL.

SWM Facility Type	Imper-vious DA (acres)	Perv-ious DA (acres)	Total Nitrogen			Total Phosphorus			Sediment		
			Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)
BioRetention, A/B soils, no underdrain	0.00	0.00	0.0	80%	0.0	0.0	85%	0.0	0.0	90%	0
BioRetention, A/B soils, with underdrain	19.38	15.36	455.2	70%	318.6	43.1	75%	32.3	43,418.7	80%	34,735
BioRetention, C/D soils, with underdrain	36.32	29.54	860.4	25%	215.1	80.9	45%	36.4	81,582.0	55%	44,870
BioSwale	1.22	4.79	66.6	70%	46.6	3.8	75%	2.9	3,824.5	80%	3,060
Dry Ponds	58.84	109.88	2,009.7	5%	100.5	149.2	10%	14.9	149,925.9	10%	14,993
Extended Dry Ponds	17.25	45.83	724.5	20%	144.9	47.7	20%	9.5	47,859.1	60%	28,715
Urban Filtering Practices	35.42	40.23	952.5	40%	381.0	82.2	60%	49.3	82,831.1	80%	66,265
Urban Infiltration Practices, w/o S/V, A/B soils	20.63	13.22	453.5	80%	362.8	44.9	85%	38.2	45,334.1	95%	43,067
Urban Infiltration Practices, w/o S/V, C/D soils	27.34	25.13	676.4	85%	575.0	61.8	85%	52.5	62,238.3	95%	59,126
Urban Infiltration Practices, w S/V, A/B soils	16.50	7.70	334.0	85%		35.1	85%		35,420.3	95%	
Urban Infiltration Practices, w S/V, C/D soils	1.06	0.45	21.1	85%	17.9	2.2	85%	1.9	2,268.8	95%	2,155
Permeable Pavement, w/o S/V, UD, C/D soils	1.19	0.17	20.3	10%	2.0	2.4	20%	0.5	2,441.0	55%	1,343
Step Pool Stormwater Conveyance	3.63	3.42	56.7	57%	32.3	7.2	66%	4.8	7,311.5	70%	5,118
Vegetated Open Channels - C/D soils, no UD	0.49	0.26	10.2	10%	1.0	1.0	10%	0.1	1,058.8	50%	529
Wet Ponds	220.21	317.15	6,587.5	20%	1,317.5	530.9	45%		534,173.4	60%	320,504
BioRetention, A/B soils, no underdrain	0.00	0.00	0.0	80%	0.0	0.0	85%	0.0	0.0	90%	0
Total	**459.62**	**613.15**	**13,231**		**3,516**	**1,093**		**243**	**1,099,990**		**624,692**

Table 6-7. Existing Stormwater Management Practices in the Little Patuxent Watershed installed after 2004, showing potential pollutant load reductions applicable to the local sediment TMDL.

SWM Facility Type	Imper-vious DA (acres)	Pervious DA (acres)	Total Nitrogen			Total Phosphorus			Sediment		
			Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)
BioRetention, A/B soils, no underdrain	0.00	0.00	0.0	70%	0	0.0	75%	0	0.0	80%	0
BioRetention, A/B soils, with underdrain	29.76	26.08	731.3	5%	37	58.5	10%	6	52,421.4	10%	5,242
BioRetention, C/D soils, with underdrain	51.24	50.24	1,310.6	20%	262	102.5	20%	20	91,529.6	60%	54,918
BioSwale	34.90	60.96	1,150.9	40%	460	79.0	60%	47	68,754.6	80%	55,004
Dry Ponds	135.87	167.90	3,810.2	80%	3,048	283.6	85%	241	251,025.6	95%	238,474
Extended Dry Ponds	57.96	119.67	2,089.2	20%	418	137.5	45%	62	118,598.4	60%	71,159
Urban Filtering Practices	62.91	77.91	1,765.9	70%	1,236	131.4	75%	99	116,277.2	80%	93,022
Urban Infiltration Practices, w/o S/V, A/B soils	48.16	43.11	1,192.2	80%	954	94.9	85%	81	85,049.6	90%	76,545
Urban Infiltration Practices, w/o S/V, C/D soils	42.45	30.41	977.6	80%	782	81.0	85%	69	73,147.4	90%	65,833
Urban Infiltration Practices, w S/V, A/B soils	16.50	7.70	340.1	85%	289	30.1	85%	26	27,438.0	90%	24,694
Urban Infiltration Practices, w S/V, C/D soils	7.17	1.55	130.6	85%	111	12.5	85%	11	11,504.2	90%	10,354
Step Pool Stormwater Conveyance	3.63	3.42	58.5	57%	33.4	6.0	66%	4.0	5,633.4	70%	3,943
Permeable Pavement, w/o S/V, no underdrain, C/D soils	1.19	0.17	20.8	10%	2.1	2.0	20%	0.4	1,884.1	55%	1,036
Vegetated Open Channels - A/B soils, no UD	0.15	0.00	2.4	45%	1.1	0.2	45%	0.1	232.7	70%	163
Vegetated Open Channels - C/D soils, no UD	0.49	0.26	10.4	10%	1.0	0.9	10%	0.1	820.8	50%	410
Wet Ponds	624.14	901.71	18,762.2	20%	3,752	1,347.7	45%	606	1,184,400.9	60%	710,641
Total	**1116.52**	**1491.09**	**32,353**		**11,387**	**2,368**		**1,272**	**2,088,718**		**1,411,438**

6.3 Stormwater Management Pond Conversions (Model Tab T2)

This analysis calculates the anticipated pollutant load reductions that would result from implementing stormwater facility conversions, as per the opportunities identified in the watershed assessment (see Section 4.3.1). Results are presented for all opportunities identified, including those with and without concept plans.

Some dry ponds and extended detention dry ponds can be converted to facilities with higher capacity for nutrient removal. Pollutant reductions for these SWM pond conversions are calculated based on the approximate pollutant load received from the DA and the increase in RE based on BMP efficiencies in MAST for detention and extended detention facilities (See Table 6-5). The equation used to estimate nutrient and sediment load reductions for SWM pond conversion is expressed as

[#(lbs/ac/yr)*DA (acres)]*RE (%)

The pollutant load received from the drainage area contribution to the SWM pond is denoted by the first expression in brackets in the equation above. Similar to existing SWM, the pollutant loading rates, # lbs Total Nitrogen/ac/yr, # lbs Total Phosphorus/ac/yr, or # lbs Sediment ac/yr, represent the impervious and pervious urban rates in the pollutant loading analysis (Tables 6-3 and 6-4) since this represents the likely sources of runoff being treated. The increased pollutant removal capacity is represented by the third expression in the equation above. This is the difference between percent pollutant removal efficiencies of the facilities, based on CBP guidance shown in Table 6-5. A summary of SWM pond conversion load reduction calculations and results are shown in Table 6-8.

Additionally, each individual BMP conversion project is listed in Appendix I, Table I-1.

Table 6-8. Stormwater Management Facility (SWM) conversions proposed for the Little Patuxent Watershed and potential pollutant load reductions, summarized by MAST category

Pollutant	Impervious DA for Conversion (acres)	Pervious DA for Conversion (acres)	Original Removal Efficiency	New Removal Efficiency	Increase in Efficiency	Max Potential Load Reduction (lbs/yr)
Dry Ponds to BioSwale, with concepts						
TN	3.47	9.13	5%	70%	65%	94
TP	3.47	9.13	10%	75%	65%	6
Sediment	3.47	9.13	10%	80%	70%	6,716
Dry Ponds to Extended Dry Ponds, with concepts						
TN	42.06	45.41	5%	20%	15%	166
TP	42.06	45.41	10%	20%	10%	10
Sediment	42.06	45.41	10%	60%	50%	48,849
Dry Ponds to Wet Ponds, with concepts						
TN	38.42	79.20	5%	20%	15%	208
TP	38.42	79.20	10%	45%	35%	35
Sediment	38.42	79.20	10%	60%	50%	50,014
Extended Dry Ponds to Filter, with concepts						
TN	8.81	10.63	20%	40%	20%	49
TP	8.81	10.63	20%	60%	40%	8
Sediment	8.81	10.63	60%	80%	20%	4,156
Extended Dry Ponds to Wet Pond, with concepts						
TN	9.76	8.04	20%	20%	0%	0
TP	9.76	8.04	20%	45%	25%	5
Sediment	9.76	8.04	60%	60%	0%	0
Dry Ponds to Bioretention with underdrain and A/B soils, without concepts						
TN	4.97	2.26	5%	70%	65%	65
TP	4.97	2.26	10%	75%	65%	7
Sediment	4.97	2.26	10%	80%	70%	7,452
Dry Ponds to Bioretention with underdrain and C/D soils, without concepts						
TN	4.12	8.18	5%	25%	20%	29
TP	4.12	8.18	10%	45%	35%	4
Sediment	4.12	8.18	10%	55%	45%	4,783
Dry Ponds to Swale, without concepts						
TN	6.33	3.93	5%	70%	65%	90
TP	6.33	3.93	10%	75%	65%	9
Sediment	6.33	3.93	10%	80%	70%	9,714
Dry Ponds to Extended Dry Ponds, without concepts						
TN	18.81	38.94	5%	20%	15%	102
TP	18.81	38.94	10%	20%	10%	5
Sediment	18.81	38.94	10%	60%	50%	24,511
Dry Ponds to Urban Filtering Practices, without concepts						
TN	64.96	61.19	5%	40%	35%	568
TP	64.96	61.19	10%	60%	50%	74
Sediment	64.96	61.19	10%	80%	70%	103,818

Table 6-8. (Continued)

Pollutant	Impervious DA for Conversion (acres)	Pervious DA for Conversion (acres)	Original Removal Efficiency	New Removal Efficiency	Increase in Efficiency	Max Potential Load Reduction (lbs/yr)
Dry Ponds to Infiltration Practices w/o Sand, Veg., without concepts						
TN	5.83	15.14	5%	80%	75%	181
TP	5.83	15.14	10%	85%	75%	12
Sediment	5.83	15.14	10%	95%	85%	13,655
Dry Ponds to Wet Ponds, without concepts						
TN	186.37	261.54	5%	20%	15%	826
TP	186.37	261.54	10%	45%	35%	157
Sediment	186.37	261.54	10%	60%	50%	225,065
Extended Dry Ponds to Bioretention with underdrain and A/B soils, without concepts						
TN	1.69	4.26	20%	70%	50%	34
TP	1.69	4.26	20%	75%	55%	3
Sediment	1.69	4.26	60%	80%	20%	924
Extended Dry Ponds to Bioretention with underdrain and C/D soils, without concepts						
TN	7.77	14.47	20%	25%	5%	13
TP	7.77	14.47	20%	45%	25%	5
Sediment	7.77	14.47	60%	55%	-5%	-989
Extended Dry Ponds to Biowale, without concepts						
TN	6.85	2.40	20%	70%	50%	65
TP	6.85	2.40	20%	75%	55%	8
Sediment	6.85	2.40	60%	80%	20%	2,896
Extended Dry Ponds to Urban Filtering Practices, without concepts						
TN	18.04	34.44	20%	40%	20%	125
TP	18.04	34.44	20%	60%	40%	18
Sediment	18.04	34.44	60%	80%	20%	9,238
Extended Dry Ponds to Infiltration Practices w/o Sand, Veg., without concepts						
TN	3.31	8.22	20%	80%	60%	80
TP	3.31	8.22	20%	85%	65%	6
Sediment	3.31	8.22	60%	95%	35%	3,159
Extended Dry Ponds to Stormwater to the MEP - Step Pool Stormwater Conveyance, without concepts						
TN	1.66	4.37	20%	57%	37%	26
TP	1.66	4.37	20%	66%	46%	2
Sediment	1.66	4.37	60%	70%	10%	459
Extended Dry Ponds to Wet Ponds, without concepts						
TN	144.21	131.54	20%	20%	0%	0
TP	144.21	131.54	20%	45%	25%	81
Sediment	144.21	131.54	60%	60%	0%	0

6.4 New Stormwater Control Measures (Model tab T3)

This analysis calculates the anticipated pollutant load reductions that would result from implementing new BMPs, as per the opportunities identified in the watershed assessment (see Section 4.3.2). Results are presented for all opportunities identified, including those with and without concept plans.

New BMPs are proposed to capture and treat runoff from impervious surfaces (e.g., buildings, parking lots, alleys) which are currently untreated. Pollutant reductions for new BMPs are calculated based on the approximated pollutant load received from the DA and RE of these structural BMPs. The equation used to estimate nutrient and sediment load reductions for new BMPs is expressed as

[# (lbs/ac/yr)*DA (acres)]*RE (%)

The pollutant load received from the drainage area contributing to the BMP is denoted by the first expression in brackets in the equation above. The pollutant loading rates shown, # lbs Total Nitrogen/ac/yr, # lbs Total Phosphorus/ac/yr, or # lbs Sediment/ac/yr, are the pervious and impervious urban rates used in the pollutant loading analysis (Tables 6-3 and 6-4) since this represents the source of runoff being treated. Pollutant removal efficiencies are those from Table 6-5. A summary of these BMP load reduction calculations and results are shown in Table 6-9.

Additionally, each individual new BMP project is listed in Table I-2 in Appendix I.

Table 6-9. Proposed Stormwater Management (SWM) facilities for the Little Patuxent Watershed showing potential pollutant load reductions summarized by MAST category type and those with and without concept designs

SWM Facility Type	Impervious DA (acres)	Pervious DA (acres)	Total Nitrogen			Total Phosphorus			Sediment		
			Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)
Bioretention with underdrain on CD soils, Concepts	4.63	2.22	80.6	25%	20.2	9.9	45%	4.4	9958	55%	5477
Filter, Concepts	12.99	0.88	142.7	40%	57.1	26.1	60%	15.7	26409	80%	21127
Wet Pond, Concepts	15.85	9.56	306.6	20%	61.3	34.3	45%	15.5	34652	60%	20791
Bioretention with underdrain on AB soils, No Concepts	5.37	4.31	120.7	70%	84.5	12.0	75%	9.0	12053	80%	9642
Bioretention with underdrain on CD soils, No Concepts	47.68	16.82	736.1	25%	184.0	99.8	45%	44.9	100824	55%	55453
BioSwale, No Concepts	22.38	12.63	419.4	70%	293.6	48.2	75%	36.2	48684	80%	38947
DryPonds, No Concepts	1.15	0.34	16.8	5%	0.8	2.4	10%	0.2	2416	10%	242
Filter, No Concepts	152.07	30.00	1978.2	40%	791.3	311.5	60%	186.9	314806	80%	251845
Infiltration, No Concepts	8.30	3.57	138.2	80%	110.5	17.6	85%	14.9	17740	95%	16853
Permeable Pavement, NoSV, NoUD, No Concepts	21.02	2.47	247.3	75%	185.5	42.6	80%	34.1	43041	85%	36585
Wet Pond, No Concepts	24.73	8.74	382.0	20%	76.4	51.8	45%	23.3	52299	60%	31380
TOTAL	**316**	**92**	**4569**		**1865**	**656**		**385**	**662882**		**488342**

6.5 Impervious Surface Reduction (Model Tab T4)

Impervious cover removal would involve converting impervious surfaces to pervious surfaces; therefore, the loading rate would be reduced by a factor equal to the difference between impervious and pervious urban loading rates in the watershed pollutant loading analysis. The approximate reduction in pollutant load is then the reduced loading rate multiplied by the area proposed for impervious cover removal, as shown in Tables 6-10 and 6-11.

Table 6-10. Existing impervious surface reduction projects in the Little Patuxent Watershed showing potential pollutant load reductions

Pollutant	Impervious Urban Loading Rate (lbs/ac/yr)	Pervious Urban Loading Rate (lbs/ac/yr)	Reduction in Loading Rate (lbs/ac/yr)	Impervious Area (acres)	Max Potential Load Reduction (lbs/yr)
TN	15.62	9.93	5.69	27.57	157
TP	1.99	0.29	1.70	27.57	47
Sediment	2,014	286	1,727	27.57	47,632

Table 6-11. Proposed impervious surface reduction projects in the Little Patuxent Watershed showing potential pollutant load reductions

Pollutant	Impervious Urban Loading Rate (lbs/ac/yr)	Pervious Urban Loading Rate (lbs/ac/yr)	Reduction in Loading Rate (lbs/ac/yr)	Impervious Area (acres)	Max Potential Load Reduction (lbs/yr)
TN	15.62	9.93	5.69	21.02	120
TP	1.99	0.29	1.70	21.02	36
Sediment	2,014	286	1,727	21.02	36,317

6.6 Urban Tree Plantings (Model Tab T6)

Open pervious areas with reforestation potential (forest buffers and urban tree plantings) were identified in the watershed. Pollutant reductions for pervious area reforestation are calculated based on land use conversion from pervious urban to forest. The equation used to estimate nutrient and sediment load reductions for pervious area reforestation is expressed as

Land Use Conversion load reduction = [pervious urban (lbs/ac/yr) - forest (lbs/ac/yr)]* Open Pervious Area (acres)

Pervious area reforestation would involve converting open pervious area to forest; therefore, the loading rate would be reduced by a factor equal to the difference between pervious urban and forest loading rates used in the watershed pollutant analysis (Tables 6-3 and 6-4) as shown in the first expression in brackets in the equations above. The approximate reduction in pollutant load is then the reduced loading rate multiplied by the open pervious area available for reforestation. A summary of pervious area reforestation reduction calculations and results are shown in Tables 6-12 through 6-14 for the watersheds, for all opportunities identified, including those with and without concept plans.

Table 6-12. Existing (post-2009) urban tree planting in the Little Patuxent Watershed potential pollutant load reductions

Pollutant	Pervious Urban Loading Rate (lbs/ac/yr)	Forest Loading Rate (lbs/ac/yr)	Reduced Loading Rate (lbs/ac/yr)	Open Pervious Area (acres)	Max Potential Load Reduction (lbs/yr)
TN	9.93	3.49	6.44	7.0	45
TP	0.29	0.08	0.21	7.0	2
Sediment	286	194	92	7.0	646

Table 6-13. Urban tree planting in the Little Patuxent Watershed potential pollutant load reductions for sites without concept plans

Pollutant	Pervious Urban Loading Rate (lbs/ac/yr)	Forest Loading Rate (lbs/ac/yr)	Reduced Loading Rate (lbs/ac/yr)	Open Pervious Area (acres)	Max Potential Load Reduction (lbs/yr)
TN	9.93	3.49	6.44	7.5	48
TP	0.29	0.08	0.21	7.5	2
Sediment	286	194	92	7.5	686

Table 6-14. Proposed urban tree planting in the Little Patuxent Watershed potential pollutant load reductions for sites with concept plans

Pollutant	Pervious Urban Loading Rate (lbs/ac/yr)	Forest Loading Rate (lbs/ac/yr)	Reduced Loading Rate (lbs/ac/yr)	Urban Tree Planting Area (acres)	Max Potential Load Reduction (lbs/yr)
TN	9.93	3.49	6.44	88.6	570
TP	0.29	0.08	0.21	88.6	19
Sediment	286	194	92	88.6	8,123

6.7 Stream Restoration (Model Tab T7)

Nutrient and sediment reduction benefits were estimated for existing stream restoration sites from the County's BMP database and for the potential new stream restoration sites identified as part of the watershed assessments. Results are presented for all opportunities identified, including those with and without concept plans. Credits for stream restoration are based on the Chesapeake Bay Program's Expert Panel to Define Removal Rates for Individual Stream Restoration Projects (Schueler and Stack 2014). For general watershed planning, the Panel Report recommends using a factor of 0.075 pounds/linear foot of reach length (RL) for nitrogen, 0.068 pounds/linear foot for phosphorus, and 44.88 pounds/linear foot for sediment as the edge-of-stream loading reduction potential.

The equation used to estimate total nitrogen reductions for stream restoration is expressed as

0.075 (lbs/ft)*RL (ft)

The equation used to estimate total phosphorus load reductions for stream restoration is expressed as

0.068 (lbs/ft)*RL (ft)

The equation used to estimate sediment load reductions for stream restoration is expressed as

44.88 (lbs/ft)*RL (ft)

A summary of stream restoration reduction calculations and results for existing and proposed stream restoration projects are shown in Tables 6-15 through 6-18.

Table 6-15. Existing Stream Restoration practices in the Little Patuxent Watershed installed after 2009, showing estimated pollutant load reductions applicable to the Bay TMDL.

Pollutant	Reduction in Loading Rate (lbs/ft)	Stream Restoration Length (ft)	Estimated Load Reduction (lbs/yr)
TN	0.075	10,716	804
TP	0.068	10,716	729
Sediment	44.88	10,716	480,956

Table 6-16. Existing Stream Restoration practices in the Little Patuxent Watershed installed after 2004, showing potential pollutant load reductions applicable to the local sediment TMDL.

Pollutant	Reduction in Loading Rate (lbs/ft)	Potential Stream Restoration Length (ft)	Max Potential Load Reduction (lbs/yr)
TN	0.075	11,294	847
TP	0.068	11,294	768
Sediment	44.88	11,294	506,880

Table 6-17. Proposed Stream Restoration practices in the Little Patuxent Watershed, for sites with concept plans, showing potential pollutant load reductions applicable to the Bay and local TMDLs.

Pollutant	Reduction in Loading Rate (lbs/ft)	Potential Stream Restoration Length (ft)	Max Potential Load Reduction (lbs/yr)
TN	0.075	86,890	6,517
TP	0.068	86,890	5,909
Sediment	44.88	86,890	3,899,623

Table 6-18. Proposed Stream Restoration practices in the Little Patuxent Watershed, for sites without concept plans, showing potential pollutant load reductions applicable to the Bay and local TMDLs.

Pollutant	Reduction in Loading Rate (lbs/ft)	Potential Stream Restoration Length (ft)	Max Potential Load Reduction (lbs/yr)
TN	0.075	46,392	3,479
TP	0.068	46,392	3,155
Sediment	44.88	46,392	2,082,088

6.8 Regenerative Step Pool Storm Conveyance (Model Tab T10)

Regenerative Step Pool Storm Conveyance (SPSC) practices can be used for retrofitting unstable and degraded stormwater conveyance channels (MDE 2014c). The Anne Arundel County SPSC design guidelines (2012) define this practice as "open-channel conveyance structures that convert, through attenuation ponds and a sand seepage filter, surface storm flow to shallow groundwater flow." When these practices are used in ephemeral or dry channels as retrofits to capture the runoff from one inch of rainfall, the pollutant removal efficiencies from the most similar BMP type may be used. Because these practices apply to dry conveyance channels, they are located in small drainage areas (e.g., 10 acres). The SPSC performs very similar to a filtration practice, therefore, the pollutant removal efficiencies for micro-bioretention can be applied to the drainage area treated (values in Table 6 from MDE (2014c) were used for efficiencies assuming a 1" runoff treatment depth).

The equation used to estimate nutrient and sediment load reductions for SPSC practices is expressed as

[# (lbs/ac/yr)*DA (acres)]*RE (%)

The pollutant load received from the drainage area contributing to the SPSC is denoted by the first expression in brackets in the equation above. The pollutant loading rates shown, # lbs Total Nitrogen/ac/yr, # lbs Total Phosphorus/ac/yr, or # lbs Sediment/ac/yr, are the pervious and impervious urban rates used in the pollutant loading analysis (Tables 6-3 and 6-4) since this represents the source of runoff being treated. A summary of these load reduction calculations and results are shown in Tables 6-19 and 6-20.

Table 6-19. Proposed Regenerative Step Pool Conveyance projects with concept plans showing potential pollutant load reductions

Pollutant	Impervious Acre Equivalent	Impervious Urban Loading Rate (lbs/ac/yr)	Loads from DA (lbs/yr)	RE %	Max Potential Load Reduction (lbs/yr)
TN	28.35	15.62	442.8	57%	252.4
TP	28.35	1.99	56.4	66%	37.25
Sediment	28.35	2013.65	57,087	70%	39,961

Table 6-20. Potential pollutant load reductions for proposed Regenerative Step Pool Storm Conveyance projects without concept plans

Pollutant	Impervious Acre Equivalent	Impervious Urban Loading Rate (lbs/ac/yr)	Loads from DA (lbs/yr)	RE %	Max Potential Load Reduction (lbs/yr)
TN	32.58	15.62	508.9	57%	290.1
TP	32.58	1.99	64.9	66%	42.8
Sediment	32.58	2013.65	65,614	70%	45,930

6.9 Overall Pollutant Loading Reductions (Model Tab FinalSummary)

The sum of maximum potential pollutant load reductions calculated for individual BMPs represent the overall pollutant removal capacity for a maximum implementation scenario (i.e., 100% of the projects are implemented). Tables 6-21 and 6-22 present a summary of estimated pollutant load reductions for the maximum projected implementation of each BMP type, including how reductions were credited, pollutant removal efficiencies, potential load reductions, and units available for restoration. Also included are some additional credits for rain barrels, rooftop disconnects, and non-rooftop disconnects. These credits were calculated as part of the Countywide Implementation Strategy presented in a separate report (KCI 2015).

Results for the Bay TMDL indicate that the target load reduction for total phosphorus of 17.2% is easily met with a 54% load reduction if all potential projects are included; the sediment load reduction target is also met since the phosphorus target is met. If only new projects with concept plans are included, the total phosphorus goal is still exceeded with a 34% reduction. These goals are met primarily due to stream restoration and its associated reductions using the interim reduction rates. Actual phosphorus and sediment reduction could be different, depending on the actual design implemented for these projects. The total nitrogen target of 9.4% is not met, since there is only a 7.1% reduction achieved if all BMPs are implemented. An additional 2.4% reduction would be required to meet the target goal. If only new projects with concept plans are considered, there is a 4.5% reduction in total nitrogen. For the local sediment TMDL, the target goal of 48.1% is achieved with a total reduction achieved of 62% if all BMPs were implemented; if only projects with concept plans are implemented, the sediment goal is not achieved since only a 41% reduction is attained. As noted on individual concept plans, there are a number of constraints to project implementation. Other constraints may include citizen acceptance and permitting concerns.

The assumed implementation of potential restoration BMPs shows how they would approach or exceed the required percent reduction for nitrogen, phosphorus, and sediment loads needed to meet water quality standards for this watershed as specified by the local and Chesapeake Bay TMDLs. Additional reductions may also be achieved through restoration actions not included in this analysis such as street sweeping, erosion and sediment control, and public education and outreach efforts (e.g., watershed trash and recycling campaign, conservation landscaping, pet waste education). These types of actions are not included in the pollutant removal analysis

Table 6-21. Summary of potential pollutant load reductions for the Little Patuxent Watershed for existing and proposed stormwater management practices to meet the local sediment TMDL

BMP	How Credited	TN Efficiency	TP Efficiency	Sediment Efficiency	Max Potential TN Load Reduction	Max Potential TP Load Reduction	Max Potential Sediment Load Reduction	Units Available	
Existing SWM	Efficiency	varies	varies	varies	11,387	1,272	1,411,438	2,608	acres
Existing Stream Restoration	lbs per Ln Ft	0.075	0.068	44.88	847	768	506,880	11,294	ft
Existing Impervious Surface Reduction	LU Conversion	N/A	N/A	N/A	157	47	47,632	28	acres
Existing Tree Plantings	LU Conversion	N/A	N/A	N/A	45	2	646	7	acres
				Total	12,234	2,040	1,918,317		
				Total Existing Urban Load (lbs/yr)	282,269	17,259	14,629,477		
				Reduction Achieved	4.3%	11.8%	13.1%		
Impervious Surface Reduction	LU Change	N/A	N/A	N/A	120	36	36,317	21	acres
				Additional Reduction Achieved	0.04%	0.21%	0.25%		
SWM Conversion with concepts	Efficiency	varies	varies	varies	517	64	109,736	255	acres
				Additional Reduction Achieved	0.2%	0.4%	0.8%		
SWM Conversion without concepts	Efficiency	varies	varies	varies	2204	390	404685	1,066	acres
				Additional Reduction Achieved	0.8%	2.3%	2.8%		
Regenerative Step Pool Conveyance	Efficiency	57%	66%	70%	542	80	85891	61	acres
					0.2%	0.5%	0.6%		
Pervious Area Reforestation	LU Conversion	N/A	N/A	N/A	618	21	8,808	96	acres
				Additional Reduction Achieved	0.2%	0.1%	0.1%		
New Stream Restoration	lbs per Ln Ft	0.075	0.068	45	9,996	9,063	5,981,711	133,282	ft
				Additional Reduction Achieved	3.5%	52.5%	40.9%		
New BMPs	Efficiency	varies	varies	varies	1,865	385	488,342	408	acres
				Additional Reduction Achieved	0.7%	2.2%	3.3%		
Rain Barrels					7.17	0.97			
				Additional Reduction Achieved	0.003%	0.006%			
Rooftop Disconnects					81.74	98.08	147.12		
				Additional Reduction Achieved	0.029%	0.568%	0.001%		
Nonrooftop Disconnects					73.9	88.68	133.02		
				Additional Reduction Achieved	0.026%	0.514%	0.001%		
				TOTAL Reduction Achieved	10.0%	71.1%	61.8%		
		Total Potential Load Reduction			28,260	12,266	9,034,087		
		Reduction Target			N/A	N/A	48.1		

Table 6-22. Summary of potential pollutant load reductions for the Little Patuxent Watershed for existing and proposed stormwater management practices to meet the Bay TMDL

BMP	How Credited	TN Efficiency	TP Efficiency	Sediment Efficiency	Max Potential TN Load Reduction	Max Potential TP Load Reduction	Max Potential Sediment Load Reduction	Units Available	
Existing SWM	Efficiency	varies	varies	varies	3,516	243	624,692	1,073	acres
Existing Stream Restoration	lbs per Ln Ft	0.02	0.068	45	804	729	480,956	10,716	ft
Existing Impervious Surface Reduction	LU Conversion	N/A	N/A	N/A	157	47	47,632	28	acres
Existing Tree Plantings	LU Conversion	N/A	N/A	N/A	45	2	646	7	acres
				Total	4,320	972	1,105,649		
				Total Existing Urban Load (lbs/yr)	285,325	20,644	20,735,988		
				Reduction Achieved	1.5%	4.7%	5.3%		
Impervious Surface Reduction	Efficiency	N/A	N/A	N/A	120	36	36,317	21	acres
				Additional Reduction Achieved	0.04%	0.17%	0.18%		
SWM Conversion with concepts	Efficiency	varies	varies	varies	517	64	109,736	255	acres
				Additional Reduction Achieved	0.2%	0.3%	0.5%		
SWM Conversion without concepts	Efficiency	varies	varies	varies	2,204	390	404,685	1,066	acres
				Additional Reduction Achieved	0.8%	1.9%	2.0%		
Regenerative Step Pool Conveyance	Efficiency	57%	66%	70%	542	80	85,891	31	acres
				Additional Reduction Achieved	0.19%	0.39%	0.41%		
Pervious Area Reforestation	LU Conversion	N/A	N/A	N/A	618	21	8,808	96	acres
				Additional Reduction Achieved	0.22%	0.10%	0.04%		
New Stream Restoration	lbs per Ln Ft	0.075	0.068	45	9,996	9,063	5,981,711	133,282	ft
				Additional Reduction Achieved	3.5%	43.9%	28.8%		
New BMPs	Efficiency	varies	varies	varies	1,865	385	488,342	408	acres
				Additional Reduction Achieved	0.7%	1.9%	2.4%		
Rain Barrels					7.17	0.97			
					0.003%	0.005%			
Rooftop Disconnects					81.74	98.08	147.12		
					0.029%	0.475%	0.001%		
Nonrooftop Disconnects					73.9	88.68	133.02		
					0.026%	0.430%	0.001%		
				TOTAL Reduction Achieved	7.1%	54.2%	39.6%		
		Total Potential Load Reduction			20,345	11,199	8,221,418		
		Reduction Target			9.4%	17.2%	**		
		** met if TP target met							

because they require additional site-specific analyses, or reduction efficiencies are not well known and are difficult to estimate. These may be added as more information becomes available.

6.10 Proposed Implementation Timeframe

Howard County's MS4 permit requires that watershed assessments "specify pollutant load reduction benchmarks and deadlines that demonstrate progress toward meeting all applicable stormwater WLAs." To this end, an implementation timeline is presented in Tables 6-23 and 6-24 to assist the County in implementing recommended projects and tracking the program's progress toward WLA and MS4 goals.

Table 6-23. Pollutant load reduction benchmarks associated with TMDLs and impervious area restoration target, for Little Patuxent Watershed in Howard County

TMDL	Benchmarks: Pollutant Reduction	Benchmark timeframe
Chesapeake Bay TMDLs	9.4% reduction in TN from 2009 baseline	60% of reduction by 2017 100% of reduction by 2025
	17.2% reduction in TP from 2009 baseline	60% of reduction by 2017 100% of reduction by 2025
	X% reduction in TSS **	
Local Sediment TMDL	48.1% reduction in TSS from 2005 baseline	
	Impervious Area Restoration	
MS4 Permit	20% of impervious area restored, countywide	20% of impervious area restored, countywide by December 2019

** Bay sediment TMDL assumed met if TP target is met

Table 6-24. Proposed implementation timeline to meet TMDL pollutant reduction and MS4 permit deadlines, for the Little Patuxent Watershed

Action	Date Completed By	Milestone
MS4 Permit Issued	December 2014	
Completion of Little Patuxent Watershed Assessment	December 2015	
Completion of Countywide Restoration Plan (CIS)	December 2015	
Project design and implementation; annual tracking of progress toward TMDL targets	December 2016	
Continued project design and implementation; annual tracking	December 2017	Implement suite of projects and alternative BMPs providing 60% of the required TN and TP reductions in Little Patuxent Watershed, to meet Chesapeake Bay 2017 TMDL targets
Continued project design and implementation; annual tracking	December 2018	
Continued project design and implementation; annual tracking	December 2019	From December 2014 to December 2019, implement suite of projects and alternative BMPs providing 20% of impervious area restoration, countywide
New MS4 Permit	Estimated to be issued December 2019	
Continued project design and implementation; annual tracking	December 2020	
Continued project design and implementation; annual tracking	December 2021	
Continued project design and implementation; annual tracking	December 2022	
Continued project design and implementation; annual tracking	December 2023	
Continued project design and implementation; annual tracking	December 2024	From December 2019-December 2024, implement suite of projects and alternative BMPs providing impervious area restoration, countywide, to meet 2019 MS4 permit requirements (if applicable)
Continued project design and implementation; annual tracking	December 2025	Implement suite of projects and alternative BMPs providing 100% of the required TN and TP reductions in Little Patuxent Watershed, to meet Chesapeake Bay TMDL targets

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Appendices

A. Inventory of GIS Data Compiled for Howard County Watershed Assessments January 2015

Hydrologic Unit Boundaries:

Maryland 8-digit watershed names [MDE8NAME] and numbers [MDE8DIGT]
Maryland 12-digit watershed numbers [DNR12DIG]
Howard County's 15 watershed names [Subshed_Ho]
Centennial Lake, Wilde Lake, Lake Kittamaqundi [CA_shed]
66 catchments: G:\GIS-Data\Howard_County\Working\Howard_County\subwatersheds_HoCo_0508 _Countywide_and_Columbia_subshed_names.shp.
CIS watersheds: G:\GIS-Data\Howard_County\Working\Howard_County\CIS_PreAssessments\HoCo_CIS _watersheds.shp, contains a unique ID [CISshednum]
HUC14 characteristics: G:\GIS-Data\Howard_County\Working\Howard_County\subwatersheds_HoCo_0508 _Countywide_subshed_names.shp

Analysis data sets:

Data set	Date	Comment	Versar file information
Historic aerial photography	Various		
Current aerial photography	2011, March	Data in tiles; refer to grid files for 200 series	G:\GIS-Data\Howard_County\Archive_data\2013 _April \ftpDownload2011Aerials\2011\SID
Impervious areas	2014	Paved and unpaved, combined. Created in 2014, based off 2013 planimetric layers.	G:\GIS-Data\Howard_County\Working\Howard _County \Impervious_surface_2014planimetrics _HoCo_V0914_paved_unpaved1.shp
Land use	2010	Use MDP	G:\GIS-Data\Howard_County\Archive_data \LandUse _LandCover\2010_MDP_LULC
Property	2014	Received property data (with ownership) from the County	G:\GIS-Data\Howard_County\Archive_data\2014 _December\Property_parks_open_space_zoning _easements\property.shp
Zoning	2014, assumed	Received data from the County	G:\GIS-Data\Howard_County\Archive_data\2014 _December\Property_parks_open_space_zoning _easements\zoning_current_region.shp
Forest conservation areas	2014, assumed	Received data from the County	G:\GIS-Data\Howard_County\Archive_data\2014 _December\Property_parks_open_space_zoning _easements\ForestConservationEasements.shp
Natural resource areas	2014, assumed	Received data from the County	G:\GIS-Data\Howard_County\Archive_data\2014 _December\Property_parks_open_space_zoning _easements\NaturalResourceOpenSpace.shp
County parks	2014, assumed	Received data from the County	G:\GIS-Data\Howard_County\Archive_data \2014_December\Property_parks_open_space _zoning_easements\Parks_County.shp
Non-County open space	2014, assumed	Received data from the County	G:\GIS-Data\Howard_County\Archive_data\2014 _December\Property_parks_open_space_zoning _easements\NonCountyOpenSpace.shp
Storm drain pipes	2014		G:\GIS-Data\Howard_County\Archive_data\2014 _September\BMPs_AnnualReport_fromCounty& McT\McT FTP Download_082014 \final_pipes_polyline.shp

Data set	Date	Comment	Versar file information
Storm drain inlets	2014		G:\GIS-Data\Howard_County\Archive_data \2014_September\BMPs_AnnualReport_fromCou nty&McT\McT FTP Download_082014 \final_inlet_cent_point.shp
Storm drain outlets	2014		G:\GIS-Data\Howard_County\Archive_data \2014_September\BMPs_AnnualReport_fromCou nty&McT\McT FTP Download_082014 \final_outlet_cent.shp
Public water system	2012		G:\GIS-Data\Howard_County\Archive_data \2012_February\Water_master\MasterWater.shp
Public sewer system	2012		G:\GIS-Data\Howard_County\Archive_data \2012_February\Sewer_master\MasterSewer.shp
Streams	2014, assumed	Stream and river centerlines	G:\GIS-Data\Howard_County\Archive_data \2014_December\Stream_centerlines_and_Waters hed_DAs_2009\Stream_Centerline
Forest cover	2014, assumed		G:GIS-Data\Howard_County\Archive_data \2014_November\Email_CSmith_112514\Tree_Li ne.shp
Drainage complaints (frequent flooding)	Unknown	Data records have only location	G:\GIS-Data\Howard_County\Archive_data \2014_December\Flooded_roads_download\Frequ entFlooders_font_point.shp
MS4 Boundary	2011		G:\GIS-Data\Howard_County\Archive_data \2011_June\VTownes_Versar_Ftp\HoCo_MS4_B oundary.shp
Soils	2002		G:\GIS-Data\Howard_County\Archive_data\Soils\ Soils_HowardCo_with_hydgrp_MDSP83ft.shp
Howard County biological monitoring program data	2014		G:\GIS-Data\Howard_County\Working \Howard_County\HowardCo_Stream_Survey_Cou ntywide_Master.mdb
MBSS IBI Scores	Thru 2014	Maryland DNR	
SCA data	2012	MainPatux has only severity ranking in point files; HowardCo_pointlist _master.shp has a concentration of points in Upper Little Patuxent sub-watershed	G:\GIS-Data\Howard_County\Archive_data \2012_March\Stream_Corridor_Assessment_data _sets\ - separate folders for watersheds plus Hammond Branch and Dorsey Run
Contour lines	2014, assumed	Two-foot and ten-foot intervals	G:\GIS-Data\Howard_County\Archive_data\2014 _December\Contours_download\Contours2011 .gdb
BMPs	2015	new data set from McCormick Taylor	G:\GIS-Data\Howard_County\Archive_data \2014_December\BMP_Cleanup_update _McCormick_Taylor\HoCo_BMP_CleanUp.mdb
Potential BMP restoration projects	2015	new data set from McCormick Taylor	G:\GIS-Data\Howard_County\Archive_data \2014_December\BMP_Cleanup_update _McCormick_Taylor\HoCo_BMP_CleanUp.mdb

Data set	Date	Comment	Versar file information
Stream restoration projects	2015	new data set from McCormick Taylor	G:\GIS-Data\Howard_County\Archive_data \2014_December\BMP_Cleanup_update _McCormick_Taylor\HoCo_BMP_CleanUp.mdb
READY Program projects	2015	new data set from McCormick Taylor	G:\GIS-Data\Howard_County\Archive_data \2014_December\BMP_Cleanup_update _McCormick_Taylor\HoCo_BMP_CleanUp.mdb
DNR Wetlands Inventory	2005	Maryland DNR website	
Green Infrastructure	2012	Howard's GI Plan (based on MD GI Plan)	
Tier II Streams and Catchments	2012	MDE website	
Howard County IDDE Geodatabases	2000, 2002-2014	Received from the County	
Road Centerlines		Received from the County	

Data from Previous Studies:

Upper Little Patuxent Watershed Management Plan (Howard County/KCI 2009)
Columbia Watershed Management Plan - Lake Elkhorn (Columbia Association/Versar 2009)
Centennial Lake and Wilde Lake in Little Patuxent (Howard Co./CWP 2005)
Downtown Columbia - Symphony Stream/Lake Kittamaqundi (General Growth Properties/Biohabitats 2008)
Howard County Dry Pond retrofit report (Versar 2013)
Howard County LID and Tree Planting report (Versar 2013)
Little Patuxent SCA 2001
Dorsey Run SCA 2003
Hammond Branch SCA 2003
Middle Patuxent SCA

B. Descriptions of BMP Types

Appendix B: Stormwater Treatment BMP Definitions

BMP definitions are taken from the Maryland Assessment and Scenario Tool (MAST) guidance as provided on mastonline.org and edited, with the exception of regenerative step pool conveyance (RSC) which is provided by Anne Arundel County (2012); green roofs, whose definition is taken from the MDE Stormwater Design Manual (2009); and outfall stabilization, described in the August 2014 MDE guidance entitled Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated. Names in "()" next to BMP types are the MAST BMP Short Name. Not all BMPs considered here have been recognized by MAST and therefore may not have an official MAST-designated Short Name.

Extended Detention Dry Pond (ExtDryPonds)

Dry extended detention (ED) basins are depressions created by excavation or berm construction that temporarily store stormwater runoff and release it slowly via surface flow to the receiving stream or stormsewer system, at a specified rate, and / or via groundwater infiltration following storms. Dry ED basins are designed to dry out between storm events, in contrast with wet ponds, which contain standing water permanently. As such, they are similar in construction and function to dry detention basins, except that the duration of detention of stormwater is designed to be longer, theoretically improving treatment effectiveness.

Wet Ponds and Wetlands (WetPondWetland)

A wet pond and stormwater treatment wetland are water impoundment structures that intercept stormwater runoff then release it to the receiving stream or stormsewer system at a specified flow rate. These structures retain a permanent pool and usually have retention times sufficient to allow settlement of some portion of the intercepted sediments and attached nutrients/toxics. Until recently, these practices were designed specifically to meet water quantity, not water quality objectives. There is little or no vegetation living within the pooled area nor are outfalls directed through vegetated areas prior to open water release. Nitrogen reduction is minimal.

Bioretention

Bioretention/raingardens - A/B soils, no underdrain (BioRetNoUDAB)

An excavated pit backfilled with engineered media, topsoil, mulch, and vegetation. These excavated, planted areas are installed in shallow basins in which the storm water runoff is temporarily ponded and then treated by filtering through the bed components consisting of the engineered media, topsoil, mulch, and vegetation, and through biological and biochemical reactions within the soil matrix and around the root zones of the plants. This BMP has no underdrain and is in A or B soil which assumes that all water will infiltrate into the subsoils.

Bioretention/raingardens - A/B soils, underdrain (BioRetUDAB)

An excavated pit backfilled with engineered media, topsoil, mulch, and vegetation. These are planting areas installed in shallow basins in which the storm water runoff is temporarily ponded and then treated by filtering through the bed components, and through biological and biochemical reactions within the soil matrix and around the root zones of the plants. This BMP has an underdrain and is in A or B soil, in order to more carefully control dewatering of the system.

Bioretention/raingardens - C/D soils, underdrain (BioRetUDCD)

An excavated pit backfilled with engineered media, topsoil, mulch, and vegetation. These are planting areas installed in shallow basins in which the storm water runoff is temporarily ponded and then treated by filtering through the bed components, and through biological and biochemical reactions within the soil matrix and around the root zones of the plants. This BMP is in C or D soil and has an underdrain in order to more assure dewatering of the system in timely fashion in these poorly draining soils.

Appendix B: Stormwater Treatment BMP Definitions

Non-Bioretention Filtering Practices

Permeable Pavement w/ Sand, Veg. - A/B soils, no underdrain (PermPavSVNoUDAB)

Pavement or pavers that reduce runoff volume and treat water quality through both infiltration and filtration mechanisms. Water filters through open voids in the pavement surface to a washed gravel subsurface storage reservoir, where it is then slowly infiltrated into the underlying soils. This BMP has no underdrain, has sand as part of the filtration media to increase surface area and pollutant removal efficiency and/or vegetation in surface voids, and is in A or B soil.

Permeable Pavement w/ Sand, Veg. - A/B soils, underdrain (PermPavSVUDAB)

Pavement or pavers that reduce runoff volume and treat water quality through both infiltration and filtration mechanisms. Water filters through open voids in the pavement surface to a washed gravel subsurface storage reservoir, where it is then slowly infiltrated into the underlying soils or exits via an underdrain. This BMP has an underdrain to more carefully control dewatering of the system, which will preclude infiltration of some stormwater, has sand as part of the filtration media to increase surface area and pollutant removal efficiency and/or vegetation, and is in A or B soil.

Permeable Pavement w/ Sand, Veg. - C/D soils, underdrain (PermPavSVUDCD)

Pavement or pavers that reduce runoff volume and treat water quality through both infiltration and filtration mechanisms. Water filters through open voids in the pavement surface to a washed gravel subsurface storage reservoir, where it is then slowly infiltrated into the underlying soils or exits via an underdrain. This BMP has an underdrain to more carefully control dewatering of the system, which will preclude infiltration of some stormwater, has sand as part of the filtration media to increase surface area and pollutant removal efficiency and/or vegetation, and is in C or D soil.

Permeable Pavement w/o Sand, Veg. - A/B soils, no underdrain (PermPavNoSVNoUDAB)

Pavement or pavers that reduce runoff volume and treat water quality through both infiltration and filtration mechanisms. Water filters through open voids in the pavement surface to a washed gravel subsurface storage reservoir, where it is then slowly infiltrated into the underlying soils or exits via an underdrain. This BMP has no underdrain allowing for infiltration into subsoils, no sand or vegetation, and therefore lower pollutant removal rates than a system with sand and/or vegetation, and is in A or B soil.

Permeable Pavement w/o Sand, Veg. - A/B soils, underdrain (PermPavNoSVUDAB)

Pavement or pavers that reduce runoff volume and treat water quality through both infiltration and filtration mechanisms. Water filters through open voids in the pavement surface to a washed gravel subsurface storage reservoir, where it is then slowly infiltrated into the underlying soils or exits via an underdrain. This BMP has an underdrain to more carefully control dewatering of the system, which will preclude infiltration of some stormwater, no sand or vegetation and therefore lower pollutant removal rates than a system with sand and/or vegetation, and is in A or B soil.

Permeable Pavement w/o Sand, Veg. - C/D soils, underdrain (PermPavNoSVUDCD)

Pavement or pavers that reduce runoff volume and treat water quality through both infiltration and filtration mechanisms. Water filters through open voids in the pavement surface to a washed gravel subsurface storage reservoir, where it is then slowly infiltrated into the underlying soils or exits via an underdrain. This BMP has an underdrain to more carefully control dewatering of the system, which will preclude infiltration of some stormwater, no sand or vegetation and therefore lower pollutant removal rates than a system with sand and/or vegetation, and is in C or D soil.

Appendix B: Stormwater Treatment BMP Definitions

Urban Filtering Practices (Filter)

These are practices that capture and temporarily store runoff and pass it through a filter bed of either sand or an organic media. There are various designs, such as above ground, below ground, perimeter, etc. An organic media filter uses another medium besides sand to enhance pollutant removal for many compounds due to the increased cation exchange capacity (CEC) achieved by increasing the organic matter. These systems require yearly inspection and maintenance to receive pollutant reduction credit.

Urban Filter Strip Runoff Reduction (UrbFilterRR)

Urban filter strips are stable areas with vegetated cover on flat or gently sloping land. Runoff entering the filter strip must be in the form of sheet-flow and must enter at a non-erosive rate for the site-specific soil conditions. A 0.4 design ratio of filter strip length to impervious flow length is recommended for runoff reduction urban filter strips. These filter strips allow for infiltration into subsoils and therefore significant pollutant removal compared to Urban Filter Strip Storm Water Treatment.

Urban Filter Strip Storm Water Treatment (UrbFilterST)

Urban filter strips are stable areas with vegetated cover on flat or gently sloping land. Runoff entering the filter strip must be in the form of sheet-flow and must enter at a non-erosive rate for the site-specific soil conditions. A 0.2 design ratio of filter strip length to impervious flow length is recommended for stormwater treatment urban filter strips. These filter strips do not allow for infiltration of subsoils and therefore only allow for reductions in sediment load.

Regenerative Step Pool Storm Conveyance (SPSC)

Regenerative Step Pool Storm Conveyance (SPSC) practices developed by Anne Arundel County Department of Public Works, Bureau of Engineering, have been used for retrofitting unstable and degraded stormwater conveyance channels in steep conveyance circumstances. SPSC systems are open-channel conveyance structures that convert, through attenuation ponds and a sand seepage filter, surface storm flow to shallow groundwater flow. These systems safely convey, attenuate, and treat the quality of storm flow. These structures utilize a series of constructed shallow aquatic pools, riffle grade control, native vegetation, and an underlying sand/woodchip mix filter bed media. The physical characteristics of the SPSC channel are best characterized by the Rosgen A or B stream classification types, where "bedform occurs as a step/pool, cascading channel which often stores large amounts of sediment in the pools associated with debris dams" (Rosgen, 1996). The pretreatment, recharge, and water quality sizing criteria closely follow the State of Maryland's criteria for a typical stormwater filtering device. These structures feature surface / subsurface runoff storage seams and an energy dissipation design that is aimed at attenuating the flow to a desired level through energy and hydraulic power equivalency principles.

Green Roof

Green roofs are alternative surfaces that replace conventional construction materials and include a protective covering of planting media and vegetation. Also known as vegetated roofs, roof gardens, or eco-roofs, these may be used in place of traditional flat or pitched roofs to reduce impervious cover and more closely mimic natural hydrology. Green roofs produce less heat than conventional systems. Therefore, they may be used to help mitigate stormwater impacts and temperature increases caused by new development.

There are two basic green roof designs that are distinguished by media thickness and the plant varieties that are used. The more common or "extensive" green roof is a lightweight system where the media layer is between two and six inches thick. This limits plants to low-growing, hardy herbaceous varieties. An extensive green roof may be constructed off-site as a modular system with drainage layers, growing media, and plants installed in interlocking grids.

Conventional construction methods may also be used to install each component separately. "Intensive" green roofs have thicker soil layers (eight inches or greater) and are capable of supporting more diverse plant communities including trees and shrubs. A more robust structural loading capacity is needed to support the additional weight of the media and plants. Intensive green roofs are more complex and expensive to design, construct, and maintain, are less commonly used, and are therefore not covered in the Maryland Stormwater Design manual.

Vegetated Channels

Vegetated Open Channels - A/B soils, no underdrain (VegOpChanNoUDAB)

Open channels are practices that convey stormwater runoff and provide treatment as the water is conveyed, and includes bioswales. Runoff passes through either vegetation in the channel, subsoil matrix, and/or is infiltrated into the underlying soils. This BMP has no underdrain, allowing for infiltration into subsoils; however, because the system is within A or B soil infiltration is better than in a similar channel in C or D soils and allows for higher pollutant removal rates.

Vegetated Open Channels - C/D soils, no underdrain (VegOpChanNoUDCD)

Open channels are practices that convey stormwater runoff and provide treatment as the water is conveyed, includes bioswales. Runoff passes through either vegetation in the channel, subsoil matrix, and/or is infiltrated into the underlying soils. This BMP has no underdrain, allowing for infiltration into subsoils; however, C or D soils have lower infiltration rates and therefore lower pollutant removal rates relative to vegetated open channels in A or B soils.

Bioswale (BioSwale)

With a bioswale the load is reduced because, unlike other open channel designs, there is now treatment through the soil. A bioswale is designed to function as a bioretention area and therefore has much higher pollutant removal rates compared to the vegetated open channels in A/B and C/D soils.

Infiltration Practices

An infiltration practice generally is a depression to form an infiltration basin where sediment is trapped and water infiltrates into the soil. No underdrains are associated with infiltration basins and trenches, because by definition these systems provide complete infiltration. Design specifications require infiltration basins and trenches to be built in good soil (A/B soils). They are not constructed on poor soils, such as C and D soil types. Engineers are required to test the soil before approved to build is issued. To receive credit over the longer term, jurisdictions must conduct yearly inspections to determine if the basin or trench is still infiltrating runoff.

Urban Infiltration Practices w/ Sand, Veg. - A/B soils, no underdrain (InfiltWithSV)

A depression to form an infiltration basin where sediment is trapped and water infiltrates the soil. No underdrains are associated with infiltration basins and trenches, because by definition these systems provide complete infiltration. Sand provides additional surface area for more complete filtration and vegetation provides root system uptake and additional biological activity for more complete pollutant processing.

Urban Infiltration Practices w/o Sand, Veg. - A/B soils, no underdrain (Infiltration)

A depression to form an infiltration basin where sediment is trapped and water infiltrates the soil. No underdrains are associated with infiltration basins and trenches, because by definition these systems provide complete infiltration. Sand or vegetation are not included in these system.

Appendix B: Stormwater Treatment BMP Definitions

Impervious Surface Reduction (ImpSurRed)

Reducing impervious surfaces to promote infiltration and percolation of runoff storm water by removing pavement and providing vegetative cover for 95% of the area that was previously impervious surface. MDE 2014 guidance offers 0.75 impervious acre equivalent credit for every acre of impervious cover removed and replaced with vegetation.

Urban Stream Restoration (UrbStrmRest)

Stream restoration is a change to the stream corridor that improves the stream ecosystem by restoring the natural hydrology and landscape of a stream, and helps improve habitat and water quality conditions in degraded streams. Credit is provided in the form of 0.01 impervious reduction equivalents of 0.01 acre per linear foot of outfall stabilization.

Urban Tree Planting (UrbanTreePlant)

Urban tree planting is planting trees on urban pervious areas at a rate that would produce a forest-like condition over time. The intent of the planting is to eventually convert the urban area to forest. If the trees are planted as part of the urban landscape, with no intention to covert the area to forest, then this would not count as urban tree planting. Credit given is 0.38 impervious equivalent removed per acre planted with a survival rate of 100 trees/acre or greater and where at least 50% of trees have two-inch diameter or greater when measured at 4.5 ft. above ground level. (MDE 2014)

Urban Forest Buffers (ForestBufUrban)

An urban forest buffer is area of trees at least 35 feet wide on one side of a stream, usually accompanied by trees, shrubs, and other vegetation that is adjacent to a body of water. The riparian area is managed to maintain the integrity of stream channels and shorelines, to reduce the impacts of upland sources of pollution by trapping, filtering, and converting sediments, nutrients, and other chemicals.

Outfall stabilization

Outfall stabilization or repair of localized areas of erosion below a storm drain outfall will received a maximum credit is 2 acres per project as per MAST. Credit is provided in the form of 0.01 impervious reduction equivalents of 0.01 acre per linear foot of outfall stabilization. No direct pollutant reduction credits are appropriated.

CITATIONS

Anne Arundel County Government, Maryland. 2012. Design Guidelines for Step Pool Storm Conveyance (SPSC) Revision 5. Department of Public Works, Bureau of Engineering. Prepared by Hala Flores, P.E., Dennis McMonigle, and Keith Underwood. http://www.aacounty.org/DPW/Watershed /StepPoolStormConveyance.cfm

MAST 2015. Maryland Assessment and Scenario Tool. http://www.mastonline.org/

MDE 2009. Maryland Stormwater Design Manual 2000, Volumes I and II, 2009 Edition. Water Management Administration.

MDE 2014. Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated. Guidance for National Pollutant Discharge Elimination System Stormwater Permits. August 2014.

Rosgen, D., 1996, Applied River Morphology, Wildland Hydrology.

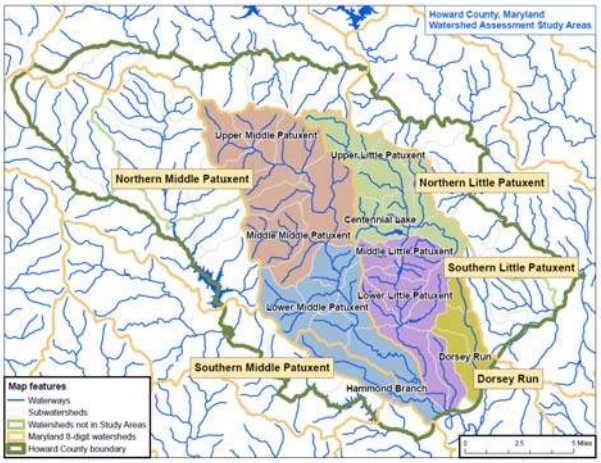
Appendix B: Stormwater Treatment BMP Definitions

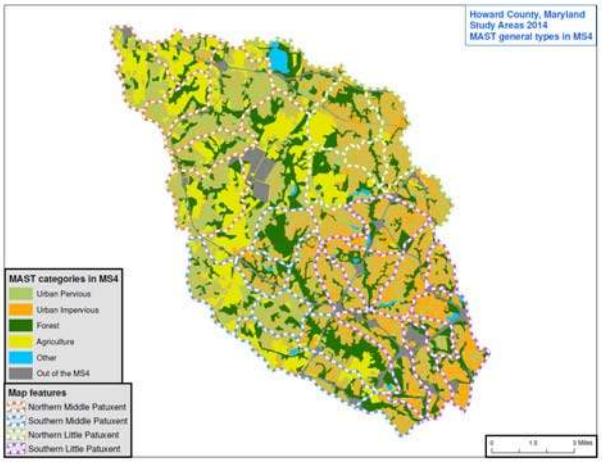
C. Field Protocols: Data Collection Guide

Field Protocols and Data Collection Guide

Howard County Watershed Assessments 2015

Middle and Little Patuxent River





Prepared for
Howard County Watershed Management Program
Howard County Department of Public Works
Bureau of Environmental Services
Stormwater Management Division

Prepared by
Versar, Inc.
Ecological Sciences and Applications
9200 Rumsey Road
Columbia, MD 21045

VERSAR

March 2015

Howard County Watershed Assessments in 2015

Study Areas and Consultant Assignments for Field Assessments

March 3, 2015 UPDATED

Watershed Assessment Study Area	Includes These Howard County Watersheds	Consultant for Field Assessments
Northern Middle Patuxent (NMP)	• Upper Middle Patuxent • Middle Middle Patuxent	McCormick Taylor
Southern Middle Patuxent (SMP)	• Lower Middle Patuxent • Hammond Branch	Biohabitats
Northern Little Patuxent (NLP)	• Upper Little Patuxent • Centennial Lake (part of Middle Little Patuxent)	KCI
Southern Little Patuxent (SLP)	• Middle Little Patuxent (except for Centennial Lake) • Lower Little Patuxent	Versar
Dorsey Run (DOR)	• Dorsey Run	McCormick Taylor

Note that Howard County Watersheds nest within Maryland 8-digit watersheds as follows:

02131106, Middle Patuxent River includes

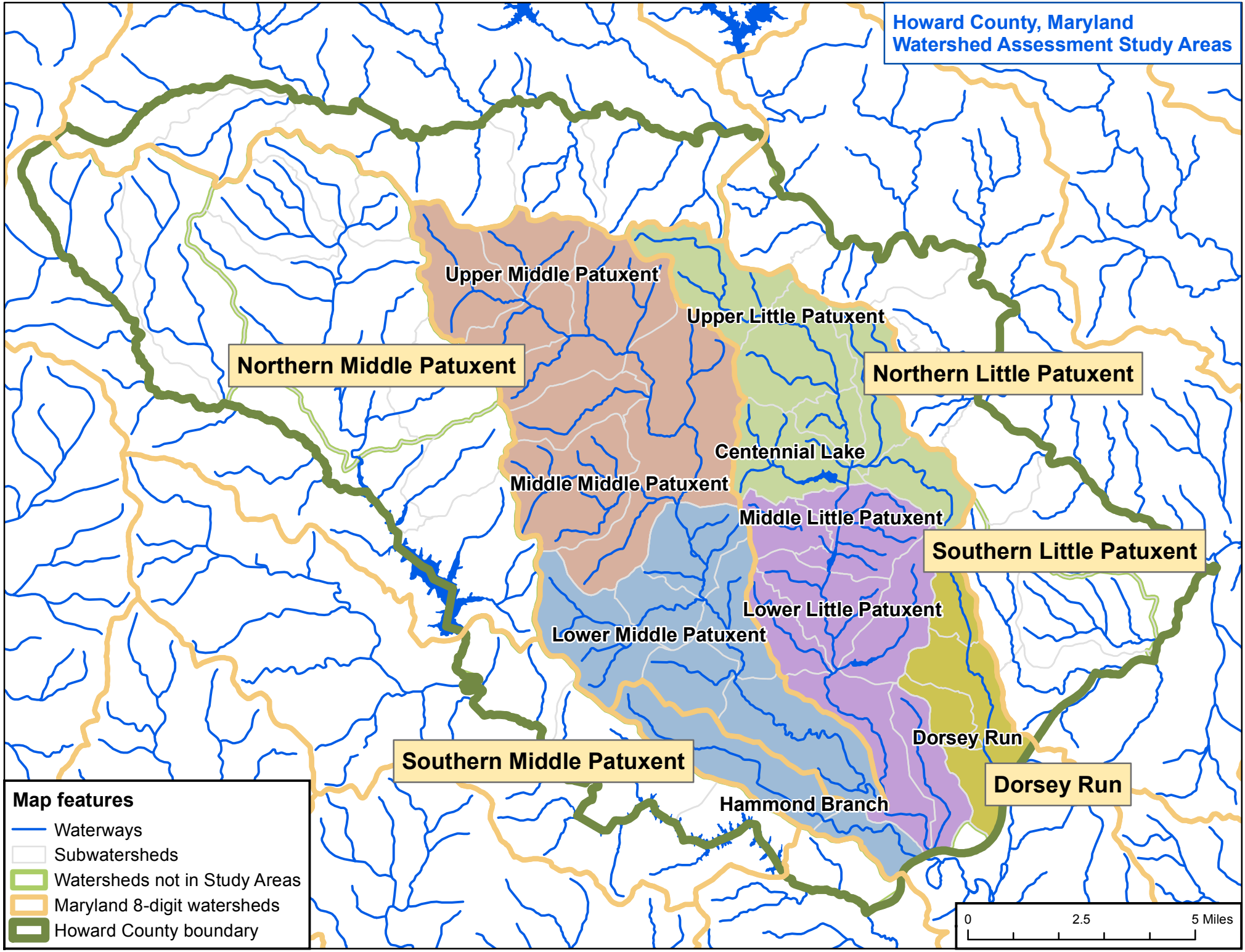
- Upper Middle Patuxent
- Middle Middle Patuxent
- Lower Middle Patuxent
- Hammond Branch

02131105, Little Patuxent River includes

- Upper Little Patuxent
- Middle Little Patuxent (includes Centennial Lake)
- Lower Little Patuxent
- Dorsey Run

Field sites identified in the desktop assessment will be properly labeled with site identifiers, before giving to the field teams. Site names will include the 3-letter Watershed Assessment Study Area identifier.

For data analysis, subwatershed designations may also be employed to aid in data organization. These subwatersheds correspond to the set of "66 Howard County subwatersheds" that nest within the 15 watersheds. Data will be managed so that all field data can be readily tied to the appropriate Study Area, 8-digit watershed, Howard County watershed, or subwatershed.


Howard County, Maryland
Watershed Assessment Study Areas
Upper Middle Patuxent
Upper Little Patuxent
Northern Middle Patuxent
Northern Little Patuxent
Centennial Lake
Middle Middle Patuxent
Middle Little Patuxent
Southern Little Patuxent
Lower Little Patuxent
Lower Middle Patuxent
Dorsey Run
Southern Middle Patuxent
Dorsey Run
Hammond Branch
Map features
Waterways
Subwatersheds
Watersheds not in Study Areas
Maryland 8-digit watersheds
Howard County boundary
0
2.5
5 Miles

Howard County Watershed Assessments Site Naming Conventions

March 3, 2015 UPDATED

Purpose: to name all field sites so they are readily recognizable by their location, site type, and unique identifier.

1. Standard site names

AAA-SS-Fxxx (Example NMP-SR-F101)

AAA = Study Area (which will also point us to which consultant team collected the data, should there be any questions)

- NMP = Northern Middle Patuxent
- SMP = Southern Middle Patuxent
- NLP = Northern Little Patuxent
- SLP = Southern Little Patuxent
- DOR = Dorsey Run

SS = Site type for the 5 types of opportunities

- BC = BMP Conversion (to upgrade existing stormwater BMP)
- NB = New BMP for currently untreated areas
- TP = Tree Planting
- OF = Outfall Stabilization
- SR = Stream Restoration

F = Field or desktop assessment

- F = Field assessment
- D = Desktop assessment (this applies to only a small number of sites that Versar and KCI will be evaluating based on past data)

xxx = 3-digit number that will be unique identifier within each type of opportunity (101, 102, etc.). These will be assigned as described in the following table. To avoid duplication, use the following guidance for any new site names added in the field:

Site numbering convention		
Consultant	Series starting with:	Study Area and Site Type (pre-assigned v. added in the field)
McCormick Taylor	101	NMP pre-assigned sites
	201	NMP sites added in the field
Biohabitats	301	SMP pre-assigned sites
	401	SMP sites added in the field
KCI	501	NLP pre-assigned sites
	651	NLP sites added in the field
Versar	701	SLP pre-assigned sites
	851	SLP sites added in the field
McCormick Taylor	901	DOR pre-assigned sites
	951	DOR sites added in the field

2. For specific types of data, there will be additional codes added:

AAA-SS-FxxxL (Example NMP-BC-F105A)

L = Letter for multiple recommendations/options (BMP conversion or new BMP Assessment) or reaches (Stream Restoration Assessment) within a site

- A = First recommendation/option or reach
- B = Second recommendation/option or reach
- C = Third recommendation/option or reach, etc.

2a. For BMP opportunities, there may be a need to keep track of multiple recommendations/options for the same site. Append A, B, C as needed to distinguish separate options.

- Example: NMP-BC-F105 has two options. Call them NMP-BC-F105A and NMP-BC-F105B

2b. For stream reaches, the first reach break along a reach will be named at the downstream end with the letter A. The upstream end will be named with the letter Z.

- Example: For stream reach NMP-SR-F101, the reach break at the downstream end will be called NMP-SR-F101A. A final reach break will be placed at the upstream end of the entire reach and be called NMP-SR-F101Z. No additional data is collected at F101Z.

If conditions vary within the reach, field crew should break the pre-selected stream restoration reach into two or more separate reaches if stream conditions warrant it.

- Example: if NMP-SR-F101 is broken into two reaches, the reach breaks at the bottom end of each will be named NMP-SR-F101A and NMP-SR-F101B. The reach break at the upstream end of Reach B will be marked NMP-SR-F101C, unless this is the final reach break, in which case it will be mark NMP-SR-F101Z.

2c. For stream assessment data, names will include additional digits as follows.

AAA-SS-FxxxL-TTyyy - For example at a stream restoration site (NMP-SR-F101A) with 3 erosion points, the erosion points would be recorded as NMP-SR-F101A-ES101, NMP-SR-F101A-ES102, NMP-SR-F101A-ES103]

TT = site type for specific stream data

- RE = Representative site - Habitat assessment
- ES = Erosion Site point
- CA = Channel Alteration point
- IB = Inadequate Buffer point
- EP = Exposed Pipe point
- UC = Unusual Condition or Comment
- PO = Pipe Outfall point
- XS = representative cross-section data

yyy = 3-digit number that will be unique identifier within each type of specific data (101, 102, etc.)

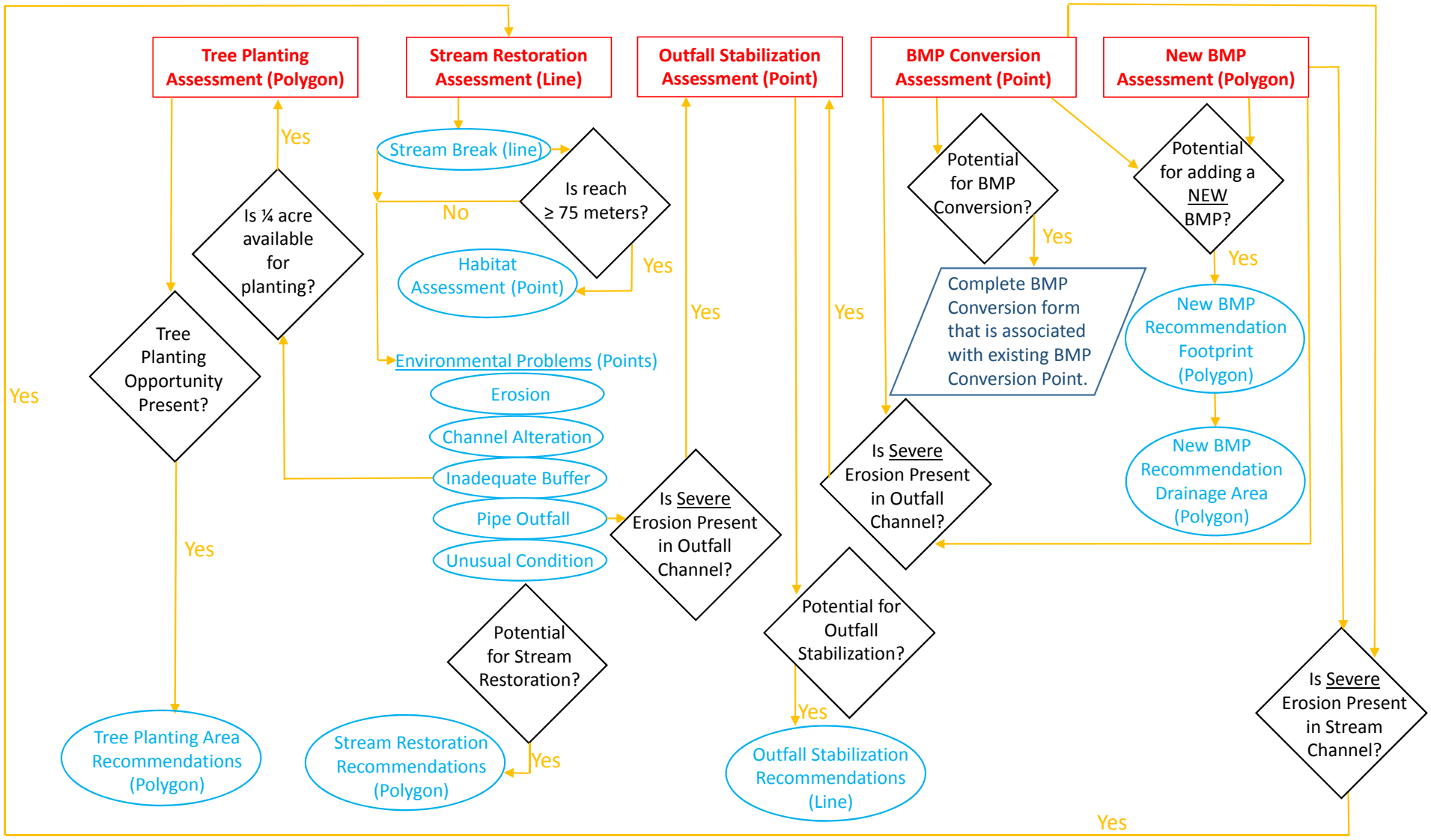
Special Notes For Field Teams

Site ID	STUDY AREA	CONTRACTOR	COMMENTS
SMP-BC-F311	Southern Middle Patuxent	Biohabitats	BMP near Engineering CIP area: U.S. Route 29 NB improvements
SMP-BC-F321	Southern Middle Patuxent	Biohabitats	On County Master List from Wilde Lake Study; listed as wet pond, but appears to be dry
SMP-NB-F303	Southern Middle Patuxent	Biohabitats	New BMP opportunities near Engineering CIP area: Hall Shop Road improvements (Site B
SMP-NB-F307	Southern Middle Patuxent	Biohabitats	New BMP opportunities near Engineering CIP area: Whiskey Bottom Road improvements
SMP-NB-F308	Southern Middle Patuxent	Biohabitats	New BMP opportunities near Engineering CIP area: Whiskey Bottom Road improvements
SMP-NB-F310	Southern Middle Patuxent	Biohabitats	New BMP opportunities near Engineering CIP area: Whiskey Bottom Road improvements
SMP-OF-F302	Southern Middle Patuxent	Biohabitats	Site is adjacent to Top Secret property; surveillance is possible for field operations
SMP-OF-F304	Southern Middle Patuxent	Biohabitats	Site is adjacent to Top Secret property; surveillance is possible for field operations
SMP-OF-F329	Southern Middle Patuxent	Biohabitats	Outfall near Engineering CIP area: Sanner Road improvements
SMP-OF-F332	Southern Middle Patuxent	Biohabitats	May be information available through MPEA
SMP-SR-F310	Southern Middle Patuxent	Biohabitats	Reach is near an Engineering CIP: Hall Shop Road at Simpson Road
SMP-SR-F320	Southern Middle Patuxent	Biohabitats	Split this section at the property line; retain downstream portion for field investigation
SMP-SR-F327	Southern Middle Patuxent	Biohabitats	On County Master List; citizen complaint of erosion; add note for field crew
SMP-SR-F328	Southern Middle Patuxent	Biohabitats	Reach crosses Engineering CIP: Stephens Road Bridge replacement
SMP-SR-F329	Southern Middle Patuxent	Biohabitats	BGE ROW - remove section that runs through ROW; retain remaining sections of the reach
SMP-SR-F351	Southern Middle Patuxent	Biohabitats	On County Master List; citizen complaint of bank erosion
SMP-SR-F354	Southern Middle Patuxent	Biohabitats	On County Master List; citizen complaint of bank erosion; private property
SMP-SR-F355	Southern Middle Patuxent	Biohabitats	On County Master List; citizen complaint of bank erosion; private property
SMP-SR-F356	Southern Middle Patuxent	Biohabitats	On County Master List; citizen complaint of bank erosion; private property
SMP-SR-F362	Southern Middle Patuxent	Biohabitats	On County Master List (Middle Patuxent WRAS); skip site if the property is a secure federal facility
SMP-TP-F301	Southern Middle Patuxent	Biohabitats	Parks review: Board of Ed. (contact before site visit)
SMP-TP-F303	Southern Middle Patuxent	Biohabitats	Parks review: No, MPEA: Mark R later confirms that Biohabitats can contact MPEA for guidance
SMP-TP-F304	Southern Middle Patuxent	Biohabitats	Parks review: No, MPEA; Mark R later confirms that Biohabitats can contact MPEA for guidance
SMP-TP-F305	Southern Middle Patuxent	Biohabitats	Biohabitats is studying MPEA; this may identify opportunities and refine field effort; Parks: No; Mark R later approve
NLP-BC-F502	Northern Little Patuxent	KCI	Believe BMP point is in the wrong location; may be Little Patuxent Study concept plan (FH1_04A); fill in form for ranking
NLP-NB-D557	Northern Little Patuxent	KCI	Good opportunity from Little Patuxent Study (FH1_04B or C); salt dome is out of MS4 - look for treatment opp
NLP-NB-D558	Northern Little Patuxent	KCI	Little Patuxent Study created a concept plan; fill out forms to conform to ranking standards
NLP-NB-D560	Northern Little Patuxent	KCI	Little Patuxent Study created a concept plan (PT1_04); fill out forms to conform to ranking standards
NLP-NB-D561	Northern Little Patuxent	KCI	Little Patuxent Study created a concept plan (PT1_03); fill out forms to conform to ranking standards
NLP-NB-D562	Northern Little Patuxent	KCI	Little Patuxent Study created a concept plan (LPX3_13); fill out forms to conform to ranking standards
NLP-NB-F503	Northern Little Patuxent	KCI	GIS Tech: Site appears to be under construction as a residential development; new homes have small BMPs
NLP-NB-F504	Northern Little Patuxent	KCI	GIS Tech: Site appears to be under construction as a residential development; new homes have small BMPs
NLP-NB-F542	Northern Little Patuxent	KCI	Home owner (3038 Southview Rd) would like drainage from the west edge of Southview to be re-routed into the County Open Space at the end of Southview
NLP-NB-F551	Northern Little Patuxent	KCI	GIS Tech: These parcels may already be treated by BMP along the entrance road; field crew could confirm
NLP-OF-F507	Northern Little Patuxent	KCI	The property owner is complaining about undermined trees and eroding banks; County wants it rated relative to others in the study
NLP-OF-F527	Northern Little Patuxent	KCI	Area could possibly use additional review for blown out area
NLP-SR-F507	Northern Little Patuxent	KCI	Reach crosses Engineering CIP: Marriottsville Road improvements
NLP-SR-F512	Northern Little Patuxent	KCI	Reach crosses Engineering CIP: Marriottsville Road improvements
NLP-SR-F515	Northern Little Patuxent	KCI	Reach is close to Engineering CIP: Marriottsville Road Bridge
NLP-SR-F517	Northern Little Patuxent	KCI	Reach is close to Engineering CIP: Marriottsville Road Bridge
NLP-SR-F519	Northern Little Patuxent	KCI	Reach crosses Alpha Ridge Park (Engineeriing CIP)
NLP-SR-F521	Northern Little Patuxent	KCI	Split segment at I-70; retain upstream section for field investigation
NLP-SR-F522	Northern Little Patuxent	KCI	Split segment at I-70; retain upstream section for field investigation
NLP-SR-F523	Northern Little Patuxent	KCI	Split the segment at the point; upstream is on ag-land (remove); retain downstream portion for field investigation
NLP-SR-F551	Northern Little Patuxent	KCI	Have field crew evaluate area on J. Schneider property for tree planting (perhaps purchase and plant)
NLP-SR-F558	Northern Little Patuxent	KCI	Remove sections downstream of Centennial Lane; retain upstream sections
NLP-SR-F559	Northern Little Patuxent	KCI	Remove sections downstream of Centennial Lane; retain upstream sections
NLP-SR-F560	Northern Little Patuxent	KCI	Split this section at the property line; retain downstream portion for field investigation
NLP-SR-F561	Northern Little Patuxent	KCI	Split this section at the property line; retain downstream portion for field investigation
NLP-SR-F562	Northern Little Patuxent	KCI	Split segment at I-70; retain upstream section for field investigation
NLP-SR-F571	Northern Little Patuxent	KCI	Retain southern extent of reach as a candidate for field investigation
NLP-SR-F573	Northern Little Patuxent	KCI	On County Master List; citizen complaint of bank erosion
NLP-SR-F591	Northern Little Patuxent	KCI	On County Master List; citizen complaint of bank erosion
NLP-SR-F593	Northern Little Patuxent	KCI	Project has been completed on the reach; split at Windflower Dr. and retain segment to the north for field investigation
NLP-SR-F601	Northern Little Patuxent	KCI	Split this reach at the point; southern section has a project; retain section to the north for field investigation
NLP-SR-F602	Northern Little Patuxent	KCI	Good opportunity from Little Patuxent Study (PT2_12)
NLP-TP-D517	Northern Little Patuxent	KCI	Little Pat. Study concept plan to enhance buffer (1752A (RHB)) - fill in form for ranking; Parks: FCA, supp. planting
NLP-TP-D518	Northern Little Patuxent	KCI	Little Pat. Study concept plan (BF_21) - fill in form for ranking; Parks: private property; Mark R confirms his approva
NLP-TP-D519	Northern Little Patuxent	KCI	Little Patuxent Study concept plan (BF_30) - fill in form for ranking; Parks: Yes

NLP-TP-D521	Northern Little Patuxent	KCI	Little Patuxent Study concept plan (BF_63) - fill in form for ranking
NLP-TP-D522	Northern Little Patuxent	KCI	Little Patuxent Study concept plan (BF_2) - fill in form for ranking; looks bare (2007 aerial) - good opportunit
NLP-TP-F514	Northern Little Patuxent	KCI	Parks review: Talk to DPW
DOR-BC-F922	Dorsey Run	McCormick Taylor	BMP near Engineering CIP area: Gateway at Robert Fulton intersection improvements
DOR-NB-F907	Dorsey Run	McCormick Taylor	New BMP opportunity near Engineering CIP area: Dorsey Run Road improvements
DOR-NB-F908	Dorsey Run	McCormick Taylor	New BMP opportunity near Engineering CIP area: Dorsey Run Road improvements
DOR-NB-F910	Dorsey Run	McCormick Taylor	New BMP opportunity near Engineering CIP area: Dorsey Run Road improvements
DOR-NB-F911	Dorsey Run	McCormick Taylor	New BMP opportunity near Engineering CIP area: Dorsey Run Road improvements
DOR-NB-F917	Dorsey Run	McCormick Taylor	New BMP opportunity near Engineering CIP area: Dorsey Run Road improvements
DOR-NB-F920	Dorsey Run	McCormick Taylor	New BMP opportunity near Engineering CIP area: Dorsey Run Road improvements
DOR-NB-F923	Dorsey Run	McCormick Taylor	New BMP opportunity near Engineering CIP area: Dorsey Run Road improvements
DOR-NB-F927	Dorsey Run	McCormick Taylor	New BMP opportunity near Engineering CIP area: Snowden River Pkwy improvements
DOR-NB-F928	Dorsey Run	McCormick Taylor	New BMP opportunity near Engineering CIP area: Snowden River Pkwy improvements
DOR-NB-F931	Dorsey Run	McCormick Taylor	New BMP opportunity near Engineering CIP area: Snowden River Pkwy improvements
DOR-NB-F932	Dorsey Run	McCormick Taylor	New BMP opportunity near Engineering CIP area: Snowden River Pkwy improvements
DOR-NB-F933	Dorsey Run	McCormick Taylor	New BMP opportunity near Engineering CIP area: Snowden River Pkwy improvements
DOR-NB-F943	Dorsey Run	McCormick Taylor	New BMP opportunity near Engineering CIP areas: Gateway at Robert Fulton intersection improvements and Snowden River Pkwy improvement
DOR-OF-F912	Dorsey Run	McCormick Taylor	Outfall near Engineering CIP area: Dorsey Run Road improvements
DOR-OF-F921	Dorsey Run	McCormick Taylor	Outfall near Engineering CIP area: Dorsey Run Road improvements
DOR-OF-F923	Dorsey Run	McCormick Taylor	Good opportunity; on County Master Plan; citizen complaint of bank erosior
DOR-OF-F926	Dorsey Run	McCormick Taylor	Outfall near Engineering CIP area: Snowden River Pkwy improvements
DOR-SR-F904	Dorsey Run	McCormick Taylor	Reach crosses Engineering CIP: Dorsey Run Road improvements
DOR-SR-F912	Dorsey Run	McCormick Taylor	Reach crosses Engineering CIP: Snowden River Pkwy improvements
NMP-NB-F104	Northern Middle Patuxent	McCormick Taylor	Lagoon being considered for improvement; retrofitting up to BMP standard
NMP-SR-F120	Northern Middle Patuxent	McCormick Taylor	Split this section at I-70; retain downstream portion for field investigatior
NLP-BC-D543	Northern Little Patuxent	Versar	Concept plan from Little Patuxent Study; fill out form for ranking
SLP-BC-D782	Southern Little Patuxent	Versar	BMP near Engineering CIP area: Snowden River Pkwy widening
SLP-BC-F717	Southern Little Patuxent	Versar	BMP near Engineering CIP area: U.S. Route 29 NB improvements
SLP-BC-F734	Southern Little Patuxent	Versar	BMP near Engineering CIP area: Snowden River Pkwy widening
SLP-BC-F757	Southern Little Patuxent	Versar	BMP near Engineering CIP area: U.S. Route 29 NB improvements
SLP-NB-D777	Southern Little Patuxent	Versar	General note in County Master List to add bioretention; Versar confirms interest in revisiting site for opportunitie
SLP-NB-F701	Southern Little Patuxent	Versar	New BMP opportunity near and in Engineering CIP area: Cradlerock Channel improvements
SLP-NB-F716	Southern Little Patuxent	Versar	New BMP opportunity near Engineering CIP area: Guilford Road from U.S. Route 1 to Dorsey Rur
SLP-NB-F720	Southern Little Patuxent	Versar	New BMP opportunity near Engineering CIP area: Oakland Mills Road widening
SLP-NB-F734	Southern Little Patuxent	Versar	CA is redesigning a sand filter here, but the rest of it is still potential for new BMI
SLP-NB-F739	Southern Little Patuxent	Versar	New BMP opportunity near Engineering CIP area: Snowden River Pkwy improvements
SLP-NB-F740	Southern Little Patuxent	Versar	New BMP opportunity near Engineering CIP area: Snowden River/Brokenland Pkwy intersectior
SLP-NB-F744	Southern Little Patuxent	Versar	General note in County Master List to add bioretention; Versar confirms interest in revisiting site for opportunitie
SLP-NB-F755	Southern Little Patuxent	Versar	New BMP opportunities near Engineering CIP area: U.S. Route 29 NB improvements
SLP-NB-F756	Southern Little Patuxent	Versar	New BMP opportunities near Engineering CIP area: U.S. Route 29 NB improvements
SLP-NB-F765	Southern Little Patuxent	Versar	New BMP opportunity near Engineering CIP area: Oakland Mills Road widening
SLP-NB-F767	Southern Little Patuxent	Versar	New BMP opportunity near Engineering CIP area: Snowden River/Brokenland Pkwy intersectior
SLP-NB-F770	Southern Little Patuxent	Versar	New BMP opportunity is in an Engineering CIP area: Oakland Mills Road interchange
SLP-NB-F771	Southern Little Patuxent	Versar	New BMP opportunities near Engineering CIP area: U.S. Route 29 NB improvements
SLP-NB-F772	Southern Little Patuxent	Versar	New BMP opportunity near Engineeing CIP area: Cedar Lane ped improvements
SLP-OF-F717	Southern Little Patuxent	Versar	Outfalls throughout this reach should be inspected; new sheet pile weirs installed and CA is designing a repair for the most downstream devic
SLP-OF-F718	Southern Little Patuxent	Versar	Outfalls throughout this reach should be inspected; new sheet pile weirs installed and CA is designing a repair for the most downstream devic
SLP-OF-F719	Southern Little Patuxent	Versar	Outfalls throughout this reach should be inspected; new sheet pile weirs installed and CA is designing a repair for the most downstream devic
SLP-OF-F720	Southern Little Patuxent	Versar	Outfalls throughout this reach should be inspected; new sheet pile weirs installed and CA is designing a repair for the most downstream devic
SLP-OF-F721	Southern Little Patuxent	Versar	Outfalls throughout this reach should be inspected; new sheet pile weirs installed and CA is designing a repair for the most downstream devic
SLP-OF-F722	Southern Little Patuxent	Versar	Outfalls throughout this reach should be inspected; new sheet pile weirs installed and CA is designing a repair for the most downstream devic
SLP-OF-F723	Southern Little Patuxent	Versar	Outfalls throughout this reach should be inspected; new sheet pile weirs installed and CA is designing a repair for the most downstream devic
SLP-OF-F724	Southern Little Patuxent	Versar	Outfalls throughout this reach should be inspected; new sheet pile weirs installed and CA is designing a repair for the most downstream devic
SLP-OF-F725	Southern Little Patuxent	Versar	Outfalls throughout this reach should be inspected; new sheet pile weirs installed and CA is designing a repair for the most downstream devic
SLP-OF-F726	Southern Little Patuxent	Versar	Outfalls throughout this reach should be inspected; new sheet pile weirs installed and CA is designing a repair for the most downstream devic
SLP-OF-F727	Southern Little Patuxent	Versar	Outfalls throughout this reach should be inspected; new sheet pile weirs installed and CA is designing a repair for the most downstream devic
SLP-OF-F728	Southern Little Patuxent	Versar	Outfalls throughout this reach should be inspected; new sheet pile weirs installed and CA is designing a repair for the most downstream devic
SLP-OF-F739	Southern Little Patuxent	Versar	Outfall near Engineering CIP areas: Guilford Road from U.S. Route 1 to Dorsey Rur
SLP-OF-F742	Southern Little Patuxent	Versar	Outfall near Engineering CIP areas: Guilford Road from U.S. Route 1 to Dorsey Rur
SLP-OF-F743	Southern Little Patuxent	Versar	Outfall near Engineering CIP areas: Guilford Road Ped/bike improvements and Mission Road sidewall

SLP-OF-F785	Southern Little Patuxent	Versar	Citizen concern area
SLP-OF-F787	Southern Little Patuxent	Versar	CA is designing an imbricated wall at the upstream end to protect a home foundatior
SLP-OF-F788	Southern Little Patuxent	Versar	CA is designing an imbricated wall at the upstream end to protect a home foundatior
SLP-OF-F789	Southern Little Patuxent	Versar	CA is designing an imbricated wall at the upstream end to protect a home foundatior
SLP-SR-F704	Southern Little Patuxent	Versar	CA is doing a stream restoration on the tributary that enters this reach from along Oakland Mills Roa
SLP-SR-F720	Southern Little Patuxent	Versar	EPA-installed sheet pile weirs (3) in the stream reach to Jackson Pond. CA will repair the most downstream wei
SLP-SR-F721	Southern Little Patuxent	Versar	EPA-installed sheet pile weirs (3) in the stream reach to Jackson Pond. CA will repair the most downstream wei
SLP-SR-F722	Southern Little Patuxent	Versar	EPA-installed sheet pile weirs (3) in the stream reach to Jackson Pond. CA will repair the most downstream wei
SLP-SR-F723	Southern Little Patuxent	Versar	EPA-installed sheet pile weirs (3) in the stream reach to Jackson Pond. CA will repair the most downstream wei
SLP-SR-F724	Southern Little Patuxent	Versar	Split segment at upstream pond; retain upstream segment for field investigatior
SLP-SR-F726	Southern Little Patuxent	Versar	Reach is near Engineering CIP: Oakland Mills Road widening
SLP-SR-F727	Southern Little Patuxent	Versar	Reach is near Engineering CIP: Oakland Mills Road widening
SLP-SR-F736	Southern Little Patuxent	Versar	On County Master List; citizen complaint
SLP-SR-F737	Southern Little Patuxent	Versar	Reach crosses Engineering CIP: U.S. 29 NB improvements
SLP-SR-F738	Southern Little Patuxent	Versar	On County Master List; citizen complaint of bank erosior
SLP-SR-F741	Southern Little Patuxent	Versar	On County Master List; citizen complaint of bank erosior
SLP-SR-F748	Southern Little Patuxent	Versar	On County Master List; citizen complaint of bank erosior
SLP-SR-F751	Southern Little Patuxent	Versar	CA is designing an imbricated wall at the upstream end to protect a home foundation; reach crosses Eng. CIP:US 29 impr
SLP-SR-F752	Southern Little Patuxent	Versar	On County Master List; citizen complaint of bank erosior
SLP-SR-F755	Southern Little Patuxent	Versar	Evaluate stream, including area upstream toward Thicket Lane
SLP-SR-F758	Southern Little Patuxent	Versar	EPA-installed sheet pile weirs (3) in the stream reach to Jackson Pond. CA will repair the most downstream wei
SLP-TP-F703	Southern Little Patuxent	Versar	Parks review: HCC, has forest conservation plan; GIS Tech: May ask HCC about more opportunities

Howard County Field Assessment Decision Flow Chart



Howard County Watershed Assessments
BMP Conversion Assessment – Data Collection Field Protocol
March 6, 2015

General Data Collection Instructions

- If any illicit discharges or other safety concerns (e.g., missing manhole cover) are observed in the field, notify the County as soon as possible by contacting Kelly Hargadin (khargadin@howardcountymd.gov, Office 410-313-0844 or Cell 720-979-1519). Provide location, information about the problem observed, and a photograph.
- Locate site on map layer for BMP Conversion Assessment **(*point*)** and fill in data for the fields below.

Fields - BMP Conversion Assessment *(Point)*

Overall

- Site ID (pre-assigned, unique number. Example: SLP-BC-F701)
- Field Crew [initials]
- Create a site name [This will be considered the common name for the site. Example: name of school, business, or nearest road.]
- Can site be evaluated? (if no, do not fill out other data)
  - Yes
  - No, landowner did not grant access
  - No, fence or other barrier
  - No, BMP does not exist at present
  - No, another reason
- Other reason site cannot be evaluated (describe)
- Can existing BMP be converted? [Answer this question after assessing the site and constraints. Use CONSTRAINTS SECTION BELOW to document constraints.]
  - Yes
  - No
- Notes: Reason BMP cannot be converted

General Site Description – Existing Conditions

- BMP Structure ID of existing pond [pre-filled from GIS data]
- BMP type from database [e.g., Dry Pond or Extended Detention Dry Pond]
- Owner Name [pre-filled from GIS data]
- BMP Address [pre-filled from GIS data]
- Drainage Area of Existing BMP (ac) [pre-filled from GIS data]
- Impervious Area of Existing BMP Drainage Area (ac) [pre-filled from GIS data]
- Study Area [pre-filled from GIS data]
- Contractor [pre-filled from GIS data]
- Comments [pre-filled from GIS data; information for field crew]
- Site Note [pre-filled from GIS data; information for field crew]
- Ownership [In most cases, this should be evident in GIS parcel layer.]
  - County School
  - County Parks
  - County – other

    - Private
    - Other
    - Unknown
- Notes, if ownership other
- Existing Pond Type (as YOU see it in field)
    - Dry Pond
    - Wet Pond
    - Other
- Describe type, if Other
- Is pond type same as listed in County database?
    - Yes/no
- Is repair needed?
    - Yes/No
- Other information describing existing pond condition (describe) [Such as need for maintenance, invasive vegetation removal, under construction, etc.]
- Existing Drainage area land use (predominant type)
    - Residential – single family homes <1 ac lots
    - Residential – single family homes > 1 ac lots
    - Townhouses
    - Multi-Family
    - Institutional
    - Industrial (not necessarily related to 02-SW or 12-SW permits)
    - Commercial
    - Transport-Related
    - Park
    - Undeveloped
    - Other
- Other information related to land use type within existing drainage area (describe) [This is a super-hotspot, lots of floatables or pet/goose waste, or other major issue.]

Downstream or Outfall Condition

Note: sites with < 200 feet of erosion below outfall will be considered *outfall channels*. Sites with >200-300 feet of erosion below outfall will be considered for stream restoration and evaluated for *downstream condition*.)

- Condition of outfall channel
    - 1-3: Minor erosion. Less than 1 foot of eroded banks. Healing may be present.
    - 4-6: Moderate erosion. Eroded banks are 1-2 feet in height. Erosion looks relatively recent.
    - 7-10: Severe Erosion. Eroded banks are greater than 2 feet in height. Erosion typically recent/active. (Fill out Outfall Stabilization Evaluation form)
- Reason Condition of outfall channel could not be inspected
    - Not applicable - discharges directly into MS4
    - Not applicable – discharges directly into large perennial stream
    - Could not inspect outfall [If behind fence etc.]
- Length of outfall channel erosion (ft.)

- Condition of stream channel [extending beyond 200 feet from discharge point]
    - 1-3: Minor erosion. 2-3 feet in eroded bank height, not causing significant stream degradation. Showing signs of healing.
    - 4-6: Moderate erosion. 3-5 feet in eroded bank height. Relatively recent/raw.
    - 7-10: Severe Erosion. 5 ft or greater eroded bank height. Erosion typically recent/active. Obvious instream degradation. If threatening utilities or structures rate 9-10. (Fill in Stream Restoration Assessment Form)
- Reason Condition of stream channel could not be inspected
    - Not applicable [make N/A the default]
    - Too far to warrant inspection
- Length of stream erosion (ft.)
- Notes: Describe Existing Site Conditions, Including Existing Site Drainage and Conveyance

Candidate BMP Constraints

- Property for Sale or Lease?
    - Yes/No
- Are there many constraints to new BMP project?
    - None
    - Some
    - Many
- Type (check all that apply)
    - Slope
    - Utilities
    - Structures
    - Space insufficient
    - Significant impact to trees
    - Specimen tree removal
    - Property Ownership
    - Access
    - Proximity to neighboring properties
    - Other adjacent landowner issues
    - Safety
    - Aesthetics
    - Other
- Other information on BMP project constraints or conflicts (describe)
- Impact to Existing Trees
    - Minimal
    - Moderate
    - Significant
- Ease of access
    - Easy
    - Moderate
    - Difficult
- Conflicts with Existing Utilities – Sewer
    - Yes
    - No
    - Possible
- Conflicts with Existing Utilities – Water
    - Yes

    - No
    - Possible
- Conflicts with Existing Utilities – Gas
    - Yes
    - No
    - Possible
- Conflicts with Existing Utilities – Cable
    - Yes
    - No
    - Possible
- Conflicts with Existing Utilities – Electric
    - Yes
    - No
    - Possible
- Conflicts with Existing Utilities – Electric to Streetlights
    - Yes
    - No
    - Possible
- Conflicts with Existing Utilities – Overhead Wires
    - Yes
    - No
    - Possible
- Conflicts with Existing Utilities – Other
    - Yes
    - No
    - Possible
- Other information on conflicts with existing utilities (describe)

[Whatever additional details you can think of which are relevant to conflicts which cannot be answered by YES or NO]

Potential Permitting Factors

- Dam Safety Permits Necessary [make "not probable" the default] (height of the pond measured from the upstream toe to the top of dam is more than 20 feet)
    - Probable
    - Not probable
- Impacts to Wetlands [make "not probable" the default]
    - Probable
    - Not probable
- Impacts to a Stream [make "not probable" the default]
    - Probable
    - Not probable
- Floodplain Fill [make "not probable" the default] (Will new BMP cause changes to floodplain elevation?)
    - Probable
    - Not probable
- Impacts to Specimen Trees (≥30 inch DBH)
    - Probable
    - Not probable
- Number of Trees Impacted (number)
- Other permitting or impact factors (describe)

Soils

- Evidence of poor infiltration [clays, fines]

    - Yes/No/Unknown
- Evidence of shallow bedrock
    - Yes/No/Unknown
- Evidence of high water table [gleying, saturation]
    - Yes/No/Unknown
- Notes on soils

Other Project Types

- Is Site a Candidate for Other Restoration Projects?
    - No
    - Yes, BMP conversion
    - Yes, Tree planting
    - Yes, Stream restoration
    - Yes, Outfall stabilization
- Other Types of Projects Appropriate Here (describe)

Recommendations Summary

Proposed BMP Conversion Recommendations

- Proposed Treatment Option within pond boundary (check all that apply)
    - Extended Detention
    - Wet Pond
    - Created Wetland
    - Bioretention
    - Step Pool Conveyance
    - Filtering Practice other than Bioretention
    - Infiltration (not recommended for hotspots)
    - Swale (engineered)
    - Other
- If other type, describe proposed treatment option
- Will new BMP drainage area be the same as existing drainage area?
    - Yes/No
- If no, describe area to be treated by newly converted BMP
- Describe Elements of Proposed Retrofit, Including Surface Area, Maximum Depth of Treatment, and Conveyance. Give a short narrative of BMP conversion to be done, as would be given on the first page of construction drawings.
- Notes on BMP conversion proposed. [Space for anything more that could not fit above.]
- Initial Feasibility and Construction Considerations (describe)

  Summarize some of the above criteria such as utility conflicts, neighborhood aesthetics consideration, treatment trains, technical complexity such as need for flow splitters etc.

- BMP Conversion Potential [This is a quick evaluation of "convertibility", not the pollutant removal efficiency gains anticipated.]
    - High
    - Medium
    - Low

- Optional: Sketch the proposed BMP conversion and attach sketch as photo. Sketch elements may include existing head available, surface area, minimum depth of treatment, conveyance, inlet, outlet, utility lines / other constraints, flow lines, property lines

Howard County Watershed Assessments
New BMP Assessment – Data Collection Field Protocol
March 6, 2015

General Data Collection Instructions

- If any illicit discharges or other safety concerns (e.g., missing manhole cover) are observed in the field, notify the County as soon as possible by contacting Kelly Hargadin (khargadin@howardcountymd.gov, Office 410-313-0844 or Cell 720-979-1519). Provide location, information about the problem observed, and a photograph.

- Locate site on map layer for New BMP Assessment **(*polygon*)** and fill in data for the fields below.

Fields – New BMP Assessment *(Polygon)*

Overall

- Site ID (pre-assigned, unique number. Example: SLP-NB-F701)
- Field Crew [initials]
- Create a site name [This will be considered the site's common name. Example: name of school, business, or nearest road.]
- Can site be evaluated? (if no, do not fill out other data)
    - Yes
    - No, landowner did not grant access
    - No, fence or other barrier
    - No, another reason
- Other reason site cannot be evaluated (describe)
- Is a new BMP retrofit possible on this site? Answer this question after assessing the site and constraints. Use CONSTRAINTS SECTION BELOW to document constraints.
    - Yes
    - No, too many constraints

General Site Description – Existing Conditions

- Owner Name [If known]
- BMP Address
- Study Area [pre-filled from GIS data]
- Contractor [pre-filled from GIS data]
- Comments [pre-filled from GIS data; information for field crew]
- Site Note [pre-filled from GIS data; information for field crew]
- Site Area - acres [prefilled from GIS]
- Ownership [In most cases, this should be evident in GIS parcel layer]
    - County School
    - County Parks
    - County – other
    - Private
    - Other
    - Unknown
- Notes, if ownership other
- Existing Land Use in Site Vicinity [predominant type]
    - Residential – single family homes <1 ac lots
    - Residential – single family homes > 1 ac lots
    - Townhouses
    - Multi-Family

    - Institutional
    - Industrial (not necessarily related to 02-SW or 12-SW permits)
    - Commercial
    - Transport-Related
    - Park
    - Undeveloped
    - Other
- Additional information about the land use type within existing drainage area (describe)
- Adjacent Land Use (check all that apply)
    - Residential
    - Commercial
    - Institutional
    - Industrial
    - Transport-Related
    - Park
    - Undeveloped
    - Other
- Other information on adjacent land use (describe)
- Is repair/replacement of an existing structure needed? [example: older pipe or parking lot in need of replacement]
    - Yes/No
- Other information describing existing conditions (describe) such as need for maintenance, invasive vegetation removal.

Downstream or Outfall Condition

Note that sites with < 200 feet of erosion below outfall will be considered *outfall channels*. Sites with >200-300 feet of erosion below outfall will be considered for stream restoration and evaluated for *downstream condition*.

- Condition of outfall channel
    - 1-3: Minor erosion. Less than 1 foot of eroded banks. Healing may be present.
    - 4-6: Moderate erosion. Eroded banks are 1-2 feet in height. Erosion looks relatively recent.
    - 7-10: Severe Erosion. Eroded banks are greater than 2 feet in height. Erosion typically recent/active. [Fill out Outfall Stabilization Assessment form]
- Reason Condition of outfall channel could not be inspected
    - Not applicable – discharges directly into MS4
    - Not applicable – discharges directly into large perennial stream
    - Could not inspect outfall [If behind fence etc.]
- Length of outfall channel erosion (ft.)
- Condition of stream channel [extending beyond 200 feet from discharge point]
    - 1-3: Minor erosion. 2-3 feet in eroded bank height, not causing significant stream degradation. Showing signs of healing.
    - 4-6: Moderate erosion. 3-5 feet in eroded bank height. Relatively recent/raw.
    - 7-10: Severe Erosion. 5 ft or greater eroded bank height. Erosion typically recent/active. Obvious instream degradation. If threatening utilities or structures rate 9-10. [Fill in Stream Restoration Assessment Form]
- Reason Condition of stream channel could not be inspected

    - Not applicable
    - Too far away, no access, to warrant inspection
- Length of stream erosion (ft.)
- Notes: Describe Existing Site Conditions, Including Existing Site Drainage and Conveyance

Candidate BMP Constraints

- Property for Sale or Lease?
    - Yes/No
- Are there many constraints to new BMP project?
    - None
    - Some
    - Many
- Constraint Type [check all that apply]
    - Slope
    - Utilities
    - Structures
    - Space insufficient
    - Significant impact to trees
    - Specimen tree removal
    - Property Ownership
    - Access
    - Proximity to neighboring properties
    - Other adjacent landowner issues
    - Safety
    - Aesthetics
    - Other
- Other information on BMP project constraints or conflicts (describe)
- Impact to Existing Trees
    - Minimal
    - Moderate
    - Significant
- Ease of access
    - Easy
    - Moderate
    - Difficult
- Conflicts with Existing Utilities – Sewer
    - Yes
    - No
    - Possible
- Conflicts with Existing Utilities – Water
    - Yes
    - No
    - Possible
- Conflicts with Existing Utilities – Gas
    - Yes
    - No
    - Possible
- Conflicts with Existing Utilities – Cable
    - Yes
    - No
    - Possible
- Conflicts with Existing Utilities – Electric
    - Yes
    - No
    - Possible
- Conflicts with Existing Utilities – Electric to Streetlights

    - Yes
    - No
    - Possible
- Conflicts with Existing Utilities – Overhead Wires
    - Yes
    - No
    - Possible
- Conflicts with Existing Utilities – Other
    - Yes
    - No
    - Possible

- Other information on conflicts with existing utilities (describe)

Potential Permitting Factors

- Dam Safety Permits Necessary [make "not probable" the default] (height of the pond measured from the upstream toe to the top of dam is more than 20 feet)
    - Probable
    - Not probable
- Impacts to Wetlands [make "not probable" the default]
    - Probable
    - Not probable
- Impacts to a Stream [make "not probable" the default]
    - Probable
    - Not probable
- Floodplain Fill [make "not probable" the default] (Will new BMP cause changes to floodplain elevation?)
    - Probable
    - Not probable
- Impacts to Specimen Trees [≥30 inch DBH]
    - Probable
    - Not probable
- Number of Trees Impacted (number)
- Other permitting or impact factors (describe)

Soils

- Evidence of poor infiltration [clays, fines]
    - Yes/No/Unknown
- Evidence of shallow bedrock
    - Yes/No/Unknown
- Evidence of high water table [gleying, saturation]
    - Yes/No/Unknown
- Notes on soils

Other Project Types

- Is Site a Candidate for Other Restoration Projects?
    - No
    - Yes, BMP conversion
    - Yes, Tree planting
    - Yes, Stream restoration
    - Yes, Outfall stabilization
- Other Types of Projects Appropriate Here (describe)

Recommendations: New BMP (Polygon) and Drainage Area (DA) (Polygon) [This will be 2 polygons – one for the project footprint, one for the DA.]

- Draw footprint of proposed project – on tablet in layer called "Sketch – Proposed New BMP Footprint"
- Draw proposed Drainage Area in layer called "Sketch – Proposed New BMP – Drainage Area"
- Comments
- Drainage Area Estimate [No need to enter - will be calculated with hand drawn polygon.]

NEW BMP Recommendation Summary – complete the form in the layer "New BMP Recommendation Footprint" (polygon)"

- Site ID (Example: NMP-NB-F101A)
- Proposed Treatment Option (check all that apply)
  - Extended Detention
  - Wet Pond
  - Created Wetland
  - Bioretention
  - Step Pool Conveyance
  - Filtering Practice other than Bioretention
  - Infiltration
  - Swale
  - Green roof
  - Impervious surface removal
  - Impervious pavement replacement
  - Other
- If other proposed treatment, describe type.
- Demonstration/Education value?
  - Yes/no
- Notes: Describe Elements of Proposed Retrofit, Including Surface Area, Maximum Depth of Treatment, and Conveyance.

  Give a short narrative of BMP to be built, as would be given on the first page of construction drawings
- Initial Feasibility and Construction Considerations (describe)

  Summarize some of the above criteria such as utility conflicts, neighborhood aesthetics consideration, technical complexity such as need for flow splitters etc.
- Other notes on new BMP proposed: [Space for anything more that could not fit above.]
- New Stormwater BMP – Retrofit Potential [This is quick evaluation of retrofitability / feasibility of constructing this BMP - not a ranking of quality of the BMP to remove pollutants]
  - High
  - Medium
  - Low

- Optional: Sketch the proposed BMP and attach sketch as photo. Sketch elements may include existing head available, surface area, minimum depth of treatment, conveyance, inlet, outlet, utility lines / other constraints, flow lines, property lines.

NEW BMP Recommendation Drainage Area – complete the form in the layer "New BMP Recommendation Drainage Area" (Polygon)"

- Site ID (Example: NMP-NB-F101A)
- Comments

Howard County Watershed Assessments
Tree Planting Assessment – Data Collection Field Protocol
March 6, 2015

General Data Collection Instructions

- If any illicit discharges or other safety concerns (e.g., missing manhole cover) are observed in the field, notify the County as soon as possible by contacting Kelly Hargadin (khargadin@howardcountymd.gov, Office 410-313-0844 or Cell 720-979-1519). Provide location, information about the problem observed, and a photograph.
- Locate site on map layer for opportunity for Tree Planting Assessment **(*polygon*)** and fill in data for the fields below.

Fields – Tree Planting Assessment *(Polygon)*

Overall

- Site ID (pre-assigned, unique number. Example: SLP-TP-F701)
- Field Crew [Initials]
- Create a site name [This will be considered the common name of the site. Example: name of school, business, or nearest road.]
- Can site be evaluated? (if no, do not fill out other data)
  - Yes
  - No, landowner did not grant access
  - No, fence or other barrier
  - No, another reason
- Other reason site cannot be evaluated (describe)
- Is tree planting possible on this site? Answer this question after assessing the site and constraints. Use CONSTRAINTS SECTION BELOW to document constraints.
  - Yes
  - No, too many constraints
- Is tree planting opportunity at least 0.25 acres?
  - Yes/No

General Site Description

- Owner Name [prefilled from GIS]
- Owner Address [prefilled from GIS]
- Ownership [In most cases, this should be evident in GIS parcel layer.]
  - County School
  - County Parks
  - County – other
  - Private
  - Other
  - Unknown
- Notes, if ownership other
- Study Area [pre-filled from GIS data]
- Contractor [pre-filled from GIS data]
- Comments [pre-filled from GIS data; information for field crew]
- Site Note [pre-filled from GIS data; information for field crew]
- Parcel size: ____ acre(s) [prefilled - from GIS]
- Access to site (check all that apply)

    - Foot access
    - Vehicle access
    - Heavy equipment access
- Current Management
    - School District
    - Charter School
    - Park
    - Tot Lot
    - Public Right-of-way
    - Private Right-of-way
    - Vacant land
    - Other

Climate

- Sunlight exposure
    - Full sun (6 hours or more of direct sun per day)
    - Part sun or filtered light (<6 hours per day)
    - Shade (<3 hours of direct sun per day)
- Microclimate features: High wind exposure (Yes/No)
- Microclimate features: Re-reflected heat load (Yes/No)
- Microclimate features: Other (describe)

Topography

- Any slopes >15% present in proposed planting area? (Yes/No)
- If yes, estimate slope
- Any low-lying areas present in proposed planting area? (Yes/No)
- If yes, notes on low lying area

Vegetation

- Regional forest association or dominant species from reference site
- Current vegetative cover (estimate percent)
    - Mowed Turf _____% [1,2,3,4,5, 10, 15, 20, 25, 30 …100 by 5's]
    - Other Herbaceous _____% [as above]
    - Trees/Shrubs _____% [as above]
    - None (bare soil) _____% [as above]
- Note species to be preserved
- Are invasive species or noxious weeds present in proposed planting area? (Yes/No)
- % coverage by invasives in proposed planting area: _____
- List dominant types of invasive species in proposed planting area, if any _____
- Adjacent vegetative cover: is forest present? (Yes/No)
- If yes, note dominant forest species
- Are invasive species or noxious weeds present in adjacent vegetated area? (Yes/No)
- % coverage by invasives in adjacent area: _____
- List dominant types of invasive species in adjacent area, if any _____
- Is there heavy browsing by deer? (Yes/No)
- Is there beaver activity? (Yes/No)
- Evidence of previous tree planting? (Yes/No)
- Comment on success of previous tree planting, if evidence present
- Notes

Soils

- Soil texture
  - Clay
  - Loam
  - Sand
- Soil Compaction
  - None
  - Moderate
  - Severe
- Active or severe soil erosion? (Yes/No)
- Potential soil contamination? (Yes/No)
- Debris and rubble in soil? (Yes/No)
- Recent construction or other soil disturbance? (Yes/No)
- Other soil characteristics (describe)

Hydrology

- Site hydrology
  - Upland
  - Riparian
- Stormwater runoff to planting site – bypasses site in pipe? (Yes/No)
- Stormwater runoff to planting site – Upslope drainage area outfalls to site? (Yes/No)
- Note diameter of pipe outfall, if present (inches)
- Stormwater runoff to planting site – Open channel directs flow across or around site? (Yes/No)
- Stormwater runoff to planting site – Shallow concentrated flow (for example, evidence of rills, gullies, sediment deposits)? (Yes/No)
- Stormwater runoff to planting site – Sheetflow? (Yes/No)
- Contributing flow length (ft) [The distance over which runoff travels before entering planting area. For larger planting areas, distance runoff travels before leaving the planting area.]
- Contributing flow length, slope (%)
- Contributing flow length, cover type
  - Impervious
  - Pervious
- Floodplain connection (riparian areas only) – bank height (ft)
- If riparian planting is proposed on both sides of stream, explain/describe differences in hydrology or flow path.

Potential Planting Conflicts or Constraints

- Space Limitations
  - Overhead wires? (Yes/No)
  - Height of overhead wires, if present (ft)
  - Pavement? (Yes/No)
  - Structures? (Yes/No)
  - Signs? (Yes/No)
  - Height of signs, if present (ft)
  - Lighting? (Yes/No)
  - Height of lighting, if present (ft)
  - Underground Utilities? (Yes/No)

    - Note type of underground utilities present
    - Other space limitations (describe)
- Other limiting factors or constraints
    - Trash dumping/debris (Yes/No)
    - If trash present, note type, volume (estimated number pickup truck loads) and source if known.
    - Deer, beaver, or other animal impacts (Yes/No)
    - Site mowed regularly (Yes/No)
    - Wetland present (Yes/No)
    - Insect infestation or disease (Yes/No)
    - Access (Yes/No)
    - Ownership (Yes/No)
    - Heavy pedestrian traffic (Yes/No)
- Other limiting factors/constraints (describe)
- Notes

    - Overbank flow from river or stream? (Yes/No)
    - Fire hydrant nearby? (Yes/No)
- Other water source (describe)
- Estimated distance to nearest water source (ft)

Planting and Maintenance Logistics

- Site Access
    - Delivery Access for planting materials present? (Yes/No)
    - Temporary storage areas for soils, mulch, etc. present? (Yes/No)
    - Heavy equipment access? (Yes/No)
    - Volunteer parking area available? (Yes/No)
    - Nearby facilities for volunteers? (Yes/No)
- Water source
    - Rainfall only? (Yes/No)
    - Stormwater runoff? (Yes/No)
    - Hose hook-up nearby? (Yes/No)
    - Irrigation system in place? (Yes/No)

TREE PLANTING RECOMMENDATIONS

Tree Planting Recommendation Summary – complete the form in the layer "Tree Planting Area Recommendations" [polygon]

Sketch footprint of proposed tree planting area – on tablet, outline area(s) to be planted

- Site ID (Example: SLP-TP-F701A)
- Site Preparation Required
    - High (e.g., clearing of dumpsite)
    - Medium (e.g., extensive clearing of invasives)
    - Low
    - None
- Type of site prep needed (describe)
- Potential Demonstration/Education Project? (Is site public/highly visited v. remote location?)
    - Yes/No/Maybe

- Notes: _____
- Tree Planting Areas - Restoration Potential [This is quick, overall evaluation of feasibility of tree planting at this site.]

    - High
    - Medium
    - Low

- Comments

- Optional: Sketch the proposed tree planting area and attach sketch as photo. Sketch elements may include:
    - Property boundary and features such as roads, streams, and adjacent land use/cover
    - Boundary and approximate dimensions of proposed planting area
    - Variations in sun exposure, microclimate, and topography within planting area
    - Current vegetative cover, location of trees to be preserved, and invasive species
    - Flow paths to planting area and contributing flow length
    - Above or below ground space limitations (e.g., utilities, structures)
    - Other limited factors such as trash dumping, pedestrian paths
    - Water source and access points
    - Scale bar and north arrow.

Howard County Watershed Assessments

Stream Restoration Assessment – Data Collection Field Protocol

March 6, 2015

General Data Collection Instructions

- All reaches are assessed while walking upstream
- If there is a significant change in biological, physical or geomorphic conditions within a reach, then the field team has the ability to draw a Stream Reach Break Line to designate separate reaches.
- Each reach, including new reaches designated in the field, must have a habitat assessment point if reach is at least 75 meters long.
- If a portion of a reach cannot be assessed due to access or safety issues, then place a Reach Break Line at the point in the reach where the team can no longer walk upstream. Place a new Reach Break Line when the reach is assessable again.
- Right and left bank are determined while facing downstream.
- A minimum of two photos must be taken at each feature (point, line or polygon). First photo is taken looking upstream (or upslope in the case of outfalls), second photo is taken while looking downstream. Additional photos may be taken at the discretion of the field team.
- If any illicit discharges or other safety concerns (e.g., missing manhole cover) are observed in the field, notify the County as soon as possible by contacting Kelly Hargadin (khargadin@howardcountymd.gov, Office 410-313-0844 or Cell 720-979-1519). Provide location, information about the problem observed, and a photograph.

Stream Restoration Assessment Data Layers

Stream Restoration Assessment (line) – No editing; base layer with Site IDs. Check here for comments that may contain special notes for field crews.

Stream Reach Break (line)……pg. 2

Rapid Biology/Habitat Assessment (point)……..pg. 4

Erosion Site (point)……pg. 5

Channel Alteration Site (point)……pg. 7

Inadequate Buffer Site (point)……pg. 8

Pipe Outfall Site (point)……..pg. 9

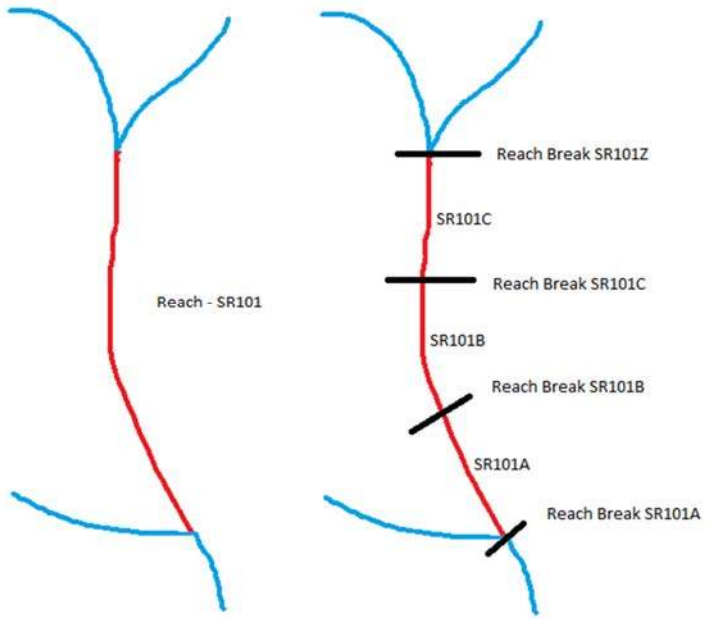
Unusual Condition (point)……pg. 10

Stream Restoration Recommendations (polygon)……pg. 11

Stream Reach Break Data *(line)*

Data Collection Instructions

Add a Stream Reach Break line at the beginning of a new stream reach assessment for either a pre-selected reach or a new reach within a pre-selected reach. This line signifies the downstream end of a new section of stream that is assessed. Each line will be perpendicular to and crossing the stream reach. Break line may be at or slightly below the downstream end of the stream reach. The last reach break will be labelled with Z to signify the upstream end of the study reach; do not fill in any other data for the "Z" reach.



Fill out all fields prior to assessing reach, except for the final field, Stream Restoration Opportunities Present, which you will complete after the assessment.

Fields

- Site ID of Stream Reach [fill in ID from the Stream Reach base layer, in which the number will be pre-assigned (e.g., NMP-SR-F101); add A for the first reach break. Add B, C, D, etc. for each additional break. Assign Z to the break at the end of reach.]
- Field Crew [Initials]
- Can site be evaluated? (if no, do not fill out other data)
    - Yes
    - No, landowner did not grant access
    - No, fence or other barrier
    - No, another reason
- Notes
- Create a site name [This wil be considered the common name for the site. Example: name of school, business, or nearest road.]
- Is this an end of reach? (if Yes, do not answer further questions)
    - Yes
    - No
- Past Weather (24 hours) – yes/no for all
    - Clear
    - Cloudy
    - Trace of Rain
    - Rain
    - Snow
    - Extreme Cold [consistently < 32 degrees F]
    - Extreme Hot ([consistently > 80 degrees F])

    - Other
- Current Weather
    - Same Options as above
- Stream Type – check one
    - Perennial
    - Intermittent
    - Ephemeral
    - Unknown
    - If stream type is unknown, explain
- Notes
- Stream Restoration Opportunities Present (Filled out after walking reach) [Note if opportunities present, then also fill in Stream Restoration Recommendations form.]
    - None
    - One
    - Several

Rapid Biology/Habitat Assessment Data *(Point)*

Data Collection Instructions

At least one Habitat Assessment point needs to be placed within each stream reach. If a reach is >1000 ft long, place a Stream Reach Break and collect another Habitat Assessment Point.

The assessment is conducted within a representative 75-meter reach. It is at the discretion of the field crew to choose a representative location for the 75-m reach assessment.

See example RBP data form for habitat parameter scoring guidance. For each RBP parameter, scale runs from 1 (worst condition) to 10 or 20 (best condition).

Fields

- Site ID (e.g. NMP-SR-F101A-RE101) [Fill in, using Stream Reach ID and adding RE###, RE for Representative Site]
- Stream Bed Particle Size (note percentage, estimate to the nearest 5%)
    - Clay
    - Silt
    - Sand
    - Gravel
    - Cobble
    - Boulder
    - Bedrock
    - Concrete
- Epifaunal Substrate/Available Cover (0-20 score)
- Embeddedness (0-20)
- Velocity/Depth Regime (0-20)
- Sediment Deposition (0-20)
- Channel Flow Status (0-20)
- Channel Alteration (0-20)
- Frequency of Riffles (or bends) (0-20)
- Bank Stability (Right) (0-10)
- Bank Stability (Left) (0-10)
- Vegetative Protection (Right) (0-10)
- Vegetative Protection (Left) (0-10)
- Riparian Vegetative Zone Width (Right) (0-10)
- Riparian Vegetative Zone Width (Left) (0-10)
- Percent Shading (estimate to nearest 10%, assuming leaf-on)
- Trash Rating (0-20)
- Notes

Erosion Site (*Point, placed at downstream end of erosion)*

Data Collection Instructions

Document all stream bank erosion that has an eroded surface of at least 2 feet high and 10 feet long. Shorter instances of erosion can be documented if the erosion is threatening a utility, property, or structure. Erosion points are placed at the downstream end of erosion. A new erosion point is placed on the map if the average height of erosion changes by more than 2-3 feet, or any of the erosion point parameters have a significant change. See BEHI diagram for guidance on collecting the applicable parameters. If there is erosion on both banks, record BEHI parameters for whichever bank is more extreme. If there are multiple areas of erosion that are vastly different in degree of erosion hazard, additional erosion points may be added if needed.

A gully associated with an outfall channel will be recorded as an erosion point. If the actual outfall is located, that will also be recorded, as a pipe outfall.

Fields

- Site ID (e.g. NMP-SR-F101A-ES101) [Fill in using Stream Reach ID and adding ES###, ES for Erosion Site]
- Type of Erosion (check all that apply)
    - Headcutting
    - Downcutting
    - Widening
    - Other
- Right Bank Length of Erosion (ft) - extending upstream of point, estimate or measure to the nearest 10 ft the length along bank
- Left Bank Length of Erosion (ft) - extending upstream of point, estimate or measure to the nearest 10 ft the length along bank
- Height of Erosion on Right Bank (ft) – to nearest 0.1 ft
- Height of Erosion on Left Bank (ft) – to nearest 0.1 ft
- Right Bank Total Height (ft) – to nearest 0.1 ft, measure from thalweg to top of bank
- Left Bank Total Height (ft) – to nearest 0.1 ft, measure from thalweg to top of bank
- Bankfull Depth (ft) – to nearest 0.1 ft, measure from thalweg to bankfull
- Note bankfull indicators
- Predominant Bank Material
    - Clay
    - Silt
    - Sand
    - Gravel
    - Cobble
    - Boulder
    - Bedrock
- Bank angle as degrees, Bank Erosion Potential category
    - 0 – 20 degrees, Very Low
    - 21 – 60 degrees, Low
    - 61 – 80 degrees, Moderate
    - 81 – 90 degrees, High
    - 90 – 119 degrees, Very High
    - >119 degrees, Extreme

- Root Density as percentage, Bank Erosion Potential category
  - 80 - 100% Very Low
  - 55 - 79% Low
  - 30 - 54% Moderate
  - 15 - 29% High
  - 5 – 14% Very High
  - <5% Extreme
- Root Depth as proportion of bank height, Bank Erosion Potential category
  - 0.90 – 1.0 Very Low
  - 0.50 – 0.89 Low
  - 0.30 - 0.49 Moderate
  - 0.15 – 0.29 High
  - 0.05 - 0.14 Very High
  - <0.05 Extreme
- Surface protection as percentage, Bank Erosion Potential category
  - 80 - 100% Very Low
  - 55 - 79% Low
  - 30 - 54% Moderate
  - 15 - 29% High
  - 10 – 14% Very High
  - <10% Extreme
- Near Bank Stress Rating [narrative category]
  - Very Low
  - Low
  - Moderate
  - High
  - Very High
  - Extreme
- Soil Stratification
  - None/Low
  - Medium
  - High
- Headcut height, ft, to the nearest 0.5 ft [if applicable]
- Headcut angle, degrees [if applicable]
  - 0 – 30 degrees
  - 31 - 60 degrees
  - 61 – 90 degrees
- Headcut length, ft [bottom to top; if applicable]
- Overall Erosion Severity Rating (1-10)
  - 1-3: Minor erosion. 2-3 feet in eroded bank height, not causing significant stream degradation. Showing signs of healing.
  - 4-6: Moderate erosion. 3-5 feet in eroded bank height. Relatively recent/raw.
  - 7-10: Severe Erosion. 5 ft or greater eroded bank height. Erosion typically recent/active. Obvious instream degradation. If threatening utilities or structures rate 9-10.
- Notes

Channel Alteration Site *(Point, placed at downstream end of channel alteration)*

Data Collection Instructions

Document instances of the channel bed, bank, or nearby floodplain being altered by placing a Channel Alteration point at the downstream extent of the alteration and completing the electronic form. Only document instances where the alteration is detrimental to the stream (e.g. concrete-lined channel) or needs to be fixed (e.g. failing bank stabilization project). Do not document stable utility line protection or successful stream restoration projects. Channel Alteration points are placed at the downstream end of erosion.

Fields

- Site ID (e.g. NMP-SR-F101A-CA101) [Fill in using Stream Reach ID and adding CA###, CA for Channel Alteration]
- Type
    - Concrete
    - Riprap
    - Gabion Basket
    - Earthen Channel
    - Channelization/Straightening
    - Other
- Alteration Length (ft) (extending upstream of point, estimate or measure to the nearest 10 ft)
- Alteration Width (ft) (Bed only)
- Alteration Location
    - Bed
    - Bank
    - Bed and Bank
    - Floodplain
- Signification vegetation in channel?
    - Yes, No, Unknown
- Signification Aggradation
    - Yes, No, Unknown
- Significant Degradation
    - Yes, No, Unknown
- Associated with a Road Crossing
    - Yes, No, Unknown
- Alteration Severity (1-10)
    - 1-3: Alteration is detrimental to the health of the stream, but alteration is relatively short and is not causing any current channel instability.
    - 4-6: Alteration is causing noticeable channel instability (e.g. channel starting to erode around riprap placed on bank or channelized stream banks slumping in stream) and should be corrected.
    - 7-10: Alteration is relatively long, causing significant channel instability/loss of habitat and should be corrected as soon as possible.
- Notes

Inadequate Buffer Site *(Point, placed at downstream end of inadequate buffer)*

Data Collection Instructions

Document non-natural areas with a minimum length along the stream (parallel to the channel) of 100 feet. A buffer will be considered adequate if it is tree-covered within 75 ft of the stream.

A more detailed assessment of the area can be completed with the Tree Planting Area form (polygon feature) if adequate space is available for planting (at least 0.25 acre).

Inadequate buffer points are placed at the downstream end of the inadequate buffer.

Fields

- Site ID (e.g. NMP-SR-F101A-IB101) [Fill in using Stream Reach ID and adding IB###, IB for Inadequate Buffer]
- Inadequate buffer length – Right (ft)
- Inadequate buffer length – Left (ft)
- Existing Buffer width – Right (ft) (to 150 ft maximum)
- Existing Buffer width – Left (ft) (to 150 ft maximum)
- Opportunity for tree planting project? (yes/no) – If Yes, fill out Tree Planting assessment form
- Notes

Pipe Outfall Site *(Point)*

Data Collection Instructions

Document all outfall pipes or channels that can be seen from the stream by placing an outfall point on the map. If the outfall is a pipe then place the point at the opening of the pipe, if the outfall is a channel then place the point at the termination of the formal conveyance (i.e. do not place point at end of erosional gully, this will be documented within the field form).

Use this form to record unmapped outfalls and problematic outfalls observed while conducting stream assessment. This is not intended to be a comprehensive inventory of outfalls.

Fields

- Site ID (e.g. NMP-SR-F101A-PO101) [Fill in using Stream Reach ID and adding PO###, PO for Pipe Outfall]
- Mapped outfall number, if available [from GIS]
- Type of Outfall
    - Stormwater BMP Outfall
    - Stormwater Outfall, no BMP
    - BMP Overflow Channel / Spillway
    - Agricultural Drainage Pipe
    - Roof Drains (only record if there are major problems to address)
    - Sewage Plant
    - Unknown
    - Other
- Enclosed Pipe or Open Channel (choose one)
- Material
    - Earth Channel
    - Concrete Channel
    - Concrete Pipe
    - Smooth Metal Pipe
    - Corrugated Metal Pipe
    - Smooth Plastic Pipe
    - Corrugated Plastic Pipe
    - Unknown
    - Other
- Pipe Diameter [inside – inches]
- Lcoation in relation to stream channel (choose one)
    - Right side
    - Left side
    - In-line with stream
- Evidence of dry weather flow (e.g. staining, excessive vegetation, oil sheen, etc.)?
    - Yes, No
- Is there a suspected illicit discharge that needs to be addressed?
    - Yes, No – If yes, notify Howard County
- Trash Rating (0-20)
- Evidence of Erosion below outfall?
    - Yes, No - If yes, erosion is observed, fill out Outfall Stabilization Assessment form [point feature].
- Notes

Unusual Condition/Other *(Point)*

Data Collection Instructions

Document any unusual conditions found during the stream assessments. These may not necessarily be good indicators for targeting restoration sites, but these conditions may be leading to (or indicative of) instream degradation and are worth documenting for the County's use if the condition is severe. Place a new point on the map where the unusual condition is found.

Fields

- Site ID (e.g. NMP-SR-F101A-UC101) [Fill in using Stream Reach ID and adding UC###, UC for Unusual Condition]
- Near-stream construction with poor ESC (yes/no)
- Suspected illicit discharge (yes/no)
- Illegal Dumping (yes/no)
- Exposed Pipe (yes/no)
- Unusual Water Color (yes/no)
- Unusual Water Clarity (yes/no)
- Unusual Water Odor (yes/no)
- Excessive Algae (yes/no)
- Excessive Bacteria Indicators (yes/no)
- Severe Fish Blockage/Barrier (yes/no)
- Other (describe) (yes/no)
- Notes

Stream Restoration Recommendations *(Polygon)*

Data Collection Instructions

Use this feature to indicate the location and extent of one or many potential stream restoration projects within the assessed reach. Draw a polygon that includes the extent of stream length to be restored, including side tributaries if they are to be included in project.

Also, document the potential of adding one or many restoration projects in the Stream Reach Break line shapefile.

Fields

- Site ID (e.g., NMP-SR-F101A)
- Instream Restoration Potential
    - High
    - Medium
    - Low
- Restoration Length (ft) [will be calculated later in GIS]
- Are there many constraints to restoration project?
    - None
    - Some
    - Many
- Stream Restoration Project Constraints - Type
    - Utility
    - Roadway
    - Buildings
    - Other Structure
    - Ownership
    - Access
    - Significant Impact to Trees
    - Specimen Tree Removal
    - Wetland Impacts
    - Other
- Approximate length of project affected by constraint (ft)
- Impact to Existing Trees
    - Minimal
    - Moderate
    - Significant
- Ease of access
    - Easy
    - Moderate
    - Difficult
- Potential Demonstration/Educational Value? (yes/no)
- Notes

Howard County Watershed Assessments
Outfall Stabilization Assessment (Point) – Data Collection Field Protocol
March 6, 2015

General Data Collection Instructions

- If any illicit discharges or other safety concerns (e.g., missing manhole cover) are observed in the field, notify the County as soon as possible by contacting Kelly Hargadin (khargadin@howardcountymd.gov, Office 410-313-0844 or Cell 720-979-1519). Provide location, information about the problem observed, and a photograph.

- Edit an existing (preselected) outfall stabilization point OR add a new outfall stabilization point. If adding a new point and the outfall is a pipe then place the point at the opening of the pipe. If the outfall is a channel then place the point at the termination of the formal conveyance (i.e. do not place point at end of erosional gully, this will be documented within the field form).

Fields – Outfall Stabilization Assessment (*Point)*

- Site ID (prefilled) (example: NMP-OF-F101). If site was a Pipe Outfall Site in Stream Restoration reach, use that outfall point site ID (example: SR-F101-PO103).
- Field Crew [Initials]
- Create a site name [This will be considered the common name of the site. Example: name of school, business, or nearest road.]
- Study Area [pre-filled from GIS data]
- Contractor [pre-filled from GIS data]
- Comments [pre-filled from GIS data; information for field crew]
- Site Note [pre-filled from GIS data; information for field crew]
- Can site be evaluated? (if no, do not fill out other data)
    - Yes
    - No, landowner did not grant access
    - No, fence or other barrier
    - No, another reason
- Notes
- Past Weather (24 hours) – yes/no for all
    - Clear
    - Cloudy
    - Trace of Rain
    - Rain
    - Snow
    - Extreme Cold (consistently < 32 degrees F)
    - Extreme Hot (consistently > 80 degrees F)
    - Other
- Current Weather
    - Same Options as above
- Outfall Pipe Height (inches)
- Outfall Pipe Width (inches)
- Outfall Pipe Shape
    - Round
    - Rectangular
- Outfall Type
    - Pipe
    - Headwall
- Is repair needed?
    - Yes/No

- Is sediment removal needed?
  - Yes/No
- Is there baseflow?
  - Yes/No
- Outfall Material
  - Earth Channel
  - Concrete Channel
  - Concrete Pipe
  - Smooth Metal Pipe
  - Corrugated Metal Pipe
  - Smooth Plastic Pipe
  - Corrugated Plastic Pipe
  - Unknown
  - Other
- Trash Rating (0-20)
- Evidence of Erosion below outfall?
  - Yes, No
- Location of Erosion
  - Outfall Channel (yes/no)
  - Main Stream Channel (yes/no)
- Length of outfall channel erosion (ft)
- Length of stream channel erosion that is attributable to the outfall (ft)
- Distance from outfall to Stream Channel (ft)
- Height of pipe above stream bed (ft)
- Severity of outfall channel Erosion/degradation (1-10)
  - 1-3: Minor erosion. Less than 1 foot of eroded banks. Healing may be present.
  - 4-6: Moderate erosion. Eroded banks are 1-2 feet in height. Erosion looks relatively recent.
  - 7-10: Severe Erosion. Eroded banks are greater than 2 feet in height. Erosion is typically recent/active.
- Does this site have potential for outfall stabilization?
  - Yes (if yes, go to Outfall Stabilization Recommendation, add line, and fill out form)
  - No
- Does this site have potential for stream restoration?
  - Yes (if yes, go to Stream Restoration Assessment, beginning with Stream Reach Break Data and fill out forms, including Erosion Site form)
  - No
- Notes

Outfall Stabilization Recommendation *(Line)*

Data Collection Instructions

Add line to map and fill out the form below if "Yes" was answered for "potential for outfall stabilization". Draw line to indicate proposed location and length of outfall stabilization project. Note: portions of Outfall Stabilization projects that extend beyond 200-300 feet will be categorized as stream restoration projects.

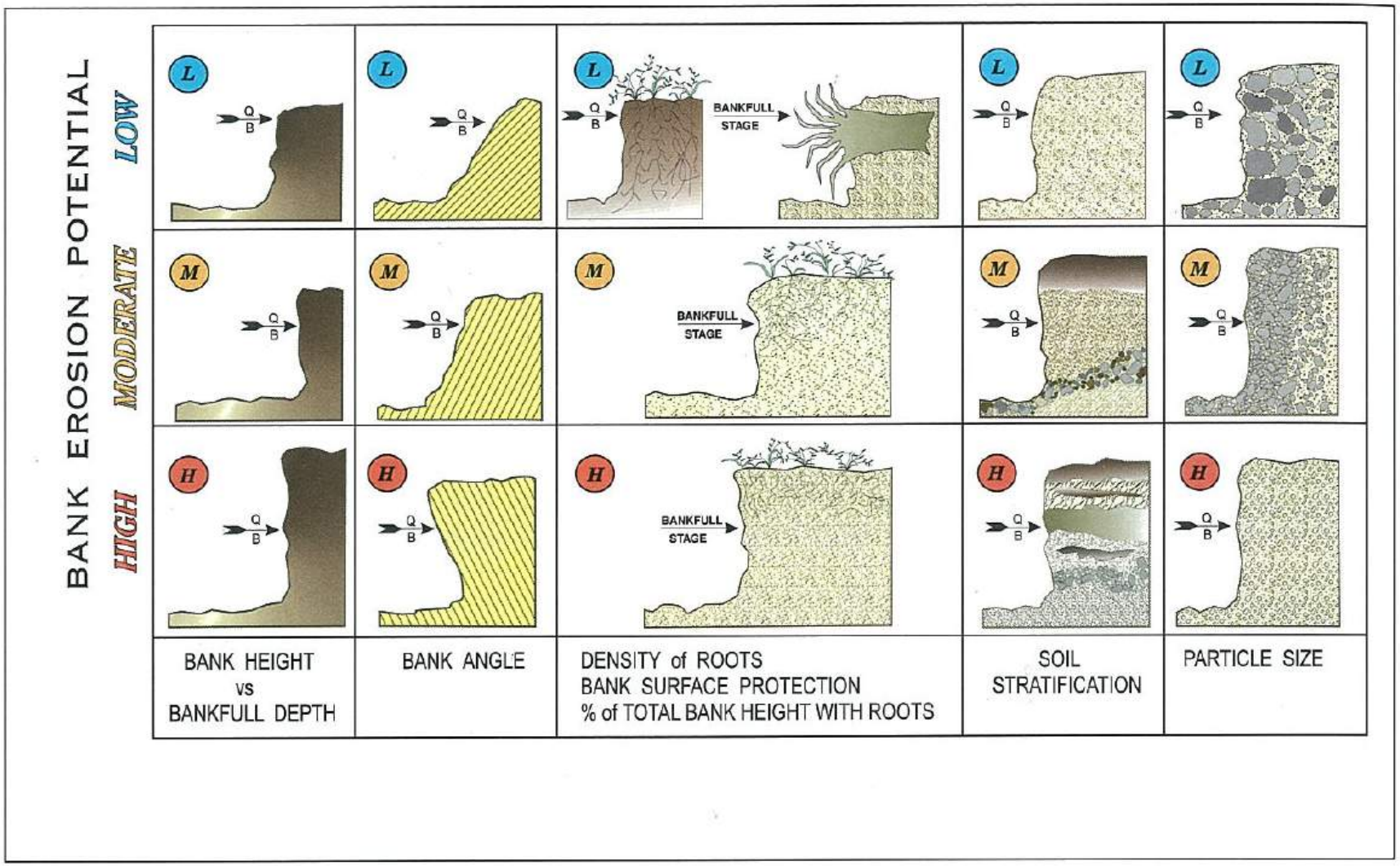
Fields

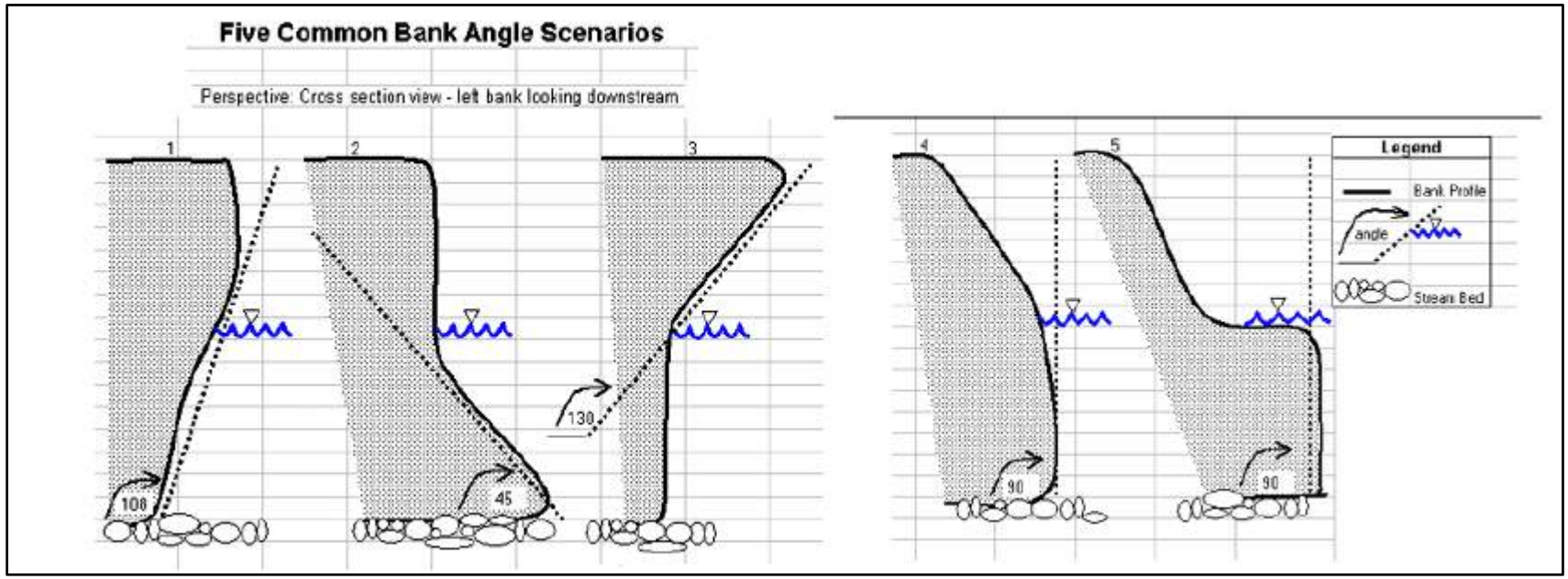
- Site ID (e.g. NMP-OF-F101) (match Outfall Stabilization Assessment Site ID)
- Overall Outfall Stabilization Potential
  - High
  - Medium
  - Low
- Type of Outfall Stabilization Project
  - Rip Rap
  - Drop Structure
  - Regenerative Stormwater Conveyance
  - Other
- Describe Other type of stabilization
- Proposed project length (ft) (estimate to nearest 10 ft)
- Are there many constraints to an outfall stabilization project?
  - None
  - Some
  - Many
- Outfall Stabilization Project Constraints - Type
  - Utility
  - Roadway
  - Buildings
  - Other Structure
  - Ownership
  - Access
  - Draining a hotspot
  - Significant impact to trees
  - Specimen tree removal
  - Wetland Impacts
  - Other
- Approximate length of project affected by constraint (ft)
- Impact to Existing Trees
  - Minimal
  - Moderate
  - Significant
- Ease of access
  - Easy
  - Moderate
  - Difficult
- Potential Demonstration/Educational Value? (yes/no)
- Notes

	Habitat Parameter	Condition Category			
		Optimal	Suboptimal	Marginal	Poor
Parameters to be evaluated in sampling reach	**1. Epifaunal Substrate/ Available Cover**	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	3. Velocity/Depth Regime	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Slow is < 0.3 m/s, deep is > 0.5 m.)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/ depth regime (usually slow-deep).
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Parameters to be evaluated broader than sampling reach	Habitat Parameter	Condition Category			
		Optimal	**Suboptimal**	**Marginal**	**Poor**
	7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	8. Bank Stability (score each bank) Note: determine left or right side by facing downstream.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
	SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
	9. Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
	SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
	10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
	SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Habitat Parameter	Optimal 16-20	Sub-Optimal 11-15	Marginal 6-10	Poor 0-5
Trash Rating	Little or no human refuse visible from stream channel or riparian zone	Refuse present in minor amounts	Refuse present in moderate amounts	Refuse abundant and unsightly


BANK EROSION POTENTIAL
LOW
MODERATE
HIGH
L
M
H
Q
B
BANKFULL
STAGE
BANK HEIGHT
vs
BANKFULL DEPTH
BANK ANGLE
DENSITY of ROOTS
BANK SURFACE PROTECTION
% of TOTAL BANK HEIGHT WITH ROOTS
SOIL
STRATIFICATION
PARTICLE SIZE

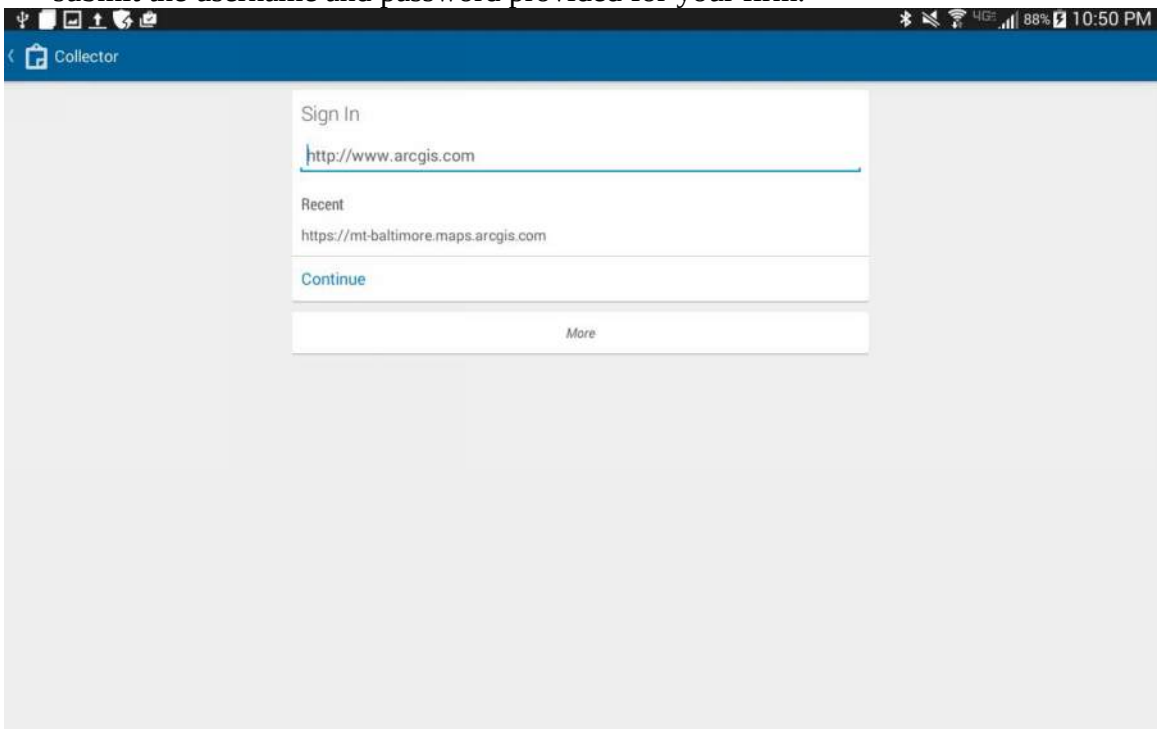

Five Common Bank Angle Scenarios
Perspective: Cross section view - left bank looking downstream
1
2
3
4
5
10
45
130
90
90
Legend
Bank Profile
angle
Stream Bed

D. Electronic Data Collection Protocols

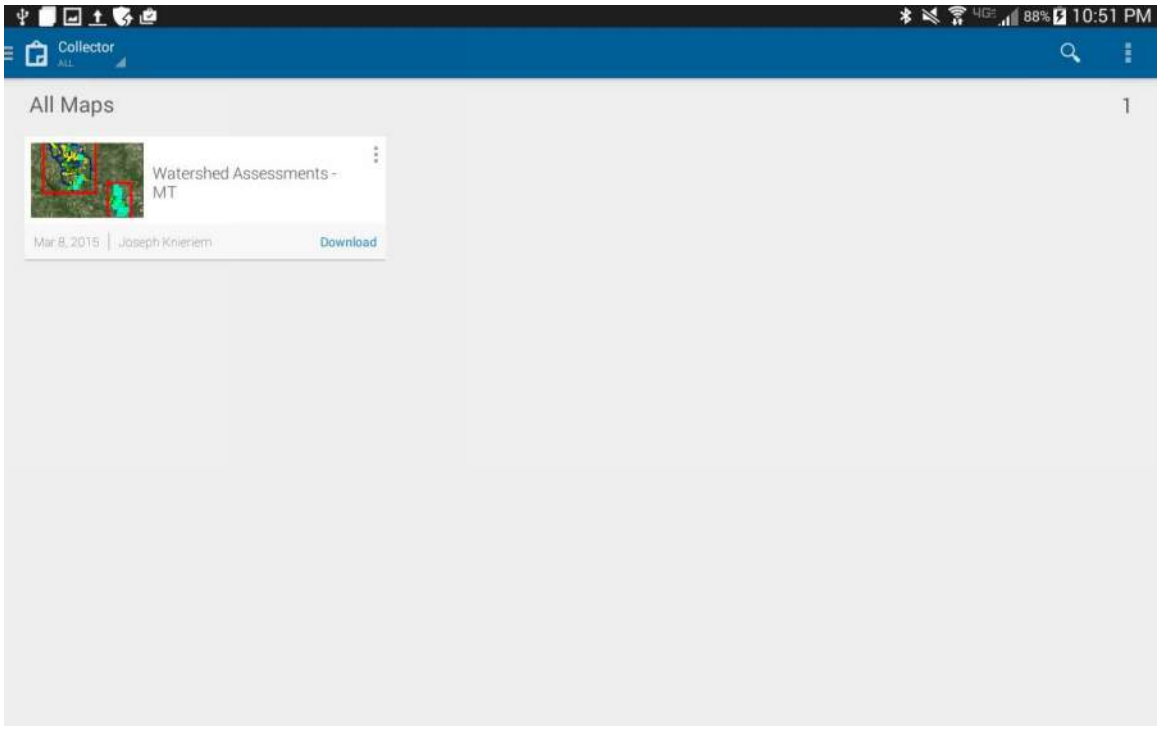
Howard County Watershed Assessments
March 9, 2015

Arc Collector Field Data Collection Instructions

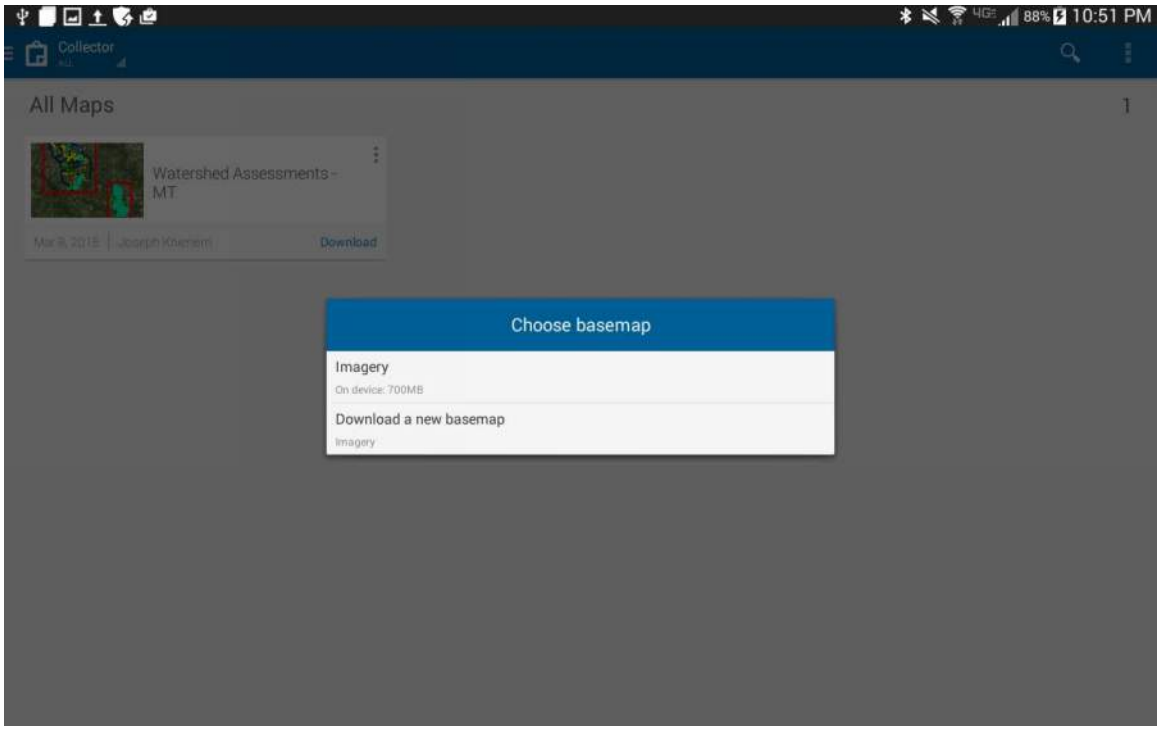
1. **Logging into ArcGIS Online with the tablet.**
   Open the Arc Collector app and create a new account. Type in the URL https://mt-baltimore.maps.arcgis.com and click continue. On the next screen, submit the username and password provided for your firm.



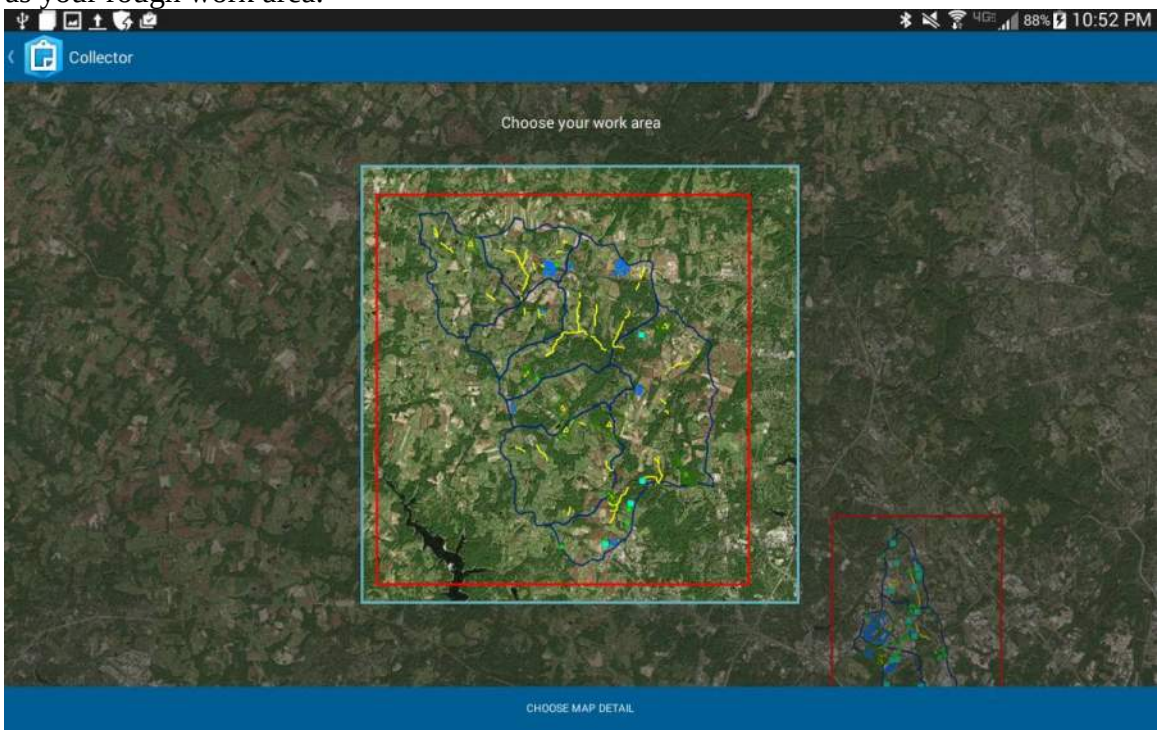
2. **Downloading data to the device for offline use.**
   a. When you sign into Collector, you will see one map available for your firm. To use the map in offline mode, click the "Download" button at the bottom right



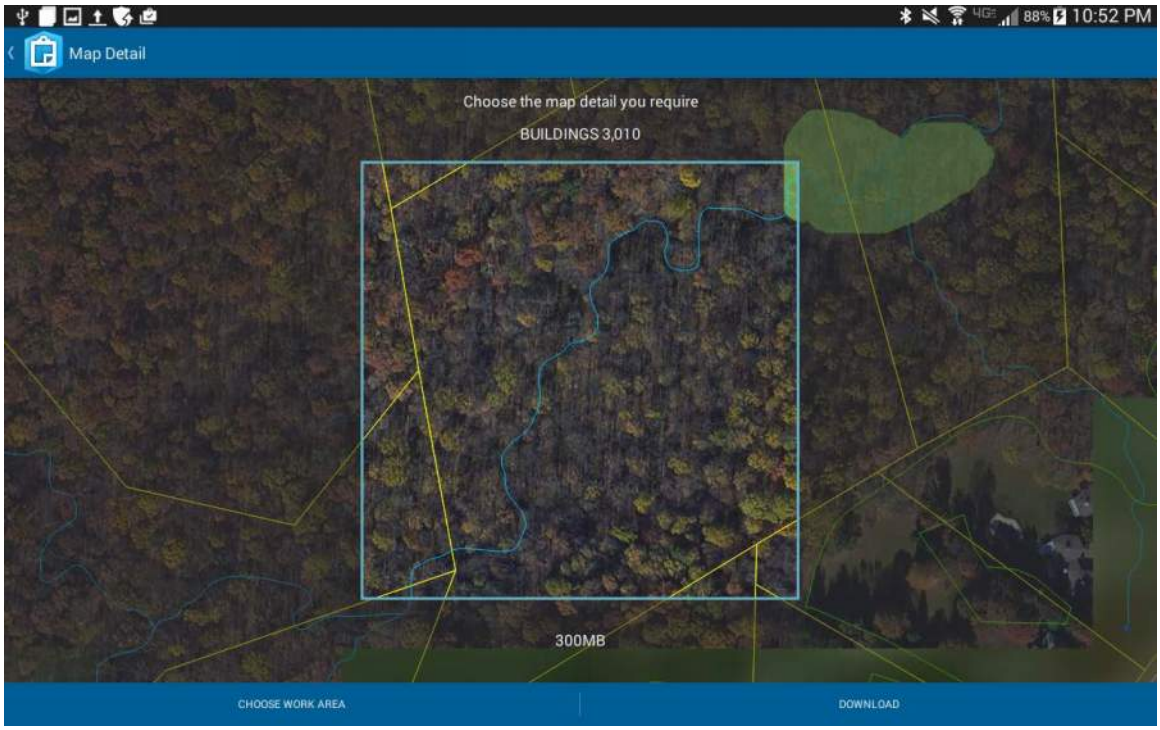
b. If you're downloading the map for the first time, you will be asked to download a new basemap. If you have downloaded a basemap previously, you may opt to reuse a previously downloaded basemap. In the screenshot below, the "Imagery" layer represents a basemap already stored on the device.



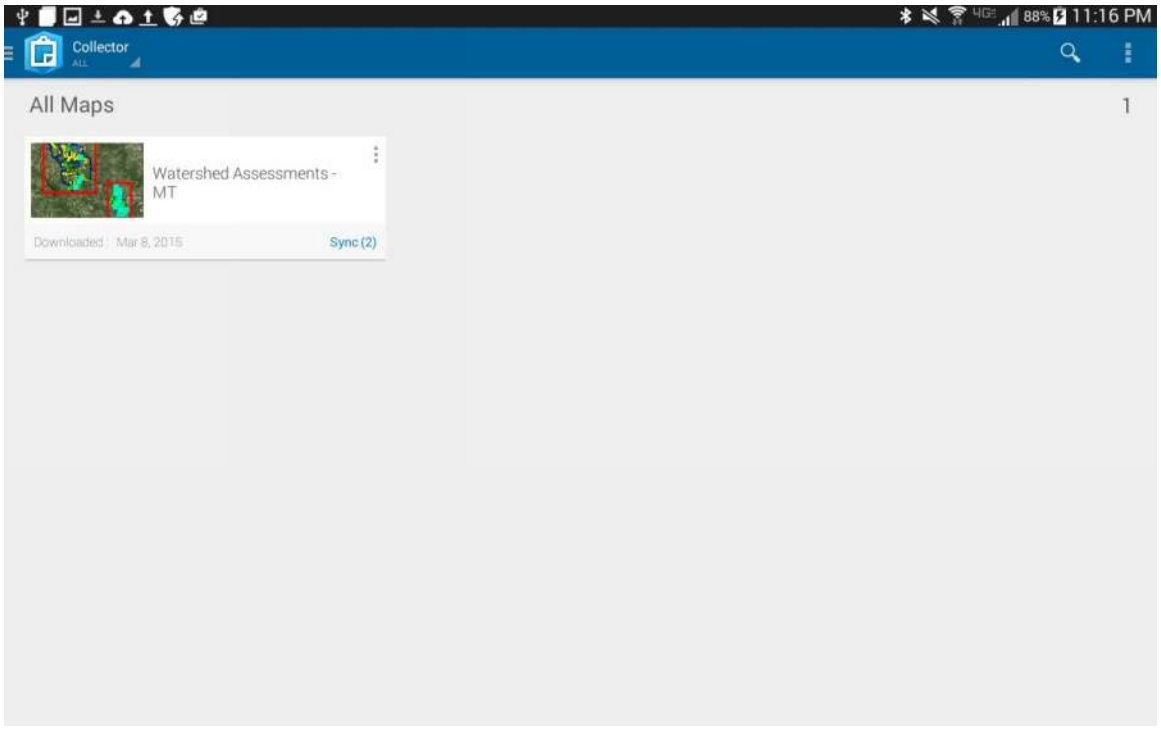
c. To download data to your device, you must specify the "work area" for which you wish to download data. Once data is downloaded to the device, if you venture outside of your work area, you won't have any data available. In each web map, there is a large red box representing the extent of all your available data. It is recommended that you use this box as your rough work area.



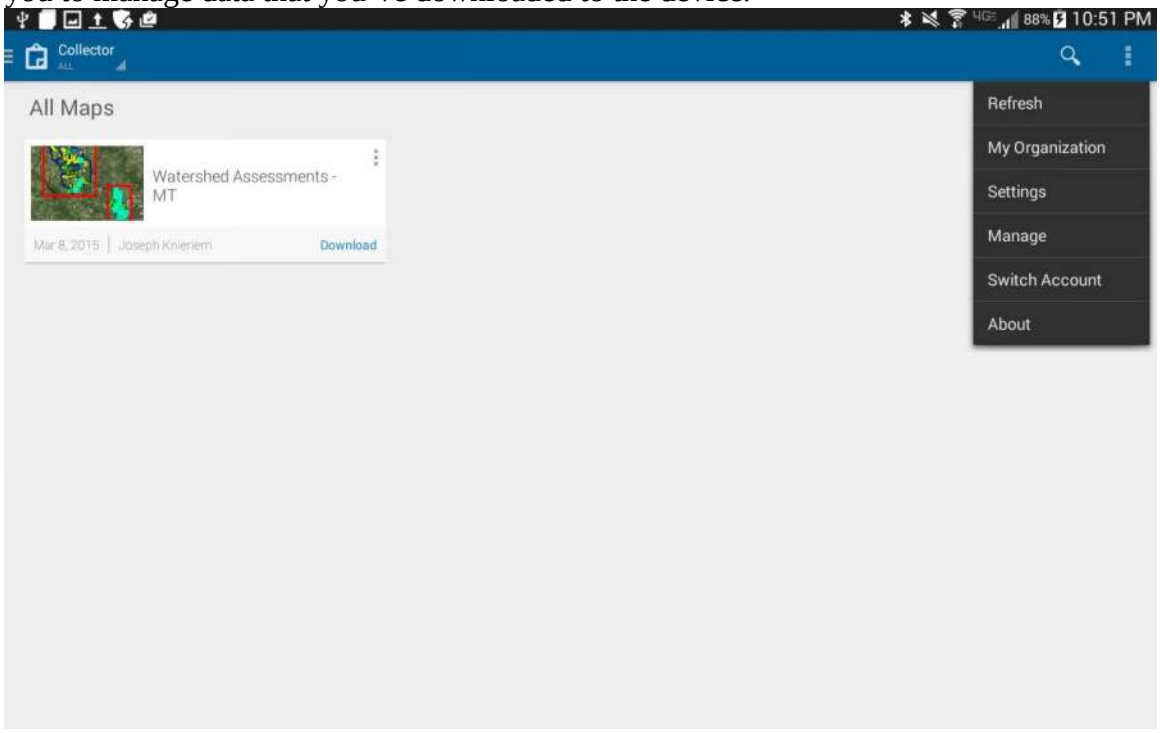
d. Once you select your work area, if you are downloading a base map, you will be asked to choose the level of detail for the base map. This level of detail affects how far you will be able to zoom in on the aerial before it gets blurry in offline mode. It is recommended that you zoom in to at least 3600 scale (1" = 300'). The more detail you want, the larger the download will be. It is recommended that you download a high resolution aerial for your study area just once and then reuse it each time.



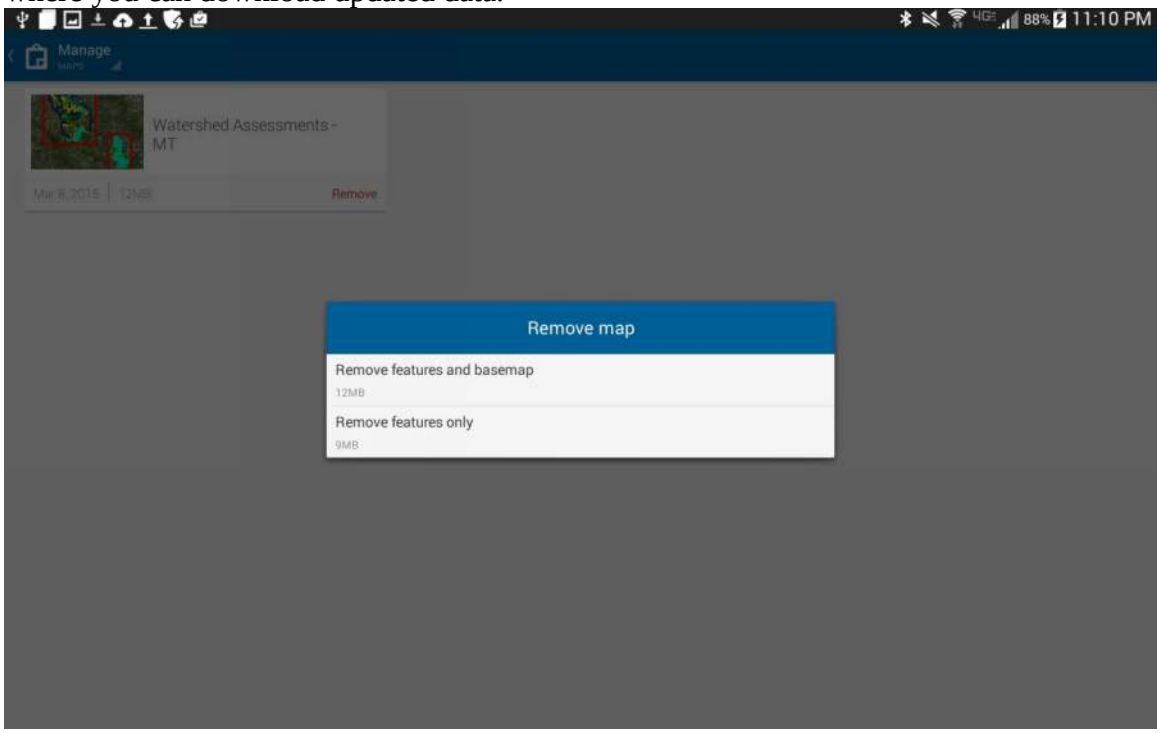
3. **Syncing Collected data**
   Once you have finished collecting data for the day, if you back out to the main map screen of the Collector app, you will see a sync button at the bottom right with a number in parenthesis indicating the number of edits you made in offline mode. Pressing the sync button will upload all of your changes to the master database on the server. This requires an internet connection. Once your data has been synced back to the master database, it is recommended that you check the web map to ensure that the data was synced properly.



4. **Managing device data**
   a. Once your data has been synced, you can remove it from the device so that you can download the latest available dataset for the next day's work. Clicking the 3 dots button at the top right of the main screen brings up a menu. Clicking the Manage option takes you to a screen which allows you to manage data that you've downloaded to the device.



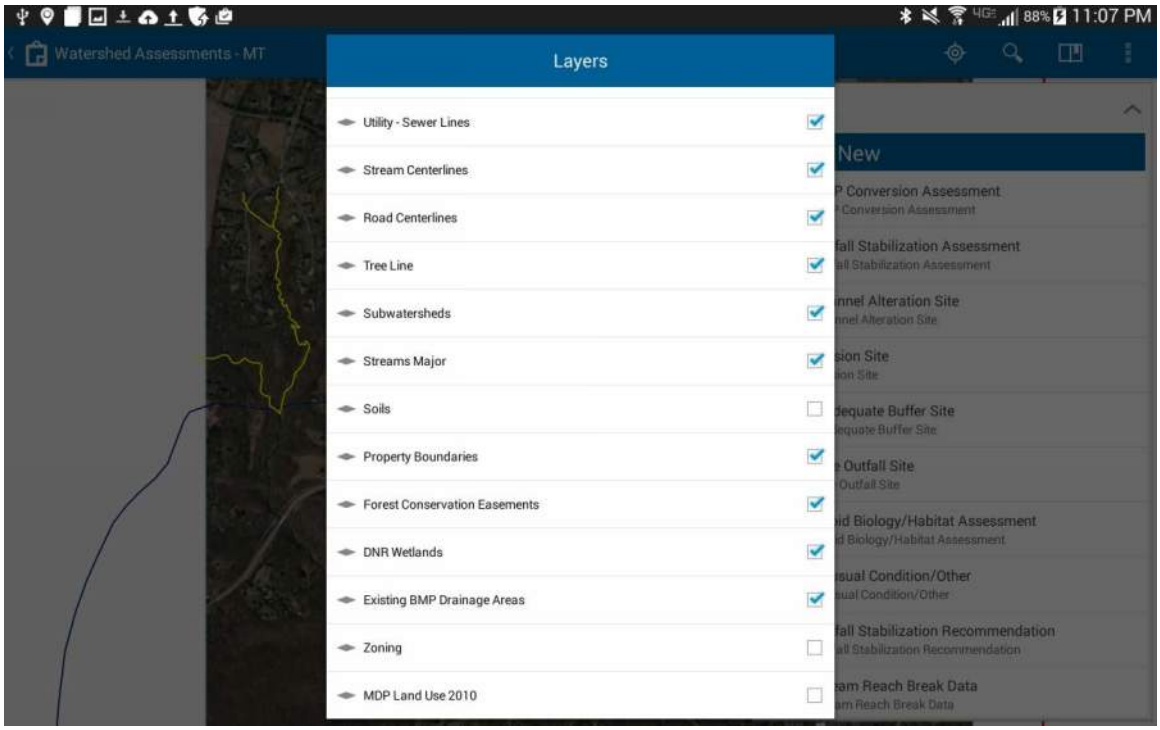
b. The maps shown on this Manage screen represent data you have downloaded to your device. Before you can download updated data to your device, you must first remove any data you currently have stored on the device. To do that, click the "Remove" button at the bottom right. A dialog box like the one below will pop up and ask if you wish to remove only the features or feature and basemap. It is recommended that you choose "remove features only". This will reduce the amount of data you have to download each time. Once your data has been removed, you may hit the back arrow at the top left to take you back to the main map page, where you can download updated data.



5. Working within the map

a. Toggling layers on and off

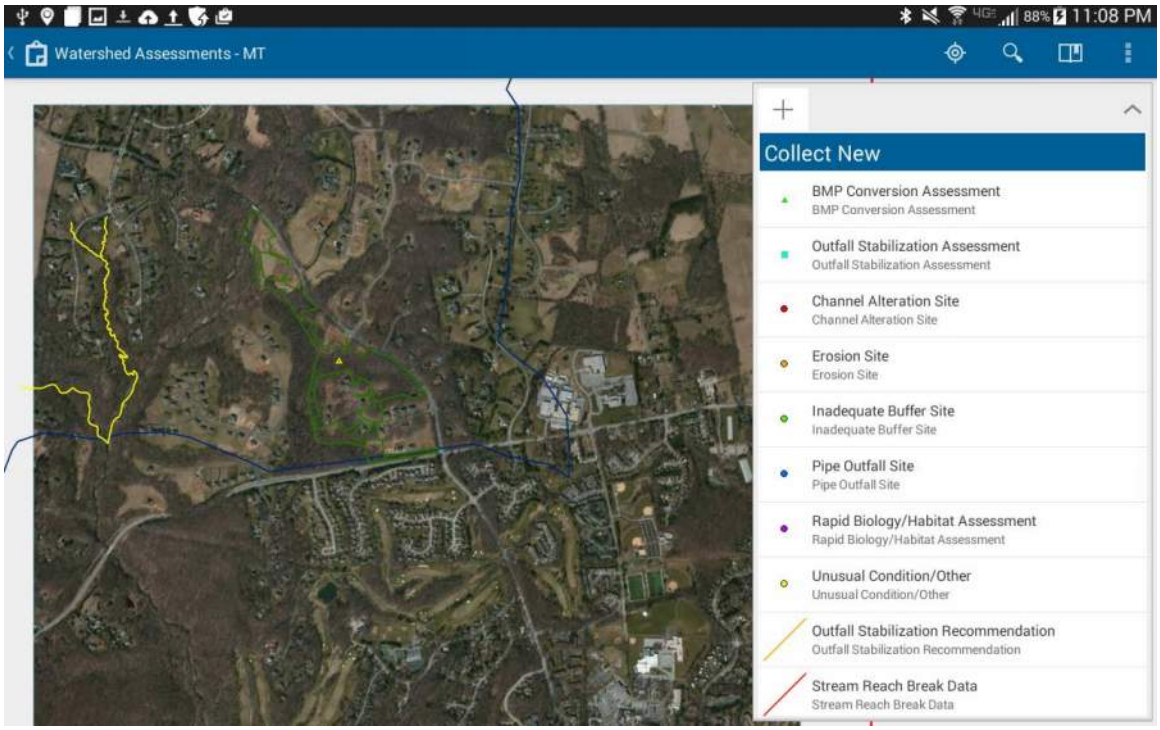
To toggle layers on and off, click the 3 dots at the top right and click the "Layers" option. This brings up a list of all layers available in the current map. Checking or unchecking a layer will make it visible or hidden respectively.



b. Collecting New Features (used for collecting data for Stream Reach Break Data, stream features such as Erosion Points and Inadequate Buffer, and all types of Recommendations)

On the right side of your screen you will see a list of available features that you can collect. Only layers that are visible will be shown in this list, so by hiding layers, you can trim down the number of options you see here. Clicking one of the feature types will collect a new feature of that type.

Warning: *When collecting new features, touching the map accidentally will move the location of the feature you are collecting to wherever you touched. You can hit the undo button (U shaped arrow) at the top right to undo any accidental movement of features.*

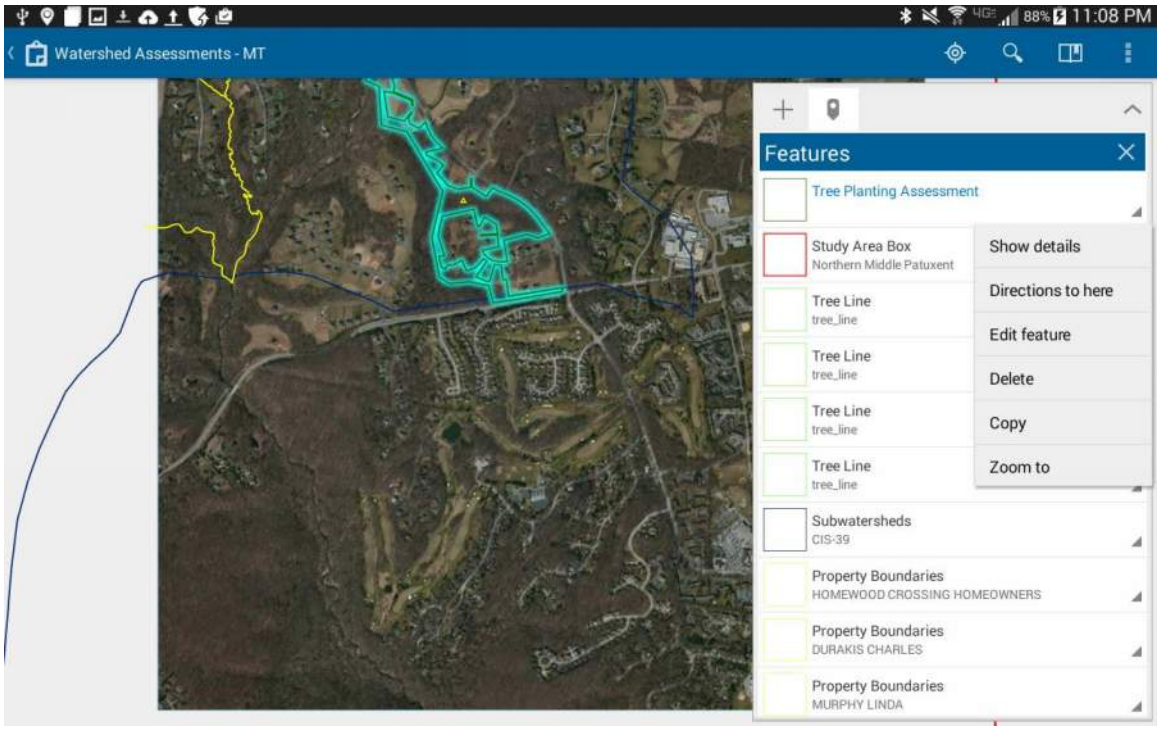


c. Updating existing features (used for collecting data for BMP Conversion Assessments, New BMP Assessments, Tree Planting Assessments, and Outfall Stabilization Assessments)

Clicking on the map will select all features near where your finger touched the map. It brings up a new tab on the right panel with a marker symbol at the top. You may click the gray triangle at the bottom right of a feature and click the "Edit Feature" option to enter edit mode on that feature.

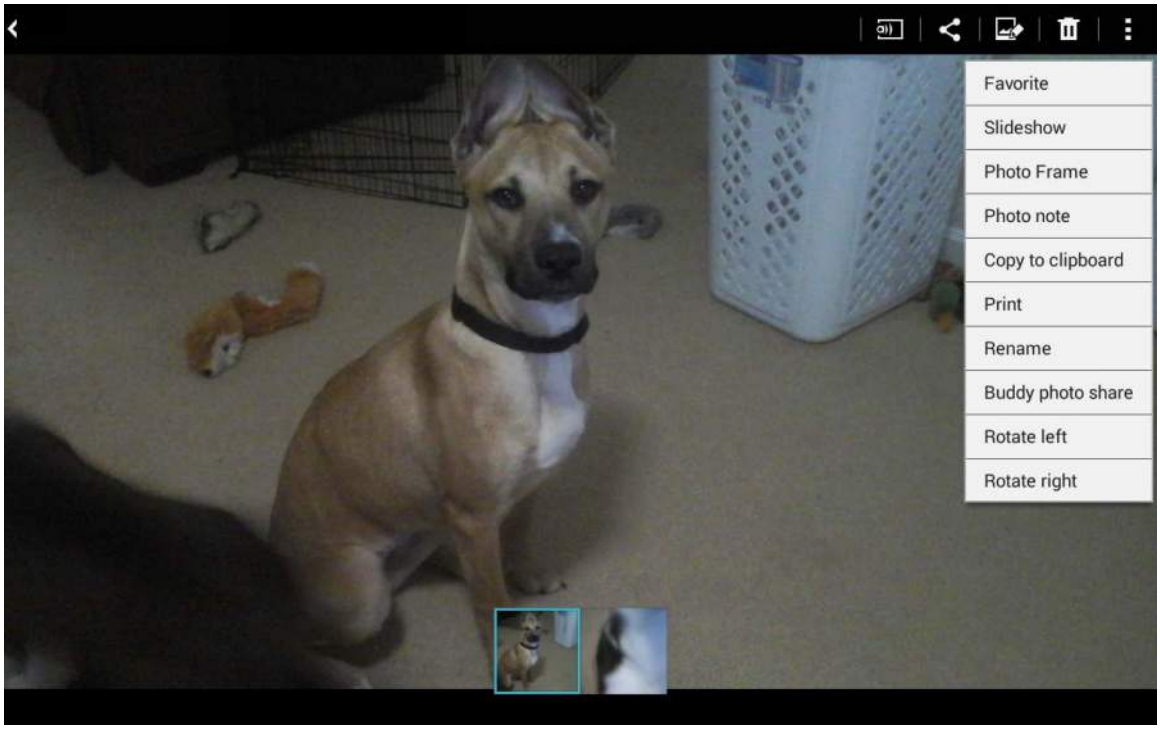
Warning: *When collecting new features, touching the map accidentally will move the location of the feature you are updating to wherever you touched. You can hit the undo button (U shaped arrow) at the top right to undo any accidental movement of features.*

The location of existing features should not be updated in the field. *If an existing feature is at the incorrect location, it is recommended that you collect a new feature of the same type, give it the same ID, and note in the comments that the location should be updated. Your assessment should still be performed on the existing feature.*

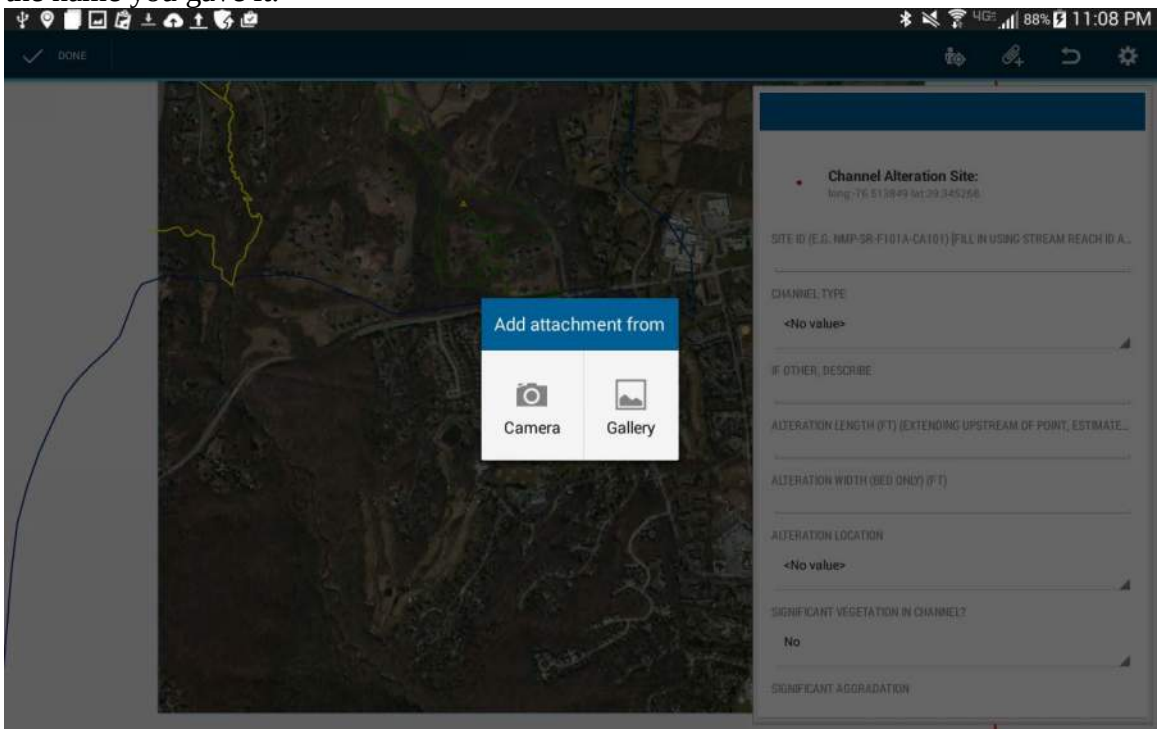


d. Renaming Photos

Renaming photos is a two part process. Specific instructions vary from device to device, so your device may differ slightly from the screenshots shown below. First, you must take the photo using the camera app on your device. This saves the photo to the device. Next, you must navigate to the photo using the Gallery app on your device. Opening the photo in this way should allow you the option to rename the photo. In the screenshot below, the 3 dot symbol at the top right brings up a menu that has a "Rename" option. We recommend naming with site name and description, e.g., "SLP-OF-F701 downstream".

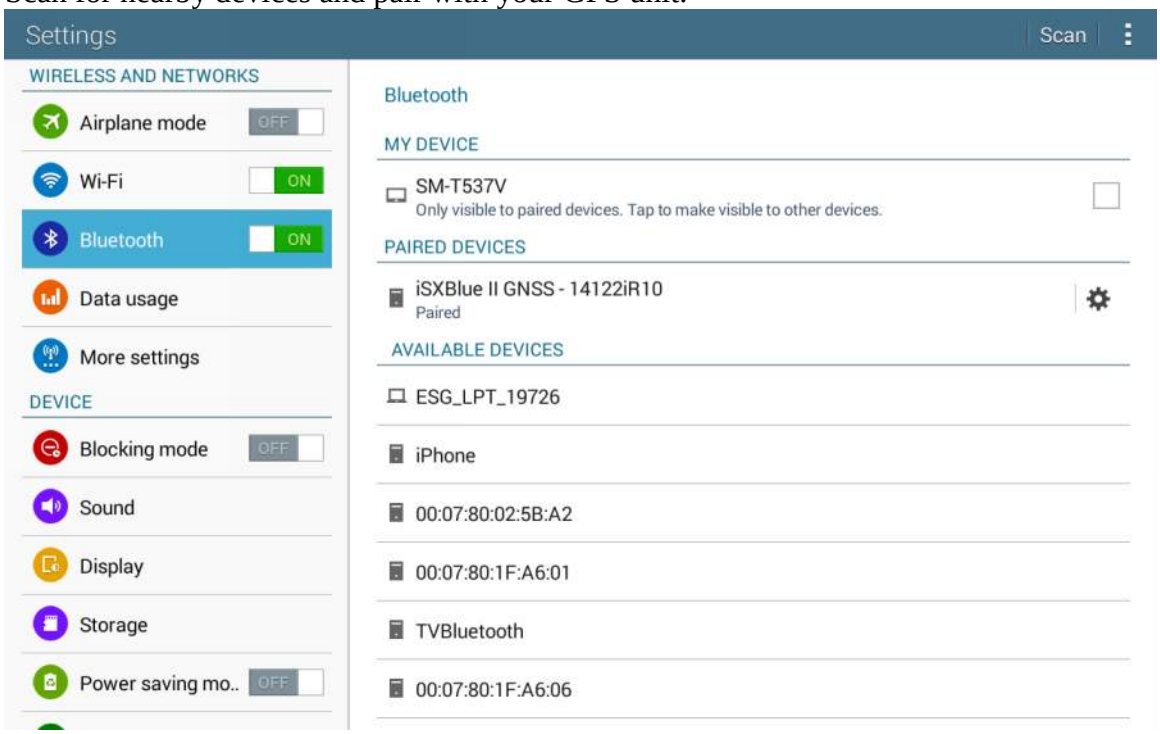


Once the photo is taken and renamed, return to the Collector app and click the paper clip button at the top right. Choose the "Gallery" option and navigate to the photo you just renamed. This will attach the photo with the name you gave it.



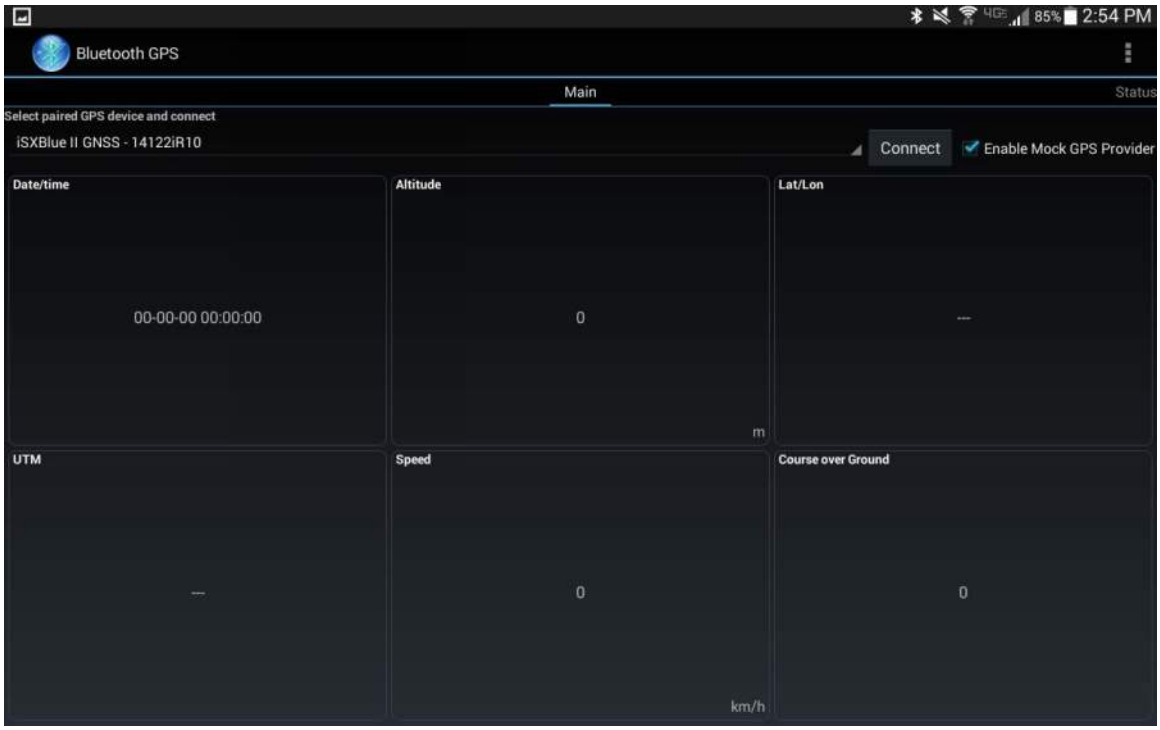
Alternatively, if you aren't concerned with the name of the photo, you can take the photo directly through the Collector app by selecting the "Camera" option from the screenshot above. Photos captured in this manner won't be able to be renamed.

6. **Connecting GPS Device to an Android Tablet** (Note that these instructions may vary slightly depending on your tablet and GPS)
   a. **Install the Bluetooth GPS App**
   b. **Pair your Bluetooth enabled GPS to your tablet.**
      On your Android device, open your settings and click the Bluetooth tab. Scan for nearby devices and pair with your GPS unit.



   c. **Using the Bluetooth GPS app**
      Once your device is successfully paired, open the Bluetooth GPS app. At the top left, you will see a dropdown to select the paired device. Select your GPS device. Ensure that "Enable Mock GPS Provider" is checked, then click the "Connect" button. If successful and your GPS is getting a signal, the Datetime, Altitude, and Lat/Long boxes will populate with actual values.

      To test that your GPS device is indeed overwriting the internal GPS of the tablet, you can lay your GPS down and walk away from it with the tablet. If your position on the map remains stationary, then the pairing is successful. If your position updates as you walk, that means the device is still pulling from the internal GPS.



Contact Info:
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Field Coordinator: Mark Voli
Firm: Versar
E-Mail: mvoli@versar.com
Office Line: 410-740-6062
Cell Phone (if urgent): 610-517-0985

E. Landowner Notification Letter

HOWARD COUNTY DEPARTMENT OF PUBLIC WORKS
6751 Columbia Gateway Drive, Suite 514 ■ Columbia Maryland 21046 ■ 410-313-6444

Mark DeLuca, P.E., Deputy Director
Chief, Bureau of Environmental Services
mdeluca@howardcountymd.gov

FAX 410-313-6490
TDD 410-313-2323

February 25, 2015

Re: Little Patuxent River and Middle Patuxent River Watershed Study

Dear Occupant:

The Howard County Department of Public Works will soon be undertaking a comprehensive watershed assessment within the Middle Patuxent River and the Little Patuxent River watersheds. The watershed assessment is being performed to create an inventory of the natural resources as well as existing problems (erosion, trash, lack of wooded stream buffers, etc.) within these watersheds. Another result of the assessment will be a list of potential projects that can be done to protect and restore these resources, address the problems, and ultimately improve water quality in our streams and water bodies.

The County welcomes participation in development of the study from watershed residents, businesses, and organizations. Public workshops will be planned after the initial field work has been completed to present the results from the assessment and to discuss proposed restoration projects suggested by the study. Exact workshop dates will be advertised when the dates are finalized.

Field crews of two or three County employees or consultants will conduct their assessments on public property to the extent possible but there may be a need for them to be on private property briefly to access certain sites. You may see a crew briefly in your neighborhood. The field crews will be there only to assess existing conditions through visual observations, taking photos, and preparing sketches. Field crews will use extreme care when on private property.

The County anticipates that the majority of the field assessment work will occur during the March to May 2015 time frame with the possibility of a quick second visit to verify field information later in summer 2015.

If you have any specific questions or concerns or would like additional information regarding the watershed assessment, please contact the County by emailing khargadin@howardcountymd.gov or calling 410-313-6444.

F. Field Reports from Consultant Field Teams

Howard County Watershed Assessments

Northern Little Patuxent Watershed

June 2015

KCI Technologies, Inc.
936 Ridgebrook Road
Sparks, MD 21152

CONTENTS

1 Introduction 1
2 Field Assessment Results 2
2.1 BMP Conversion Field Assessments 2
2.2 New BMP Field Assessments 2
2.3 Stream Restoration Assessment 2
2.4 Tree Planting Field Assessments 3
2.5 Outfall Stabilization Field Assessments 3
3 Field Recommendations Results 4
3.1 BMP Conversion Recommendations 4
3.2 New BMP Recommendations 4
3.3 Stream Restoration Recommendations 5
3.4 Tree Planting Recommendations 5
3.5 Outfall Stabilization Recommendations 5
4 Desktop Assessment Results 6
4.1 BMP Conversion Desktop Assessments 6
4.2 New BMP Desktop Assessments 6
4.3 Tree Planting Desktop Assessments 6
5 Desktop Recommendations Results 7
5.1 BMP Conversion Recommendations 7
5.2 New BMP Recommendations 7
5.3 Tree Planting Recommendations 7

TABLES

Table 1. Number of Field Assessments Completed 2
Table 2. Number of Site Recommendations Completed for Field Sites Assessed 4
Table 3. Number of Desktop Assessments Completed 6
Table 4. Number of Site Recommendations Completed for Desktop Sites Assessed 7

FIGURES

Figure 1. Watershed Assessment Study Areas 1

1 Introduction

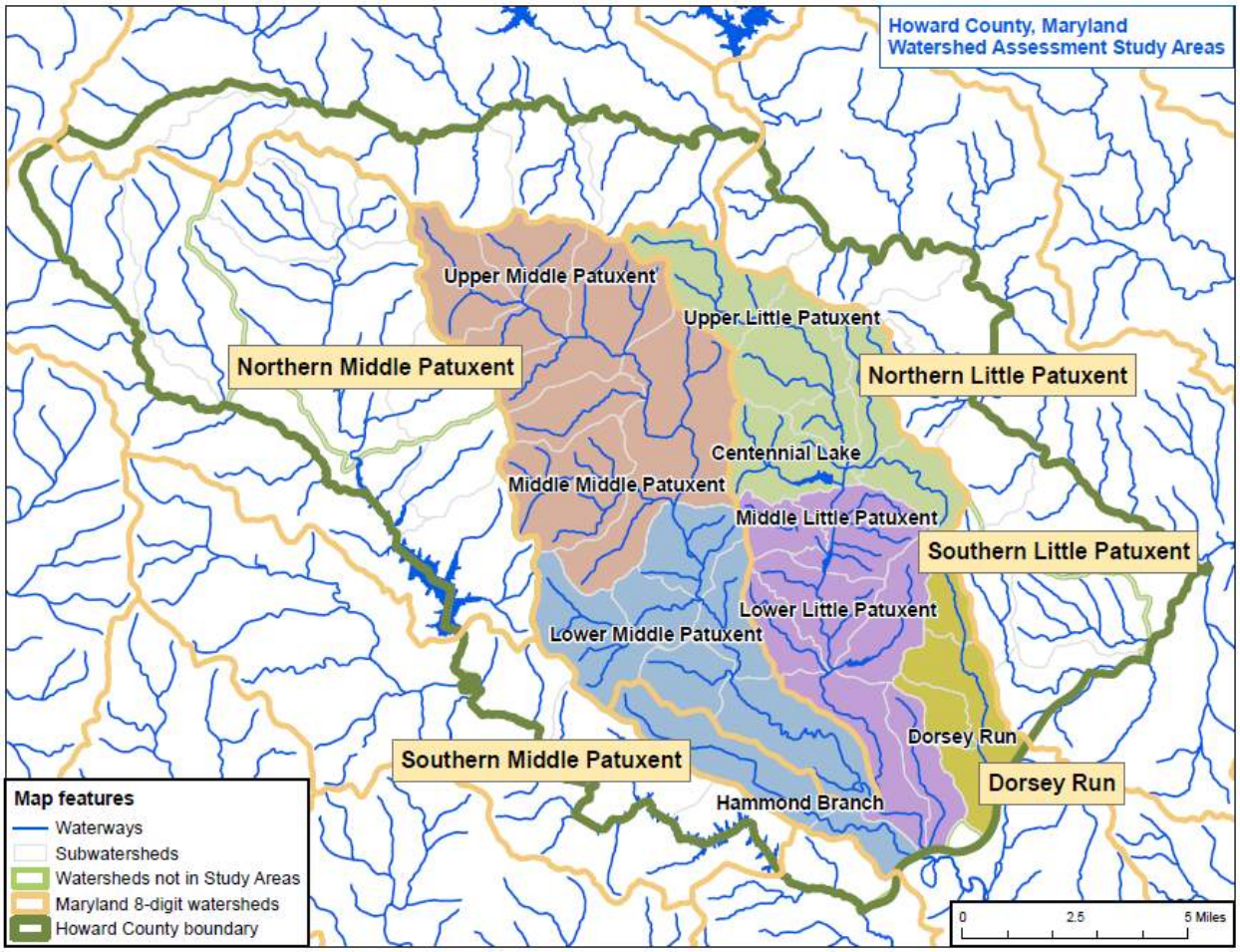
KCI Technologies, Inc. (KCI) completed detailed field and desktop watershed assessments in the Northern Little Patuxent (NLP) watershed in the Spring of 2015 in support of Howard County's efforts to complete Countywide watershed assessments in 2015 and 2016. For the purposes of this study, the NLP watershed includes the Upper Little Patuxent and Centennial Lake watersheds (Figure 1).

The assessments are designed to meet the County's National Pollutant Discharge Elimination System (NPDES) permit conditions under section III.E.1.a which requires the County to complete detailed watershed assessments for the entire County by the end of the current permit term (December 2019).

The goal of the project is to identify feasible and meaningful restoration and retrofit projects that when implemented, provide progress towards meeting the County's local and Chesapeake Bay Total Maximum Daily Load (TMDL) goals and progress toward impervious surface treatment targets. In addition to the Bay TMDL targets there are currently final approved TMDLs and Stormwater Waste Load Allocations (SW-WLA) for the Little Patuxent River for sediment for Centennial Lake for sediment and phosphorus.

Assessment and recommendation will be evaluated and sites selected and prioritized for further study, design and implementation. Results of the initial assessments are included below.

Figure 1. Watershed Assessment Study Areas



2 Field Assessment Results

The following sub-sections describe the results of the assessments in terms of the total number of sites per category completed with detail on the numbers assigned, those assigned sites completed, and any additional sites that were added and assessed through the course of the field effort. Results are summarized in Table 1.

Table 1. Number of Field Assessments Completed

Consultant Firm	**KCI Technologies, Inc.**			
Study Area	**Northern Little Patuxent**			
Type	**# Sites (or Stream Miles) Assigned (from Table A)**	**# Pre-Assigned Sites (or Stream Miles) that Were Completed**	**# Additional Sites (or Stream Miles), Added in the Field and Completed**	**Total # Sites (or Stream Miles) Completed**
BMP conversion	11	11	1	12
New BMP	52	51	0	51
Stream Restoration	24 miles	23 miles	0.6 miles	23.6 miles
Tree Planting	16	15	5	20
Outfall stabilization	37	37	18	55

2.1 BMP Conversion Field Assessments

A total of 11 BMP conversion field assessments were assigned. Site access permissions were obtained for all sites and each was evaluated in the field. An additional conversion site was added in the field because one of the New BMP assessment sites (NLP-NB-F512) was found to be located at an existing stormwater management pond, which was not listed in the original geodatabase; therefore a conversion site (NLP-BC-F651) was added. The site was located at an industrial facility and after checking into the property's office, the property owner provided the design plans for this pond dating back to 1986. Twelve total BMP conversion assessment sites were completed. A breakdown of the number of field assessment sites assigned and completed can be found in Table 1.

2.2 New BMP Field Assessments

A total of 52 new BMP field assessments were assigned. As described above, site NLP-NB-F512 was found to be an existing facility; therefore it was treated as a conversion site, and not assessed as a new BMP site. No additional sites were added in the field. In total, 51 new BMP field assessment sites were completed. A breakdown of the number of field assessment sites assigned and completed can be found in Table 1.

2.3 Stream Restoration Assessment

A total of 24 miles of stream were assigned for evaluation. All pre-assigned sites were able to be assessed with the exception of sites located within one property where access was denied by the property owner. This site included reaches F538, F539, F541, F542, and F545; for a total of 1 mile of stream. In addition, a total of 0.6 mile of stream was added in the field. Those areas that were added include pre-assigned reaches that were extended to capture continued erosion that existed beyond the

assigned reach; as well as, degraded tributaries that drain to a pre-assigned reach. In total, 23.6 miles of stream were evaluated during the field efforts.

Two points, F596b-UC101 and F588b-UC101, were found that contained questionable potential illicit discharges. These observations were discussed with KCI's illicit discharge specialist and did not seem to warrant an emergency or immediate response; however the County may want to add these sites to their regular rotation of illicit discharge checks.

Another unusual condition point (F527a-UC101) was noted where several large trees within close proximity to the channel appeared to have been recently cut down in an area that is noted as a Forest Conservation Area. The cut material was left onsite in the riparian buffer. It was unclear if this was done by the adjacent homeowners.

In general, erosion was typically found to be segmented throughout a reach, with the eroded bank alternating as the channel meanders. In these cases, the erosion was typically found to be very similar throughout and therefore, one erosion point was used to identify the total reach of observed erosion. The total length of erosion noted per bank is provided based on an estimate of actual erosion and excluding the areas that did not contain erosion. The total eroded reach length was then noted in the "Notes" section of the form.

2.4 Tree Planting Field Assessments

A total of 16 tree planting field assessments were assigned. Of these, site access permission was not obtained at only one site (NLP-TP-F515, Covenant Park), and as a result this site was not assessed in the field. An additional five sites were added in the field. Three of these sites, NLP-TP-F652, NLP-TP-F653, and NLP-TP-F654, were added and assessed during the stream restoration streamwalks effort. The other two sites, NLP-TP-F651 and NLP-TP-F655, were created at assigned tree planting assessment sites to assess a distinct portion of the assigned study area that was recommended for tree planting. Twenty total tree planting assessment sites were completed. A breakdown of the number of field assessment sites assigned and completed can be found in Table 1.

2.5 Outfall Stabilization Field Assessments

A total of 37 outfall stabilization sites were assigned for evaluation. Of those, 33 sites were able to be assessed in the field. Those sites that were not assessed were a result of the field crew being unable to locate the outfalls in the field. In these cases, the areas at and around the mapped location of the outfall was traversed; however, no sign of the outfall was observed. A total of 18 sites were added during the assessment and are linked to Pipe Outfall points that were assessed as part of the stream restoration assessments, with the exception of one site that was observed during a BMP assessment. In total, 55 outfall stabilization assessments were performed.

3 Field Recommendations Results

The following sub-sections describe the recommendations made as a result of the field assessments in terms of the total number of recommendations per category and a breakdown of the general restoration/retrofit potential within each category. Results are summarized in Table 2.

Table 2. Number of Site Recommendations Completed for Field Sites Assessed

Consultant Firm	**KCI Technologies, Inc.**			
Study Area	**Northern Little Patuxent**			
		Field Assessment of Restoration/Retrofit Potential (# Sites)		
Type	**# Recommendations**	**High**	**Medium**	**Low**
BMP conversion	10	4	6	0
New BMP	50	15	29	6
Stream Restoration	50	16	24	10
Tree Planting	17	10	6	1
Outfall stabilization	28	13	10	5

3.1 BMP Conversion Recommendations

Two sites, NLP-BC-F504, and NLP-BC-F505, were the only sites not recommended for conversion. These were listed as dry ponds in the geodatabase, but were stormdrain inlets. Based on the site conditions, there were no recommendations for these sites.

Ten sites with existing dry ponds can be converted to wet ponds to provide water quality volume treatment for their contributing drainage area. Two sites were recommended to be converted to bioretention practices as alternatives, and one site was recommended to be converted to an infiltration practice as an alternative. Four out of the ten sites were considered to have high conversion potential. A breakdown of the number of field assessment of retrofit potential can be found in Table 2. The existing site soils should be investigated to determine the best conversion options for next design phase.

3.2 New BMP Recommendations

Twenty-one sites were not recommended with any new BMP practices. The most common reason new BMPs were not recommended was a lack of open space or residential property issues within the study area. Many commercial sites were found to have large impervious areas draining directly into existing stormwater drainage systems with little or no open space available.

Thirty-one sites were considered feasible for new BMP practices. Each site was recommended with one or multiple new BMP practice types. A total of fifty new BMP footprints were recommended. The most common recommendations were wet pond and bioretention practices for these sites. Further investigations regarding soils, water balance analysis, and contributing drainage areas are needed to determine the best retrofit options for the next design phase. Of these sites, 15 were found to have a high retrofit potential, 29 sites have medium potential, and six sites have low potential (Table 2).

3.3 Stream Restoration Recommendations

Stream restoration recommendations were created for 50 sites. Of these, 16 sites were rated as having high restoration potential, 24 as medium potential, and 10 as low potential. In most cases, each stream restoration recommendation site includes multiple stream reaches. These areas were lumped together to better represent a complete and practical restoration project where similar conditions exist, the general restoration approach would be similar, and it would be cost effective to prepare design plans and mobilize construction for the entire site.

All areas that showed some restoration potential that could result in a feasible project were included in the restoration recommendations. Overall, many of the sites assessed contained only moderate erosion, but in these areas, the conditions typically existed over a long distance. As a result, many of the restoration recommendations include sites that may not appear severely degraded or be considered a high priority, but due to the consistent conditions over a long distance, are expected to result in a feasible project that will yield significant restoration credit.

3.4 Tree Planting Recommendations

A total of 17 tree planting recommendation sites were created at the field assessment sites (Table 2). Of these, 10 sites were evaluated to have a high restoration potential, 6 sites had medium potential, and 1 site had low potential. Sites with high restoration potential were generally open, mowed fields with minimal site preparation required. Sites with medium or low restoration potential generally had more site preparation required, included mowing and invasive removal, or beaver activity within the area that would reduce the survival potential of planted trees.

The most common reason planting was not recommended was lack of suitable planting area space (generally enough space for more than approximately 10 trees) within the study area. Many sites included stormwater management facilities which left little room for planting due to the facility structures and embankments. Several sites were already forested.

Many tree planting assessment sites had distinct areas of the site that would yield different assessment results (for example: sunlight exposure, vegetative cover, invasive cover), however if no planting was recommended at the site, the site was assessed as a whole and existing conditions were averaged. If planting areas were recommended, typically only the planting area conditions were assessed, however if multiple planting areas were recommended within one large study area, the conditions were averaged for the assessment. A description of the areas assessed (entire site, planting areas only, etc.) at each site is included in the Notes field.

The tree planting assessments were conducted in late March and early April, therefore invasive species and percent cover may be artificially lower and results may have been different had the site been assessed during the growing season.

3.5 Outfall Stabilization Recommendations

A total of 28 outfall stabilization recommendation sites were created during the field assessments. Of these, 13 sites were rated as having high restoration potential, 10 as medium potential, and 5 as low potential. In general, the outfall stabilization recommendations included stabilization of a degraded outfall channel located immediately downstream of the outfall. Of the 28 recommendations, eight included drop structures, five are rip-rap stabilization, six are RSC projects, and nine are projects involving riffle-pool design and bank stabilization.

4 Desktop Assessment Results

KCI was asked to prepare assessments and generate recommendations for BMP and tree planting sites that were visited previously during preparation of the Upper Little Patuxent (ULP) Watershed Management Plan, prepared by KCI in 2009. Data from site visits, photos, and concept plans were used to complete the assessments. The following sub-sections describe the results of the desktop assessments in terms of the total number of sites per category completed with detail on the numbers assigned, those assigned sites completed, and any additional sites that were added and assessed through the course of the desktop effort. Results are summarized in Table 3.

Table 3. Number of Desktop Assessments Completed

Consultant Firm	**KCI Technologies, Inc.**		
Study Area	**Northern Little Patuxent**		
Type	**# Sites (or Stream Miles) Assigned (from Table B)**	**# Sites (or Stream Miles) for Which Desktop Assessment Was Completed**	**For These Sites, Number of Concept Plans Previously Prepared**
BMP conversion	12	12	2
New BMP	5	4	4
Stream Restoration	0 miles	0 miles	0
Tree Planting	5	4	0
Outfall stabilization	0	0	0

4.1 BMP Conversion Desktop Assessments

A total of 12 BMP conversion desktop assessments were assigned. Of these, two sites had concept plans prepared previously for the ULP management plan; therefore the concept was used for the assessment. Ten sites did not have concept plans and were evaluated based on previous field notes and photos. Twelve total BMP conversion assessment sites were completed. A breakdown of the number of desktop assessment sites assigned and completed can be found in Table 3.

4.2 New BMP Desktop Assessments

A total of five new BMP desktop assessments were assigned. Of these, one site NLP-NB-D561, is the same site as NLP-BC-D525, and has been considered a BMP conversion desktop analysis site because of the existing facility located at the site; therefore four new BMP desktop assessment sites were completed. All four sites had a concept plans previously prepared during the ULP management plan development. A breakdown of the number of field assessment sites assigned and completed can be found in Table 3.

4.3 Tree Planting Desktop Assessments

A total of five tree planting desktop assessment sites were assigned. Very little information required in the planting assessment could be obtained through the desktop investigation; therefore four of the five sites were visited during the field assessments. One site could not be field evaluated due to lack of landowner permission to access the site. A breakdown of the number of field assessment sites assigned and completed can be found in Table 3.

5 Desktop Recommendations Results

The following sub-sections describe the recommendations made as a result of the desktop assessments in terms of the total number of recommendations per category and a breakdown of the restoration/retrofit potential within each category. Results are summarized in Table 4.

Table 4. Number of Site Recommendations Completed for Desktop Sites Assessed

Consultant Firm	**KCI Technologies, Inc.**			
Study Area	**Northern Little Patuxent**			
		Desktop Assessment of Restoration/Retrofit Potential (# Sites)		
Type	**# Recommendations**	**High**	**Medium**	**Low**
BMP conversion	12	3	7	2
New BMP	4	3	1	0
Stream Restoration	0	0	0	0
Tree Planting	6	3	3	0
Outfall stabilization	0	0	0	0

5.1 BMP Conversion Recommendations

Eleven sites with existing dry ponds are proposed to be converted to wet ponds to provide water quality volume treatment for the contributing drainage areas. Two sites were recommended to be converted to wetlands as an alternative, and one site was recommended to be converted to a bioretention practice as an alternative. One site with an existing dry pond was proposed to for conversion to bioretention practice. Three out of twelve sites were considered to have high conversion potential. A breakdown of the number of desktop assessment sites and retrofit potential can be found in Table 4. The existing site soils and water balance analysis should be investigated to decide the best conversion options for the next design phase.

5.2 New BMP Recommendations

All four sites were recommended with new BMP practices. Wet pond and bioretention practices were recommended for these sites. Further investigations of soils and contributing drainage areas are recommended to decide the best retrofit option for the next design phase. Of these sites, three were found to have a high retrofit potential and one site had medium potential (Table 4).

5.3 Tree Planting Recommendations

Planting was found to be possible at three of the five desktop sites assigned. Multiple planting areas were created for NLP-TP-D519 and NLP-TP-D521 and resulted in the creation of six total planting recommendation sites. At the third site, NLP-TP-D522, a smaller portion of the site was recommended for planting and separate field assessment and planting recommendation forms were filled out for this portion of the site (NLP-TP-F655A), therefore the recommendation site is linked to a field assessment site rather than the original desktop site ID. Of these sites, 3 were found to have a high restoration potential and 3 sites had medium potential (Table 4).

Field Data Summary

Howard County Watershed Assessments 2015

Southern Little Patuxent River Watershed

Prepared for
Howard County Watershed Management Program
Howard County Department of Public Works
Bureau of Environmental Services
Stormwater Management Division

Prepared by
Versar, Inc.
Ecological Sciences and Applications
9200 Rumsey Road
Columbia, MD 21045

VERSAR

June 2015

Southern Little Patuxent Field Summary
June 22, 2015

1. Number of field assessments completed

Table 1. Number of field assessments completed				
Consultant Firm Name	**Versar**			
Study Area Name*	**Southern Little Patuxent**			
Type	**# Sites (or Stream Miles) Assigned (from Table A below)**	**# Pre-Assigned Sites (or Stream Miles) that Were Completed**	**# Additional Sites (or Stream Miles), Added in the Field and Completed**	**Total # Sites (or Stream Miles) Completed**
BMP conversion	73	69	2	71
New BMP	76	72	1	73
Stream Restoration	15 miles	13.7 miles	1.2 miles	14.9 miles
Tree Planting	4	4	6	10
Outfall stabilization	95	82	14	96

2. If there were sites that could not be assessed in the field, please summarize primary reasons.

BMP Conversion Assessments: All sites were visited, but 4 BMPs either could not be found or did not exist. A total of 8 sites did not have potential for conversion due to either already being state of the art facilities, having safety issues, or are back-up type flood control without the correct elevations to treat the first flush. One site was evaluated during a past study and was thus completed as a desktop assessment.

New BMP Assessments: Four sites (SLP-NB-F708, SLP-NB-F714, SLP-NB-F763, and SLP-NB-F775) that were only rooftops were merged with adjacent parking surfaces to create a single site. The number of pre-selected sites assessed were thus reduced by 4 to 72. Some sites or portions of sites appeared to be in error. For example, Oakland Mills High School (SLP-NB-F759) had a portion of an impervious surface on a parking lot subtracted out but there appeared to be no reason for including a patch nearby as they were both in the same drainage area.

Stream Restoration Assessments: One pre-assigned stream reach (SLP-SR-F728) that totaled 1.23 miles in length was not assessed because it is located on FCC property. Versar confirmed with the County that this reach was to be left out of the assessment pool.

Tree Planting Assessments: All pre-assigned sites were assessed, and several additional sites were assessed.

Outfall Stabilization Assessments: All of the 95 pre-assigned sites were visited, but 9 sites were duplicates (either the duplicate point was marking the same outfall twice, or the duplicate

point was marking the downstream extent of the erosion surveyed during a previous SCA study), two sites could not be located (SLP-OF-F705 and SLP-OF-F788), one site was marking infrastructure that was not an outfall (SLP-OF-F755), and one site was marking a potentially submerged pond infall (SLP-OF-F712).

3. Other comments about data or assumptions made.

BMP Conversion Assessments: Two additional dry ponds were assessed due to their close proximity to a pre-assigned pond.

New BMP Assessments: One additional site was assessed due to its close proximity to a pre-assigned pond. The site consists of a large overflow parking lot that appears to get very little use and was thus recommended for impervious surface removal. The one Desktop New BMP Assessment Site that was assigned to Versar was evaluated in the field.

Stream Restoration Assessments: One additional stream reach located next to a Tree Planting Assessment site was fully assessed, and two additional stream reaches adjacent to BMP Conversion sites were photodocumented and added as Stream Restoration Recommendation sites due to the severity and longevity of erosion. The total length of stream assessed also includes outfall stabilization recommendations that extended beyond 200 feet.

Tree Planting Assessments: Six additional tree planting sites were found, three of which were discovered while conducting Stream Restoration Assessments, and the remaining three were discovered while conducting BMP Conversion Assessments.

Outfall Stabilization Assessments: A total of 14 additional outfalls were assessed during the study. 9 of these were added during Stream Restoration Assessments, 3 were added during New BMP Assessments, and two were added during BMP Conversion Assessments.

4. Number of site recommendation forms completed for field sites assessed

Table 2. Number of site recommendation forms completed for field sites assessed				
Consultant Firm Name	**Versar**			
Study Area Name*	**Southern Little Patuxent**			
		Field Assessment of Restoration/Retrofit Potential (# Sites)		
Type	**# Recommendations**	**High**	**Medium**	**Low**
BMP conversion recommendations	62	38	23	1
New BMP recommendations	144	91	50	3
Stream Restoration recommendations	37 (23,920 ft)	22 (14,950 ft)	14 (8,920 ft)	1 (50 ft)
Tree Planting recommendations	21	17	2	2
Outfall stabilization recommendations	44 (4,005 ft)	22 (2,210 ft)	19 (1,630 ft)	3 (165 ft)

5. General comments about the types of recommendations made.

BMP Conversion Recommendations: The following BMP conversion types are recommended: 33 Wet Pond, 27 Non-Bioretention Filtering Practice, 23 Created Wetland, 12 Bioretention, 7 Infiltration, 7 Extended Detention, 4 Swale, and 1 Step Pool Conveyance. The total number of recommended conversions exceeds the number of assessed BMPs because multiple BMP conversion options are feasible at several sites.

New BMP Recommendations: The following new BMP types are recommended: 59 Bioretention, 48 Non-bioretention filtering practices, 24 Underground Storage, 23 Impervious Pavement Replacement, 12 Impervious Surface Removal, 3 Green Roof, 2 Infiltration, 1 Swale, 1 Wet Pond, and 1 Buffer Enhancement. The total number of recommended BMP facilities exceeds the number of assessed sites because multiple BMP opportunities are feasible at several sites.

Stream Restoration Recommendations: In general, stream reaches recommended for restoration contained either one (or multiple) instance(s) of severe bank erosion, or consistent minor to moderate bank erosion along with unsuitable instream habitat and threatened infrastructure (e.g. exposed utility pipes, power line poles located in the stream channel, etc.). In addition, several concrete channels were recommended for removal.

Tree Planting Recommendations: Tree Planting recommendations that are rated High or Medium typically target riparian areas and areas of existing forest that can be expanded. A few

areas of open pervious land were also recommended for planting, but were rated lower due to the smaller potential for biological uplift at these sites.

Outfall Stabilization Recommendations: The following Outfall Stabilization types are recommended: 32 Regenerative Stormwater Conveyance, 7 Rip Rap, and 5 Drop Structure.

6. List of sites reported to Howard County because of suspected illicit discharges, safety concerns, or other reasons for County followup.

A sudsy discharge was observed while conducting an Outfall Stabilization Assessment for the outfall (SLP-OF-F708) associated with BMP HO101950 on 5/8/15. Field personnel inspected the BMP's drainage area, but could not identify a definitive source for the sudsy discharge. The County was notified of the issue immediately, and photos of the outfall were sent to County personnel at the end of the field day.

Field personnel discovered an unusual amount of water flowing over a stream bank in the vicinity of Rommel Drive and Gerwig Lane while conducting a Stream Restoration Assessment for SLP-SR-F732 on 5/13/15. The flow was followed up to a point where water was bubbling out of the ground approximately 100 feet east of the stream and 100 feet west of Rommel Drive. The County was notified of the issue immediately, and eventually discovered that a problem with a potable water line was the source of the bubbling water.

Outdoor washing of vehicles was observed at an auto care business located at 7248 Cradlerock Way, Columbia, MD while field personnel were conducting a BMP Conversion Assessment on 5/14/15. The County was notified of the issue immediately.

A sediment-laden discharge was discovered while conducting an Outfall Stabilization Assessment along Green Mountain Circle (SLP-OF-F766) on 5/19/15. The source of the discharge was discovered to be a pile of dirt associated with construction occurring along Twin Rivers Road, between Green Mountain Circle and Lynx Lane. The silt fence that was in place was compromised and allowing sediment to spill into the road and wash into a storm drain. The County was notified of the issue immediately.

Field personnel discovered a homeless camp within an outfall channel while conducting an Outfall Stabilization Assessment (SLP-OF-F716) behind 6560 Dobbin Rd. Columbia, MD on 5/19/15. The County was notified of the discovery the following morning.

7. Other comments/explanations related to data collected.

Ten of the 63 assigned desktop analysis sites were not previously visited by Versar, and thus full desktop assessments could not be performed.

8. Number of desktop assessments completed

Table 3. Number of desktop assessments completed			
Consultant Firm Name	**Versar**		
Study Area Name	**Southern Little Patuxent**		
Type	**# Sites (or Stream Miles) Assigned – see Table B below**	**Total # Sites (or Stream Miles) For Which Desktop Assessment was Completed**	**For These Sites, Number of Concept Plans Previously Prepared**
BMP conversion	63	53	25
New BMP	1	1*	0
Stream Restoration	NA miles	NA miles	NA miles
Tree Planting	NA	NA	NA
Outfall stabilization	NA	NA	NA
*evaluated in the field.			

9. Number of site recommendation forms completed for desktop assessment sites

Table 4. Number of site recommendation forms completed for desktop assessment sites				
Consultant Firm Name	**Versar**			
Study Area Name	**Southern Little Patuxent**			
		Desktop Assessment of Restoration/Retrofit Potential (# Sites)		
Type	**# Recommendations**	**High**	**Medium**	**Low**
BMP conversion recommendations	50	39	9	2
New BMP recommendations	NA	NA	NA	NA
Stream Restoration recommendations	NA	NA	NA	NA
Tree Planting recommendations	NA	NA	NA	NA
Outfall stabilization recommendations	NA	NA	NA	NA

Attachment. Numbers of field and desktop sites assigned.

Table A. Estimates of field effort for identifying opportunities, total and by watershed study area - based on site selection (REVISED 25FEB2015)

		Watershed Study Area				
	Total for Five Watershed Study Areas	Northern Middle Patuxent	Southern Middle Patuxent	Northern Little Patuxent	Southern Little Patuxent	Dorsey Run
	# sites (or miles)	# sites (or miles)	# sites (or miles)	# sites (or miles)	# sites (or miles)	# sites (or miles)
Convert existing BMPs (# BMP facilities)	160	12	21	11	73	43
Opportunities for new BMPs for untreated impervious areas (# sites)	207	7	29	52	76	43
Potential stream restoration (# stream miles)	78	17	18	24	15	4
Potential tree planting sites (# sites)	46	10	11	16	4	5
Outfall stabilization (# outfalls)	202	4	36	37	95	30
Total (counting 1 stream mile = 1 site)	693	50	115	140	263	125

Table B. Assigned "desktop/office visit" sites for Versar and KCI - data sheets to be filled out for sites assessed in previous studies, without field visit (or with only minimal field check).

	Total for Five Study Areas	Northern Middle Patuxent	Southern Middle Patuxent	Northern Little Patuxent	Southern Little Patuxent	Dorsey Run
Total "desktop/office visit" sites - Versar	64	5	15	10	30	4
Total "desktop/office visit" sites - KCI	22			22		

Howard County Watershed Assessments
Field Summary Report

Northern Middle Patuxent and Dorsey Run Watersheds

June 1, 2015

Prepared for:

Howard County Government

Stormwater Management Division

Bureau of Environmental Services

6751 Columbia Gateway Drive, Suite 514

Columbia, Maryland 21046-3143

Prepared by:

McCORMICK TAYLOR

509 South Exeter Street, 4th Floor
Baltimore, Maryland 21202

1.

Table 1.1 Number of field assessments completed				
Consultant Firm Name	**McCormick Taylor**			
Study Area Name*	**Northern Middle Patuxent**			
Type	**# Sites (or Stream Miles) Assigned (from Table A below)**	**# Pre-Assigned Sites (or Stream Miles) that Were Completed**	**# Additional Sites (or Stream Miles), Added in the Field and Completed**	**Total # Sites (or Stream Miles) Completed**
BMP conversion	12	12	0	12
New BMP	7	7	0	7
Stream Restoration	16.8 miles	15.9 miles	0 miles	15.9 miles
Tree Planting	10	10	18	28
Outfall stabilization	4	4	0	4

Table 1.2 Number of field assessments completed				
Consultant Firm Name	**McCormick Taylor**			
Study Area Name*	**Dorsey Run**			
Type	**# Sites (or Stream Miles) Assigned (from Table A below)**	**# Pre-Assigned Sites (or Stream Miles) that Were Completed**	**# Additional Sites (or Stream Miles), Added in the Field and Completed**	**Total # Sites (or Stream Miles) Completed**
BMP conversion	43	43	0	43
New BMP	43	42	0	42
Stream Restoration	4.3 miles	3.9 miles	0.4 miles	4.3 miles
Tree Planting	5	5	3	8
Outfall stabilization	30	26	3	29

2. If there were sites that could not be assessed in the field, please summarize primary reasons.

<u>BMP Sites:</u>

- One site could not be assessed in the field due to denied access to the property by the landowner.

<u>Stream Restoration Sites:</u>

- Portions of 19 stream restoration sites could not be evaluated in the field.
- Primary reasons assessments could not be made include:
    - Access not granted by the landowner.
    - Site was not associated with a stream, but with a wetland system or pond.

- Livestock (bull or electric fences) present on site.
- One stream site was not assessed as it was noted to be a citizen erosion complaint, but no erosion was found and the downstream portion was a wetland system. In this case the adjacent unmarked stream, which appeared to have been the intended target of the citizen erosion complaint, was assessed instead.

Tree Planting Sites:

- All sites were evaluated.

Outfall Stabilization Sites:

- 4 sites were not assessed.
- Primary reasons assessments could not be made include access not granted by the landowner, fencing, and/or no outfall in vicinity of point.

3. Other comments about data or assumptions made.

BMP Sites:

The following information should be noted for BMP Sites:

- Facilities that did not exist:
  - DOR-BC-F902 (Grass space behind Montgomery Irrigation facility)
  - DOR-BC-F923 (Parking lot on site of Bowles Fluidics)
- Facility already under design for conversion:
  - DOR-BC-F933 (CSX property)
- Facilities that were moved:
  - NMP-BC-F104 to 12056 Broad Meadow Lane, Clarksville, MD (was at facility on 12106 Dusk View Ct where NMP-BC-F105 is located)
  - NMP-BC-F108 to 12975 Livestock Rd, Sykesville, MD (was on side of I-70 where existing BMP point is still located)
- Sites with new facilities/already treated:
  - DOR-NB-F909 recently reconstructed entire site. Two Bioretention facilities, underground storage, stormceptors found.
  - DOR-NB-F935 several existing facilities are on site but drainage areas may not be represented. Several underground facilities/stormceptors located in parking lots.
  - DOR-NB-F922 and DOR-NB-F918 entire site drains to recently reconstructed facility (pond is in database as existing facility, drainage area is just incorrect)

Tree Planting Sites:

- 3 capped landfill sites were assessed from the gated fence line.

Outfall Stabilization Sites:

- Outfall stabilization points at 11 sites were moved from a pond riser or inlet structure to a nearby outfall. Additionally, 2 pond inlets were assessed at the original outfall stabilization assessment location before adding 2 site assessments at outfalls from that pond. In 3 cases, the pond outfall could either not be found or accessed due to landowner constraints; instead the pond structures were assessed.

4.

Table 2.1 Number of site recommendation forms completed for field sites assessed				
Consultant Firm Name	**McCormick Taylor**			
Study Area Name*	**Northern Middle Patuxent**			
		Field Assessment of Restoration/Retrofit Potential (# Sites)		
Type	**# Recommendations**	**High**	**Medium**	**Low**
BMP conversion recommendations	12	4	5	3
New BMP recommendations	6	0	1	5
Stream Restoration recommendations	79	14	48	17
Tree Planting recommendations	38	15	15	8
Outfall stabilization recommendations	2	0	1	1

Table 2.2 Number of site recommendation forms completed for field sites assessed				
Consultant Firm Name	**McCormick Taylor**			
Study Area Name*	**Dorsey Run**			
		Field Assessment of Restoration/Retrofit Potential (# Sites)		
Type	**# Recommendations**	**High**	**Medium**	**Low**
BMP conversion recommendations	40	21	13	6
New BMP recommendations	170	21	74	75
Stream Restoration recommendations	24	13	7	4
Tree Planting recommendations	13	2	2	9
Outfall stabilization recommendations	10	2	7	1

5. General comments about the types of recommendations made.

BMP Sites:

- Recommended conversions include wet ponds, wetlands, bioretention facilities, sand filters, and rain gardens. These facilities were recommended based on the land use in the area, existing conditions (soil, standing water, vegetation, etc.), and depth of outfall, riser, or inlet structure.
- Recommended new BMP sites include wet ponds, wetlands, bioretention facilities, sand filters, tree box filters, swales, pavement removal, underground sand filters, and rain gardens. New BMP sites were recommended based on available space with a reasonable drainage area, existing utilities (avoiding significant visible conflicts), storm drain location, and existing land use.
- A number of sites in both the BMP conversions and new BMP sites have high potential based on the need for repair, the feasibility of construction and access, minimal conflicts, size of impervious drainage area, and land use in vicinity.

Stream Restoration Sites:

- Stream restoration is generally recommended in reaches with active erosion, threatened infrastructure, and limited habitat.
- Overall, 14 stream reaches in the Northern Middle Patuxent watershed and 13 stream reaches in the Dorsey Run watershed have high stream restoration potential. Of these high priority reaches, those with the most potential are listed below:
    - DOR-SR-F906 is a heavily incised and actively eroding channel which is currently threatening private property as the stream continues to erode and meander.
    - DOR-SR-F909, DOR-SR-F910, and DOR-SR-F911 are experiencing moderate to severe erosion, an abundance of depositional areas, and pools filled with fine sediment (primarily silt) indicating large sediment loads upstream. There may be good restoration potential north of Tamar Drive as well.
    - DOR-SR-F912 has moderate to severe erosion throughout include degradation and lateral migration. Restoration could include outfall stabilization and BMPs in several locations and the length may be extended further downstream.
    - NMP-SR-F133, NMP-SR-F136, and NMP-SR-F145 have severe bank erosion, numerous tree falls, lack of riparian vegetation, and moderate bar deposition. Access may be relatively easy.
    - NMP-SR-F135 has moderate to severe erosion including headcuts and is highly sinuous.
    - NMP-SR-F152 is experiencing severe active erosion along the left bank. Homeowners mow to top of bank, but expressed interest in the County planting a stream buffer.
    - NMP-SR-F168 and NMP-SR-F-169 are the mainstem of the Northern Middle Patuxent and a large tributary to the mainstem, both experiencing severe erosion throughout. This is likely a more expensive restoration opportunity than lower-order streams.

Tree Planting Sites:

- Tree planting recommendations were ranked high when located in cleared areas within or adjacent to existing Howard County Forest Conservation Easements and some sites that are located in areas adjacent to highly erosive stream segments. Cleared areas containing recent tree plantings that exhibited low species survivability were specifically recommended for replacement plantings.

Outfall Stabilization Sites:

- Outfall stabilization recommendation types include riprap, outfall and apron replacement, and regenerative stormwater conveyance.
- Overall, only 2 outfalls located in the Dorsey Run watershed have high outfall stabilization potential. One is in need of structure replacement and riprap, while the other is not recommended at the outfall itself, but a regenerative stormwater conveyance upstream of the inlet.

6. List of sites reported to Howard County because of suspected illicit discharges, safety concerns, or other reasons for County followup.

- Homeless campsite found at DOR-SR-F901, near the intersection of I-95 and MD-175.
- Recommend county coordination with the Columbia Association stream assessments. A field crew ran into a U.S. Fish and Wildlife employee working for the Columbia Association at DOR-SF-F912. The Columbia Association assessment appears to be similar to the Howard County assessment.
- Homeless camp located in the woods on north side of Holiday Inn parking lot at MD 175 and US 1 and small wooded area bordered by Holiday Inn, Exxon Station, Burger King, and La Quinta Inn and Suites.

7. Other comments/explanations related to data collected.

- May be helpful to understand site selection process. Some selected stream sites appeared to completely stable with no problems while other streams not selected appeared to have more problems or showed some form of impairment. Due to schedule constraints and property owner permissions, these additional stream sites were not assessed. Some segments were very short with difficult access and it was challenging to understand how the site could be considered for a restoration project.
- Consider performing stream assessments on entire drainage network within local drainage areas or subwatershed areas.
- Consider simplifying database entries and/or incorporating automated data population for some fields that are populated multiple times for a given site (e.g. weather). Utilities, particularly for new BMP sites, are another example where data on utilities could include one entry for the type of utilities that conflict or possibly conflict with BMP opportunity.

Biohabitats

The Stables Building
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Baltimore, MD 21211
410.554.0156
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MEMORANDUM

Date: June 4, 2015

To: Nancy Roth, Versar
Kelly Hargadin, Howard County, Storm Water Management Division

From: Biohabitats, Inc.
Stormwater Maintenance & Consulting

RE: **Howard County Watershed Assessments in 2015**

Subject: **Southern Middle Patuxent Field Summary Report**

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1. Number of Field Assessments Completed

Table 1. Number of field assessments completed				
Consultant Firm Name	**Biohabitats and Stormwater Maintenance and Consulting**			
Study Area Name	**Southern Middle Patuxent**			
Type	**# Sites (or Stream Miles) Assigned (from Table A below)**	**# Pre-Assigned Sites (or Stream Miles) that Were Completed**	**# Additional Sites (or Stream Miles), Added in the Field and Completed**	**Total # Sites (or Stream Miles) Completed**
BMP conversion	21	21	1	22
New BMP	29	28	0	28
Stream Restoration	18.42 miles	18.37 miles	0 miles	18.37 miles
Tree Planting	11	7	7	14
Outfall stabilization	36	36	8	44

2. Primary Reasons that Sites Could Not be Assessed

Stream Restoration

- SMP-SR-F312 (0.05 miles) was visited but not assessed. Construction of a bottomless arch culvert crossing and associated stabilization work was in progress at the time of the assessment.

Tree Planting

- SMP-TP-303, 304, & 305 in the Middle Patuxent Environmental Area (MPEA) were not assessed. MPEA is actively managing these sites as meadow or old field for American woodcock habitat.
- SMP-TP-310 has already been planted with the exception of utility and SWM easements.

Outfall Stabilization

- SMP-OF-F311 is a duplicate site; no outfall was found. (Assessed SMP-OF-F314)
- SMP-OF-F315 is a duplicate site; no outfall was found. (Assessed SMP-OF-F314)
- SMP-OF-F320, no outfall to assess.
- SMP-OF-F316, no outfall to assess.

New BMP Opportunities

- SMP-NB-F322 was not assessed as access was denied at the gate.

3. Other Comments about Data or Assumptions Made

Stream Restoration

- The assessed reaches along the mainstem of the Middle Patuxent (SMP-SR-F306, F307, F308, F352, F353, F359, and F361) exhibit a channel form characteristic of a post agricultural age alluvial stream channel. These channels have historically accreted 4-6 feet of fine sediments across the valley bottom and have subsequently incised through that sediment as the supply of sediment from the watershed reduced with better land use practices. The contemporary channels typically exhibit raw 4-6' high banks and a high fine sediment load. For these reasons, restoration opportunities were not identified for the individual reaches assessed; however a focused phased restoration of the mainstem of the Middle Patuxent may be feasible and yield significant nutrient and sediment load reductions.
- In cases where the bank erosion was similar in character and flip flopped from left bank to right bank the length of erosion on left and right banks summed for the respective banks and a total length of erosion was included in the notes. This total length of erosion may be less than the sum of erosion on left and right banks if overlap occurred.
- An additional 12 Stream Restoration Assessment reaches totaling approximately 1.35 miles were added in post-processing to account for outfall restoration opportunities that exceeded the 200 LF threshold or outfall reaches that flowed to a significantly degraded receiving stream. Reach assessments were not completed for these reaches, but Stream Restoration Opportunity polygons were placed to delineate the opportunities.

Tree Planting

- Private property sites, we assumed that property owner was okay with planting.
- Watering was assessed as onsite sources available or access for a truck.
- Additional sites added in the field were identified during the stream restoration assessment. The tree planting assessment polygon for the additional sites did not always match property boundaries like the assigned sites. Since the additional sites were identified during the stream restoration assessment, the tree planting assessment polygons for additional sites could cross several properties and/or only include portions of properties adjacent to a stream.
- Regional forest association was based on USDA Forest Service Potential Natural Vegetation Groups, version 2000, available at http://www.firelab.org/sites/default/files/images/downloads/pnv2000.pdf.
- No optional sketches of the tree planting areas were completed.

Outfall Stabilization

- It was assumed that 'distance from outfall to stream channel' was the vertical distance from the invert of the outfall pipe to the immediate receiving channel (outfall channel).
- 'SMP-OF-F313' is the outfall for a newly constructed underground sand filter.

New BMP Opportunities

- 'River Hill Rain Garden' is an existing BMP, not a new recommendation, but was created as a recommended footprint to bring to County's attention
- Base maps were outdated and did not reflect active construction sites, new buildings, new BMPs, and/or had incorrect drainage areas, etc. It was assumed that a newly developed site or active construction site meets current stormwater standards for water quality. See below for summary.

Site ID	**Active or New Construction not reflected in GIS**
SMP-NB-307	Southern portion of facility drains to an existing detention structure
SMP-NB-F310	Site drains to an existing wet pond and bioretention facility
SMP-NB-F315	Site is treated; drains to an existing wet pond.
SMP-NB-F316	Site drains to newly constructed wet pond.
SMP-NB-F317	Site has an approved redevelopment plan with approved BMPs
SMP-NB-F318	Site is treated; drains to an existing wet pond.
SMP-NB-F319	Site is treated; drains to newly constructed wet pond (same as F326).
SMP-NB-F321	Site is under active development.
SMP-NB-F326	Site is treated; drains to newly constructed wet pond (same as F319).
SMP-OF-F313	Newly constructed underground sand filter and outfall.

BMP Conversions

- Four sites assessed have insufficient capacity and do not offer retrofit opportunities (SMP-BC-F305; SMP-BC-F313; SMP-BC-F317; SMP-BC-F321)

4. Number of Recommendations Made At Field Sites

Table 2. Number of site recommendation forms completed for field sites assessed				
Consultant Firm Name	**Stormwater Maintenance and Consulting**			
Study Area Name	**Southern Middle Patuxent**			
		Field Assessment of Restoration/Retrofit Potential (# Sites)		
Type	**# Recommendations**	**High**	**Medium**	**Low**
BMP conversion recommendations	21	4	7	10*
New BMP recommendations	55	8	31	16
Stream Restoration recommendations	91	28	45	18
Tree Planting recommendations	20	13	7	0
Outfall stabilization recommendations	18	8	9	1

5. General Comments about the Types of Recommendations Made

Stream Restoration

- Over 9 miles of stream restoration opportunities were identified by the field crews. The average project length was approximately 1000 LF. These opportunities varied widely from livestock fencing and straight forward gully or bank repairs to significant restoration projects along the higher order stream reaches. Field crews generally thought that tree impacts could be minimized and only 4 sites (F328, F329, F335, and F363) totaling about 0.5 miles of opportunities would result in significant tree impacts. The overall access ratings were moderate to easy, with only 12 sites (approximately 1.2 miles) rating in the significant range.
- Twelve additional stream restoration opportunities totaling over 1 mile were associated with the outfall and BMP assessments. The average length of these opportunities was approximately 500 LF and the restoration potential generally scored medium with some constraints and moderate tree impacts.

Tree Planting

- Of the sites that were rated high restoration potential, five (SMP-TP-F308, F307, F402, F403, and F406) appeared to be the best opportunities. Sites F308 and F307 were at churches, so some coordination of the planned use of these spaces will be necessary.

Outfall Stabilization

- Ten of the eighteen outfall stabilization recommendations were proposed as Regenerative Stormwater Conveyance. Twelve of the assessed outfalls were candidates for stream restoration and accounted for with stream restoration recommendation polygons.

New BMP Opportunities

- New BMP Recommendations were typically filtering practices or bioretention (39). If space was very limited green roofs were recommended but prioritized as low (4). Some site recommendations require parking spot elimination.

BMP Conversions

- BMP Conversion recommendations were typically sand filter or bioretention for existing dry pond conditions. If soils appear hydric with wetland vegetation, recommended to convert to wet pond or wetland.

6. List of Sites Reported To Howard County Because Of Suspected Illicit Discharges, Safety Concerns, or Other Reasons for County Follow-Up

- County was notified of a turbidity issue in Hammond Branch on April 17, 2015. Before and after photos showing a rapid increase in turbidity was sent to the County. These were taken at Hammond Parkway between 3:45pm (before pictures) and 3:55pm (after pictures). This information was forward to Construction Inspection, which visited the site and found that the increase in turbidity was due to construction and sediment control measures installed per the grading permit.
- County was notified of a sinkhole directly above the outfall barrel of a pond while assessing 'SMP-BC-F317'. County was previously aware of this issue and working with the property owner.
- County was notified that a pond near assessment 'SMP-NB-F316' had missing manhole lids on the outlet control structure (2).
- County was notified of piping along with severe corrosion of an outfall barrel at a pond on River Hill High School property. Issue was found while assessing 'SMP-NB-F328'. County and school was previously aware of the issue.
- County was notified of illicit discharge at the Joseph Square Shopping Center 5467 Harpers Farm Road, Columbia, MD 21044 while assessing 'SMP-BC-310'. The message was forwarded to Angela M. who handles illicit discharges for the county.

7. Other Comments/Explanations Related to Data Collected

Overall

- Unless a unique opportunity was presented, photos were not generally attached to Stream Restoration Opportunities, New BMP Recommendations, and Outfall Stabilization Recommendations because they are attached to the relevant assessment features.

Stream Restoration

- During QA/QC, it was determined that three site assessment forms (SMP-SR-F322B-ES002, SMP-SR-F330C-ES007, and SMP-SR-F303B-PO001) do not have photos in the geodatabase submitted on June 4, 2015. These sites will be revisited and photos will be uploaded to the web map or forward via email for upload within the next week.
- SMP-SR-F347-UC001 – This point was recorded to document potential erosion within a stream channel adjacent to an assessed reach (SMP-SR-F347). The assessed reach exhibited no signs of erosion, so we were not sure if it may have been mapped incorrectly.
- SMP-SR-F326A-ES001 – The channel was braided in this section and only the cutoff channel was mapped for assessment. The mapped channel was stable; however, the channel to the east exhibited significant channel erosion as documented by this point.

Outfall Stabilization

- Some outfall stabilization assessment sites require local repair or stabilization, but did not warrant a full outfall stabilization recommendation as the receiving channel appears stable. These include:

Site ID	**Name**	**Local Repair required**
SMP-OF-F310	Trotter Ridge	minor roadside rills
SMP-OF-F302	River Wood Dr	corroded, barrel, associated with SR-F362
SMP-OF-F307	New Hope Church	right side of Gabion, New Church
SMP-OF-F328	Rosemont HOA	Local Stabilization (headwall, channel ok)
SMP-OF-F326	Palace Hall	downstream end of apron
SMP-OF-F331	Linden Chapel	Budget for Pipe Repair
SMP-OF-F327	Palace Hall	right side of gabion, recent development
SMP-OF-F312	9549 Washington Blvd	headwall undermined

New BMP Opportunities

- Some sites appear to be industrial sites and may be subject to NPDES 12SW General Permit: SMP-NB-F304 and SMP-NB-F305 both (12070 and 12024 Hall Shop Road respectively); SMP-NB-F310 Nestle Factory, SMP-NB-F323 (9549 Washington Blvd). The auto salvage yard, SMP-NB-F305, likely has illicit discharges during runoff events.

Attachment: Numbers of Field and Desktop Sites Assigned

Table A. Estimates of field effort for identifying opportunities, total and by watershed study area - based on site selection (REVISED 25FEB2015)						
		Watershed Study Area				
	Total for Five Watershed Study Areas	Northern Middle Patuxent	Southern Middle Patuxent	Northern Little Patuxent	Southern Little Patuxent	Dorsey Run
	# sites (or miles)	# sites (or miles)	# sites (or miles)	# sites (or miles)	# sites (or miles)	# sites (or miles)
Convert existing BMPs (# BMP facilities)	160	12	21	11	73	43
Opportunities for new BMPs for untreated impervious areas (# sites)	207	7	29	52	76	43
Potential stream restoration (# stream miles)	78	17	18	24	15	4
Potential tree planting sites (# sites)	46	10	11	16	4	5
Outfall stabilization (# outfalls)	202	4	36	37	95	30
Total (counting 1 stream mile = 1 site)	693	50	115	140	263	125

G. Table Listing Individual Retrofit and Restoration Opportunities, with Scores and Rankings

Rankings and Scores for Little Patuxent Watershed Project Recommendations

Site ID	Type	Contractor	Acres of Impervious Treated	Acres of Impervious Treated Score	Pollutant Load Reduction Score	Cost Per Acre Score	Biological uplift - Programmatic Benefit - Feasibility Proportional Score	Total Score Combined Metrics	Concept 2015
SMP-TP-F311	Tree Planting	Biohabitats	7.6	8	6	10	8	32	Yes
NLP-BC-D528	BMP Conversion	Versar	22.1	10	3	10	8	31	
SR-43	Stream	Biohabitats	13.6	10	3	8	10	31	Yes
DOR-BC-D947	BMP Conversion	Versar	7.3	8	6	8	8	30	
NLP-SR-F552A	Stream	KCI	12.8	10	3	8	8	29	Yes
NLP-SR-F557A	Stream	KCI	17.9	10	3	8	8	29	Yes
SLP-BC-D798	BMP Conversion	Versar	10.5	10	10	5	4	29	Yes
SLP-BC-D802	BMP Conversion	Versar	14.8	10	3	10	6	29	Yes
SR-29	Stream	Biohabitats	16.1	10	3	8	8	29	Yes
SR-34	Stream	Biohabitats	13.9	10	3	8	8	29	Yes
SR-35	Stream	Biohabitats	27.7	10	3	8	8	29	Yes
SR-36	Stream	Biohabitats	27.5	10	3	8	8	29	Yes
SR-37	Stream	Biohabitats	17.5	10	3	8	8	29	Yes
SR-38	Stream	Biohabitats	16.7	10	3	8	8	29	Yes
SR-45	Stream	KCI	29.9	10	3	8	8	29	Yes
SR-47	Stream	KCI	30.5	10	3	8	8	29	Yes
DOR-NB-F912A	BMP New Footprint	McCormick Taylor	5.3	8	6	8	6	28	Yes
NLP-OF-F662	Outfall	KCI	2.0	4	6	10	8	28	Yes
NLP-TP-F511	Tree Planting	KCI	0.4	2	6	10	10	28	Yes
NLP-TP-F655	Tree Planting	KCI	1.7	4	6	10	8	28	Yes

Rankings and Scores for Little Patuxent Watershed Project Recommendations

Site ID	Type	Contractor	Acres of Impervious Treated	Acres of Impervious Treated Score	Pollutant Load Reduction Score	Cost Per Acre Score	Biological uplift - Programmatic Benefit - Feasibility Proportional Score	Total Score Combined Metrics	Concept 2015
SLP-NB-F712A	BMP New Footprint	Versar	3.1	6	6	8	8	28	Yes
SLP-NB-F739B	BMP New Footprint	Versar	5.5	8	6	8	6	28	Yes
SLP-OF-F792	Outfall	Versar	1.6	4	6	10	8	28	Yes
SLP-OF-F852	Outfall	Versar	2.0	4	6	10	8	28	Yes
SLP-TP-F703	Tree Planting	Versar	2.0	4	6	10	8	28	Yes
SMP-OF-F324	Outfall	Biohabitats	1.4	4	6	10	8	28	Yes
SMP-TP-F307	Tree Planting	Biohabitats	2.5	4	6	10	8	28	Yes
SMP-TP-F309	Tree Planting	Biohabitats	4.2	6	6	10	6	28	Yes
SMP-TP-F405	Tree Planting	Biohabitats	0.4	2	6	10	10	28	Yes
SMP-BC-D332	BMP Conversion	Versar	10.3	10	6	8	4	28	Yes
DOR-BC-F942	BMP Conversion	McCormick Taylor	6.8	8	3	10	6	27	Yes
NLP-BC-D512	BMP Conversion	Versar	16.1	10	3	10	4	27	
NLP-SR-F504A	Stream	KCI	26.6	10	3	8	6	27	Yes
NLP-SR-F509A	Stream	KCI	22.5	10	3	8	6	27	Yes
NLP-SR-F520B	Stream	KCI	23.0	10	3	8	6	27	Yes
NLP-SR-F551A	Stream	KCI	26.5	10	3	8	6	27	Yes
NLP-SR-F555A	Stream	KCI	11.9	10	3	8	6	27	Yes

Rankings and Scores for Little Patuxent Watershed Project Recommendations

Site ID	Type	Contractor	Acres of Impervious Treated	Acres of Impervious Treated Score	Pollutant Load Reduction Score	Cost Per Acre Score	Biological uplift - Programmatic Benefit - Feasibility Proportional Score	Total Score Combined Metrics	Concept 2015
NLP-SR-F555B	Stream	KCI	17.9	10	3	8	6	27	Yes
NLP-SR-F571A	Stream	KCI	10.7	10	3	8	6	27	Yes
NLP-SR-F583A	Stream	KCI	19.9	10	3	8	6	27	Yes
NLP-SR-F587D	Stream	KCI	19.8	10	3	8	6	27	Yes
NLP-SR-F590A	Stream	KCI	17.6	10	3	8	6	27	Yes
NLP-SR-F599A	Stream	KCI	22.0	10	3	8	6	27	Yes
SLP-BC-D774	BMP Conversion	Versar	10.7	10	3	10	4	27	Yes
SLP-BC-D780	BMP Conversion	Versar	6.8	8	3	10	6	27	Yes
SLP-BC-D792	BMP Conversion	Versar	9.7	8	3	10	6	27	Yes
SLP-BC-F701	BMP Conversion	Versar	4.4	6	3	10	8	27	Yes
SLP-BC-F772	BMP Conversion	Versar	1.8	4	10	5	8	27	Yes
SLP-SR-F735	Stream	Versar	20.1	10	3	8	6	27	Yes
SLP-SR-F737A	Stream	Versar	8.5	8	3	8	8	27	Yes
SLP-SR-F740A	Stream	Versar	10.5	10	3	8	6	27	Yes
SLP-SR-F753I	Stream	Versar	15.3	10	3	8	6	27	Yes
SLP-SR-F754	Stream	Versar	10.0	8	3	8	8	27	Yes
SLP-SR-F852	Stream	Versar	13.4	10	3	8	6	27	Yes
SLP-SR-F853	Stream	Versar	10.3	10	3	8	6	27	Yes

Rankings and Scores for Little Patuxent Watershed Project Recommendations

Site ID	Type	Contractor	Acres of Impervious Treated	Acres of Impervious Treated Score	Pollutant Load Reduction Score	Cost Per Acre Score	Biological uplift - Programmatic Benefit - Feasibility Proportional Score	Total Score Combined Metrics	Concept 2015
SMP-NB-F325	Stream	Biohabitats	6.1	8	3	8	8	27	Yes
SMP-SR-F324	Stream	Biohabitats	10.5	10	3	8	6	27	Yes
SR-30	Stream	Biohabitats	22.2	10	3	8	6	27	Yes
SR-31	Stream	Biohabitats	29.0	10	3	8	6	27	Yes
SR-32	Stream	Biohabitats	18.1	10	3	8	6	27	Yes
SR-33	Stream	Biohabitats	27.9	10	3	8	6	27	Yes
SR-46	Stream	KCI	44.5	10	3	8	6	27	Yes
SR-48	Stream	KCI	15.2	10	3	8	6	27	Yes
SR-49	Stream	KCI	12.6	10	3	8	6	27	Yes
SR-50	Stream	KCI	16.8	10	3	8	6	27	Yes
SR-51	Stream	KCI	26.8	10	3	8	6	27	Yes
SR-52	Stream	McCormick Taylor	11.4	10	3	8	6	27	Yes
SR-53	Stream	McCormick Taylor	18.9	10	3	8	6	27	Yes
SR-54	Stream	McCormick Taylor	23.5	10	3	8	6	27	Yes
SR-55	Stream	McCormick Taylor	13.9	10	3	8	6	27	Yes
SR-59	Stream	McCormick Taylor	28.8	10	3	8	6	27	Yes
DOR-BC-F943	BMP Conversion	McCormick Taylor	5.0	6	6	8	6	26	Yes
DOR-SR-F904C	Tree Planting	McCormick Taylor	0.1	2	6	10	8	26	Yes
DOR-TP-F901B	Tree Planting	McCormick Taylor	3.5	6	6	10	4	26	Yes
DOR-TP-F905G	Tree Planting	McCormick Taylor	1.9	4	6	10	6	26	Yes

Rankings and Scores for Little Patuxent Watershed Project Recommendations

Site ID	Type	Contractor	Acres of Impervious Treated	Acres of Impervious Treated Score	Pollutant Load Reduction Score	Cost Per Acre Score	Biological uplift - Programmatic Benefit - Feasibility Proportional Score	Total Score Combined Metrics	Concept 2015
NLP-BC-D521	BMP Conversion	Versar	1.2	4	6	8	8	26	
NLP-BC-D540	BMP Conversion	Versar	2.2	4	6	8	8	26	
NLP-OF-F508	Outfall	KCI	0.9	2	6	10	8	26	Yes
NLP-OF-F516	Outfall	KCI	1.2	4	6	10	6	26	Yes
NLP-OF-F536	Outfall	KCI	1.1	4	6	10	6	26	Yes
NLP-OF-F654	Outfall	KCI	2.0	4	6	10	6	26	Yes
NLP-OF-F661	Outfall	KCI	2.0	4	6	10	6	26	Yes
NLP-TP-D519	Tree Planting	KCI	1.6	4	6	10	6	26	Yes
NLP-TP-F514	Tree Planting	KCI	2.1	4	6	10	6	26	Yes
NLP-TP-F653	Tree Planting	KCI	1.7	4	6	10	6	26	Yes
NLP-TP-F654	Tree Planting	KCI	1.2	4	6	10	6	26	Yes
SLP-BC-D794	BMP Conversion	Versar	7.9	8	6	8	4	26	
SLP-BC-F728	BMP Conversion	Versar	8.0	8	6	8	4	26	Yes
SLP-BC-F734	BMP Conversion	Versar	3.8	6	6	8	6	26	Yes
SLP-BC-F758	BMP Conversion	Versar	1.6	4	6	8	8	26	Yes
SLP-NB-F711A	BMP New Footprint	Versar	3.2	6	6	8	6	26	Yes
SLP-NB-F712C	BMP New Footprint	Versar	2.6	4	6	8	8	26	Yes
SLP-NB-F715B	BMP New Footprint	Versar	3.2	6	6	8	6	26	Yes

Rankings and Scores for Little Patuxent Watershed Project Recommendations

Site ID	Type	Contractor	Acres of Impervious Treated	Acres of Impervious Treated Score	Pollutant Load Reduction Score	Cost Per Acre Score	Biological uplift - Programmatic Benefit - Feasibility Proportional Score	Total Score Combined Metrics	Concept 2015
SLP-NB-F722D	BMP New Footprint	Versar	2.2	4	6	8	8	26	Yes
SLP-NB-F731A	BMP New Footprint	Versar	3.2	6	6	8	6	26	Yes
SLP-NB-F740A	BMP New Footprint	Versar	4.8	6	6	8	6	26	Yes
SLP-OF-F706	Outfall	Versar	1.6	4	6	10	6	26	Yes
SLP-OF-F710	Outfall	Versar	1.7	4	6	10	6	26	Yes
SLP-OF-F711	Outfall	Versar	2.0	4	6	10	6	26	Yes
SLP-OF-F740	Outfall	Versar	1.3	4	6	10	6	26	Yes
SLP-OF-F753	Outfall	Versar	1.6	4	6	10	6	26	Yes
SLP-OF-F754	Outfall	Versar	0.9	2	6	10	8	26	Yes
SLP-OF-F773	Outfall	Versar	0.2	2	6	10	8	26	Yes
SLP-OF-F851	Outfall	Versar	0.3	2	6	10	8	26	Yes
SLP-OF-F855	Outfall	Versar	0.6	2	6	10	8	26	Yes
SLP-OF-F859	Outfall	Versar	1.6	4	6	10	6	26	Yes
SLP-TP-F701	Tree Planting	Versar	0.7	2	6	10	8	26	Yes
SLP-TP-F704	Tree Planting	Versar	0.5	2	6	10	8	26	Yes
SLP-TP-F851	Tree Planting	Versar	0.4	2	6	10	8	26	Yes
SLP-TP-F852	Tree Planting	Versar	0.3	2	6	10	8	26	Yes
SMP-BC-D323	BMP Conversion	Versar	2.3	4	6	8	8	26	
SMP-BC-D333	BMP Conversion	Versar	3.4	6	10	2	8	26	Yes
SMP-BC-D335	BMP Conversion	Versar	2.9	4	6	8	8	26	

Rankings and Scores for Little Patuxent Watershed Project Recommendations

Site ID	Type	Contractor	Acres of Impervious Treated	Acres of Impervious Treated Score	Pollutant Load Reduction Score	Cost Per Acre Score	Biological uplift - Programmatic Benefit - Feasibility Proportional Score	Total Score Combined Metrics	Concept 2015
SMP-BC-F314	BMP Conversion	Biohabitats	3.6	6	6	8	6	26	Yes
SMP-OF-F317	Outfall	Biohabitats	2.0	4	6	10	6	26	Yes
SMP-TP-F406	Tree Planting	Biohabitats	1.5	4	6	10	6	26	Yes
DOR-BC-D944	BMP Conversion	Versar	4.9	6	3	10	6	25	
DOR-BC-F915	BMP Conversion	McCormick Taylor	1.7	4	10	5	6	25	
DOR-BC-F917	BMP Conversion	McCormick Taylor	4.9	6	10	5	4	25	
NLP-BC-D513	BMP Conversion	Versar	3.3	6	3	10	6	25	
NLP-SR-F525A	Stream	KCI	20.3	10	3	8	4	25	
NLP-SR-F533A	Stream	KCI	25.7	10	3	8	4	25	
NLP-SR-F537A	Stream	KCI	5.9	8	3	8	6	25	
NLP-SR-F574A	Stream	KCI	10.0	8	3	8	6	25	
NLP-SR-F580C	Stream	KCI	14.9	10	3	8	4	25	
NLP-SR-F586A	Stream	KCI	42.9	10	3	8	4	25	
NLP-SR-F588A	Stream	KCI	12.1	10	3	8	4	25	
NLP-SR-F593	Stream	KCI	17.1	10	3	8	4	25	
NLP-SR-F596A	Stream	KCI	5.8	8	3	8	6	25	
NLP-SR-F596C	Stream	KCI	5.0	8	3	8	6	25	

Rankings and Scores for Little Patuxent Watershed Project Recommendations

Site ID	Type	Contractor	Acres of Impervious Treated	Acres of Impervious Treated Score	Pollutant Load Reduction Score	Cost Per Acre Score	Biological uplift - Programmatic Benefit - Feasibility Proportional Score	Total Score Combined Metrics	Concept 2015
NLP-SR-F601A	Stream	KCI	18.1	10	3	8	4	25	
SLP-BC-D778	BMP Conversion	Versar	6.3	8	3	10	4	25	
SLP-BC-D804	BMP Conversion	Versar	4.2	6	3	10	6	25	
SLP-BC-F711	BMP Conversion	Versar	0.8	2	10	5	8	25	
SLP-BC-F725	BMP Conversion	Versar	2.3	4	10	5	6	25	
SLP-BC-F754	BMP Conversion	Versar	0.6	2	10	5	8	25	
SLP-BC-F765	BMP Conversion	Versar	1.1	4	10	5	6	25	
SLP-SR-F741	Stream	Versar	12.5	10	3	8	4	25	
SLP-SR-F755D	Stream	Versar	3.5	6	3	8	8	25	
SLP-SR-F857	Stream	Versar	5.7	8	3	8	6	25	
SLP-SR-F858	Stream	Versar	8.7	8	3	8	6	25	
SLP-SR-F859	Stream	Versar	6.3	8	3	8	6	25	
SLP-SR-F860	Stream	Versar	5.4	8	3	8	6	25	
SMP-OF-F323	Stream	Biohabitats	8.9	8	3	8	6	25	
SMP-SR-F325A	Stream	Biohabitats	8.4	8	3	8	6	25	
SR-56	Stream	Versar	43.3	10	3	8	4	25	
SR-57	Stream	McCormick Taylor	14.4	10	3	8	4	25	
SR-58	Stream	McCormick Taylor	27.2	10	3	8	4	25	
DOR-BC-F931	BMP Conversion	McCormick Taylor	4.4	6	6	8	4	24	

Rankings and Scores for Little Patuxent Watershed Project Recommendations

Site ID	Type	Contractor	Acres of Impervious Treated	Acres of Impervious Treated Score	Pollutant Load Reduction Score	Cost Per Acre Score	Biological uplift - Programmatic Benefit - Feasibility Proportional Score	Total Score Combined Metrics	Concept 2015
DOR-OF-F902	Outfall	McCormick Taylor	2.0	4	6	10	4	24	
DOR-OF-F926	Outfall	McCormick Taylor	1.7	4	6	10	4	24	
DOR-OF-F927	Outfall	McCormick Taylor	1.8	4	6	10	4	24	
DOR-OF-F928	Outfall	McCormick Taylor	2.0	4	6	10	4	24	
DOR-OF-F930	Outfall	McCormick Taylor	1.1	4	6	10	4	24	
NLP-BC-D531	BMP Conversion	Versar	3.2	6	6	8	4	24	
NLP-OF-F517	Outfall	KCI	0.6	2	6	10	6	24	
NLP-OF-F521	Outfall	KCI	1.1	4	6	10	4	24	
NLP-TP-D521	Tree Planting	KCI	1.2	4	6	10	4	24	
NLP-TP-F505	Tree Planting	KCI	0.1	2	6	10	6	24	
SLP-BC-D781	BMP Conversion	Versar	2.7	4	6	8	6	24	
SLP-BC-D783	BMP Conversion	Versar	2.9	4	6	8	6	24	
SLP-BC-D796	BMP Conversion	Versar	3.6	6	6	8	4	24	
SLP-BC-D803	BMP Conversion	Versar	2.6	4	6	8	6	24	
SLP-BC-F703	BMP Conversion	Versar	2.1	4	6	8	6	24	
SLP-BC-F730	BMP Conversion	Versar	2.8	4	6	8	6	24	
SLP-BC-F735	BMP Conversion	Versar	2.4	4	6	8	6	24	

Rankings and Scores for Little Patuxent Watershed Project Recommendations

Site ID	Type	Contractor	Acres of Impervious Treated	Acres of Impervious Treated Score	Pollutant Load Reduction Score	Cost Per Acre Score	Biological uplift - Programmatic Benefit - Feasibility Proportional Score	Total Score Combined Metrics	Concept 2015
SLP-BC-F741	BMP Conversion	Versar	1.8	4	6	8	6	24	
SLP-BC-F749	BMP Conversion	Versar	1.6	4	6	8	6	24	
SLP-BC-F757	BMP Conversion	Versar	2.0	4	6	8	6	24	
SLP-BC-F759	BMP Conversion	Versar	1.7	4	6	8	6	24	
SLP-BC-F766	BMP Conversion	Versar	3.0	4	6	8	6	24	
SLP-NB-F703B	BMP New Footprint	Versar	2.6	4	6	8	6	24	
SLP-NB-F707A	BMP New Footprint	Versar	3.4	6	6	8	4	24	
SLP-NB-F713A	BMP New Footprint	Versar	2.8	4	6	8	6	24	
SLP-NB-F718A	BMP New Footprint	Versar	2.9	4	6	8	6	24	
SLP-NB-F728A	BMP New Footprint	Versar	3.9	6	6	8	4	24	
SLP-NB-F733A	BMP New Footprint	Versar	3.0	4	6	8	6	24	
SLP-NB-F761C	BMP New Footprint	Versar	2.7	4	6	8	6	24	
SLP-NB-F762B	BMP New Footprint	Versar	3.8	6	6	8	4	24	
SLP-NB-F762C	BMP New Footprint	Versar	2.0	4	6	8	6	24	
SLP-OF-F704	Outfall	Versar	1.0	2	6	10	6	24	
SLP-OF-F713	Outfall	Versar	1.2	4	6	10	4	24	
SLP-OF-F716	Outfall	Versar	0.6	2	6	10	6	24	

Rankings and Scores for Little Patuxent Watershed Project Recommendations

Site ID	Type	Contractor	Acres of Impervious Treated	Acres of Impervious Treated Score	Pollutant Load Reduction Score	Cost Per Acre Score	Biological uplift - Programmatic Benefit - Feasibility Proportional Score	Total Score Combined Metrics	Concept 2015
SLP-OF-F736	Outfall	Versar	0.5	2	6	10	6	24	
SLP-OF-F737	Outfall	Versar	0.4	2	6	10	6	24	
SLP-OF-F744	Outfall	Versar	1.2	4	6	10	4	24	
SLP-OF-F748	Outfall	Versar	0.7	2	6	10	6	24	
SLP-OF-F750	Outfall	Versar	1.2	4	0	10	10	24	
SLP-OF-F765	Outfall	Versar	1.6	4	6	10	4	24	
SLP-OF-F770	Outfall	Versar	1.3	4	6	10	4	24	
SLP-OF-F772	Outfall	Versar	0.7	2	6	10	6	24	
SLP-OF-F775	Outfall	Versar	0.7	2	6	10	6	24	
SLP-OF-F781	Outfall	Versar	2.0	4	6	10	4	24	
SLP-OF-F789	Outfall	Versar	0.6	2	6	10	6	24	
SLP-OF-F794	Outfall	Versar	2.0	4	6	10	4	24	
SLP-OF-F858	Outfall	Versar	1.5	4	6	10	4	24	
SLP-SR-F713B-IB101A	Tree Planting	Versar	0.5	2	6	10	6	24	
SLP-SR-F750B-IB101	Tree Planting	Versar	0.2	2	6	10	6	24	
SLP-TP-F702	Tree Planting	Versar	0.3	2	6	10	6	24	
SLP-TP-F854	Tree Planting	Versar	0.1	2	6	10	6	24	
SMP-NB-F323B	BMP New Footprint	Biohabitats	3.2	6	6	8	4	24	
SMP-NB-F323D	BMP New Footprint	Biohabitats	2.4	4	6	8	6	24	
SMP-OF-F321	Outfall	Biohabitats	0.8	2	6	10	6	24	
DOR-NB-F920B	BMP New Footprint	McCormick Taylor	2.0	4	10	5	4	23	

Rankings and Scores for Little Patuxent Watershed Project Recommendations

Site ID	Type	Contractor	Acres of Impervious Treated	Acres of Impervious Treated Score	Pollutant Load Reduction Score	Cost Per Acre Score	Biological uplift - Programmatic Benefit - Feasibility Proportional Score	Total Score Combined Metrics	Concept 2015
DOR-SR-F951	Stream	McCormick Taylor	6.4	8	3	8	4	23	
NLP-SR-F511B	Stream	KCI	8.0	8	3	8	4	23	
NLP-SR-F530B	Stream	KCI	5.9	8	3	8	4	23	
NLP-SR-F600B	Stream	KCI	13.2	10	3	8	2	23	
SLP-BC-D784	BMP Conversion	Versar	2.6	4	3	10	6	23	
SLP-BC-D797	BMP Conversion	Versar	2.8	4	3	10	6	23	
SLP-BC-D805	BMP Conversion	Versar	1.8	4	10	5	4	23	
SLP-BC-F722	BMP Conversion	Versar	0.5	2	10	5	6	23	
SLP-SR-F712B	Stream	Versar	3.2	6	3	8	6	23	
SLP-SR-F717A	Stream	Versar	6.0	8	3	8	4	23	
SLP-SR-F718A	Stream	Versar	3.2	6	3	8	6	23	
SLP-SR-F719B	Stream	Versar	6.3	8	3	8	4	23	
SLP-SR-F723C	Stream	Versar	4.9	6	3	8	6	23	
SLP-SR-F730	Stream	Versar	5.6	8	3	8	4	23	
SLP-SR-F732B	Stream	Versar	5.7	8	3	8	4	23	
SLP-SR-F747C	Stream	Versar	3.9	6	3	8	6	23	

Rankings and Scores for Little Patuxent Watershed Project Recommendations

Site ID	Type	Contractor	Acres of Impervious Treated	Acres of Impervious Treated Score	Pollutant Load Reduction Score	Cost Per Acre Score	Biological uplift - Programmatic Benefit - Feasibility Proportional Score	Total Score Combined Metrics	Concept 2015
SLP-SR-F750A	Stream	Versar	5.7	8	3	8	4	23	
SLP-SR-F751E	Stream	Versar	4.6	6	3	8	6	23	
SLP-SR-F751G	Stream	Versar	1.1	4	3	8	8	23	
SLP-SR-F752E	Stream	Versar	5.1	8	3	8	4	23	
SLP-SR-F854	Stream	Versar	6.0	8	3	8	4	23	
SMP-BC-F301	BMP Conversion	Biohabitats	0.4	2	10	5	6	23	
SMP-NB-F309	Stream	Biohabitats	7.5	8	3	8	4	23	
DOR-BC-F927	BMP Conversion	McCormick Taylor	3.0	6	10	2	4	22	
DOR-NB-F907B	BMP New Footprint	McCormick Taylor	4.1	6	10	2	4	22	
DOR-NB-F910B	BMP New Footprint	McCormick Taylor	2.3	4	6	8	4	22	
DOR-NB-F914A	BMP New Footprint	McCormick Taylor	2.5	4	6	8	4	22	
DOR-NB-F916	BMP New Footprint	McCormick Taylor	3.4	6	10	2	4	22	
DOR-OF-F924	Outfall	McCormick Taylor	1.0	4	6	10	2	22	
NLP-BC-F508	BMP Conversion	KCI	0.9	2	6	8	6	22	
NLP-OF-F664	Outfall	KCI	0.8	2	6	10	4	22	
SLP-BC-D785	BMP Conversion	Versar	2.9	4	6	8	4	22	
SLP-BC-F723	BMP Conversion	Versar	0.7	2	6	8	6	22	

Rankings and Scores for Little Patuxent Watershed Project Recommendations

Site ID	Type	Contractor	Acres of Impervious Treated	Acres of Impervious Treated Score	Pollutant Load Reduction Score	Cost Per Acre Score	Biological uplift - Programmatic Benefit - Feasibility Proportional Score	Total Score Combined Metrics	Concept 2015
SLP-BC-F724	BMP Conversion	Versar	0.4	2	6	8	6	22	
SLP-BC-F726	BMP Conversion	Versar	1.2	4	6	8	4	22	
SLP-BC-F733	BMP Conversion	Versar	0.4	2	6	8	6	22	
SLP-BC-F742	BMP Conversion	Versar	1.4	4	10	2	6	22	
SLP-BC-F743	BMP Conversion	Versar	0.6	2	6	8	6	22	
SLP-BC-F745	BMP Conversion	Versar	1.0	2	6	8	6	22	
SLP-BC-F750	BMP Conversion	Versar	1.1	4	6	8	4	22	
SLP-NB-F710A	BMP New Footprint	Versar	2.2	4	6	8	4	22	
SLP-NB-F753A	BMP New Footprint	Versar	2.3	4	6	8	4	22	
SLP-OF-F749	Outfall	Versar	0.3	2	0	10	10	22	
SLP-OF-F759	Outfall	Versar	0.8	2	6	10	4	22	
SLP-OF-F761	Outfall	Versar	1.0	2	6	10	4	22	
SLP-OF-F779	Outfall	Versar	0.8	2	6	10	4	22	
SLP-OF-F853	Outfall	Versar	0.5	2	6	10	4	22	
SLP-OF-F856	Outfall	Versar	0.4	2	0	10	10	22	
SLP-OF-F857	Outfall	Versar	0.5	2	6	10	4	22	
SLP-OF-F864	Outfall	Versar	1.4	4	0	10	8	22	
SLP-TP-F853	Tree Planting	Versar	0.4	2	6	10	4	22	
SMP-BC-F315	BMP Conversion	Biohabitats	0.3	2	6	8	6	22	

Rankings and Scores for Little Patuxent Watershed Project Recommendations

Site ID	Type	Contractor	Acres of Impervious Treated	Acres of Impervious Treated Score	Pollutant Load Reduction Score	Cost Per Acre Score	Biological uplift - Programmatic Benefit - Feasibility Proportional Score	Total Score Combined Metrics	Concept 2015
DOR-BC-F903	BMP Conversion	McCormick Taylor	1.5	4	3	10	4	21	
DOR-BC-F904	BMP Conversion	McCormick Taylor	0.7	2	3	10	6	21	
DOR-BC-F926	BMP Conversion	McCormick Taylor	0.1	2	10	5	4	21	
DOR-BC-F936	BMP Conversion	McCormick Taylor	14.9	10	3	2	6	21	
DOR-SR-F953	Stream	McCormick Taylor	4.3	6	3	8	4	21	
NLP-BC-F506	BMP Conversion	KCI	0.2	2	10	5	4	21	
NLP-SR-F521B	Stream	KCI	2.8	4	3	8	6	21	
NLP-SR-F532A	Stream	KCI	3.6	6	3	8	4	21	
NLP-SR-F562A	Stream	KCI	3.9	6	3	8	4	21	
SLP-BC-D788	BMP Conversion	Versar	1.5	4	3	10	4	21	
SLP-BC-F739	BMP Conversion	Versar	0.7	2	10	5	4	21	
SLP-BC-F740	BMP Conversion	Versar	0.5	2	10	5	4	21	
SLP-BC-F767	BMP Conversion	Versar	7.6	8	3	2	8	21	
SLP-SR-F711A	Stream	Versar	1.9	4	3	8	6	21	
SLP-SR-F720	Stream	Versar	3.2	6	3	8	4	21	
SLP-SR-F739A	Stream	Versar	0.6	2	3	8	8	21	

Rankings and Scores for Little Patuxent Watershed Project Recommendations

Site ID	Type	Contractor	Acres of Impervious Treated	Acres of Impervious Treated Score	Pollutant Load Reduction Score	Cost Per Acre Score	Biological uplift - Programmatic Benefit - Feasibility Proportional Score	Total Score Combined Metrics	Concept 2015
SLP-SR-F851A	Stream	Versar	2.7	4	3	8	6	21	
SLP-SR-F855	Stream	Versar	2.3	4	3	8	6	21	
SLP-SR-F856	Stream	Versar	3.4	6	3	8	4	21	
SLP-SR-F861	Stream	Versar	2.2	4	3	8	6	21	
DOR-BC-F909	BMP Conversion	McCormick Taylor	0.5	2	6	8	4	20	
DOR-BC-F934	BMP Conversion	McCormick Taylor	0.3	2	6	8	4	20	
DOR-BC-F935	BMP Conversion	McCormick Taylor	0.3	2	6	8	4	20	
DOR-BC-F939	BMP Conversion	McCormick Taylor	2.9	4	10	2	4	20	
DOR-BC-F940	BMP Conversion	McCormick Taylor	3.0	4	10	2	4	20	
DOR-BC-F941	BMP Conversion	McCormick Taylor	1.6	4	10	2	4	20	
DOR-NB-F905B	BMP New Footprint	McCormick Taylor	2.1	4	10	2	4	20	
DOR-NB-F907A	BMP New Footprint	McCormick Taylor	2.1	4	10	2	4	20	
DOR-OF-F915	Outfall	McCormick Taylor	0.1	2	0	10	8	20	
NLP-BC-D538	BMP Conversion	Versar	3.0	6	3	5	6	20	
NLP-OF-F501	Outfall	KCI	2.0	4	0	10	6	20	
NLP-OF-F507	Outfall	KCI	1.2	4	0	10	6	20	
NLP-OF-F523	Outfall	KCI	2.0	4	0	10	6	20	
NLP-OF-F525	Outfall	KCI	2.0	4	0	10	6	20	
NLP-OF-F527	Outfall	KCI	2.0	4	0	10	6	20	

Rankings and Scores for Little Patuxent Watershed Project Recommendations

Site ID	Type	Contractor	Acres of Impervious Treated	Acres of Impervious Treated Score	Pollutant Load Reduction Score	Cost Per Acre Score	Biological uplift - Programmatic Benefit - Feasibility Proportional Score	Total Score Combined Metrics	Concept 2015
NLP-OF-F528	Outfall	KCI	0.6	2	0	10	8	20	
NLP-OF-F653	Outfall	KCI	1.9	4	0	10	6	20	
NLP-OF-F665	Outfall	KCI	1.6	4	0	10	6	20	
NLP-OF-F667	Outfall	KCI	1.5	4	0	10	6	20	
NLP-OF-F670	Outfall	KCI	1.1	4	0	10	6	20	
SLP-BC-F709	BMP Conversion	Versar	0.9	2	6	8	4	20	
SLP-BC-F714	BMP Conversion	Versar	0.4	2	10	2	6	20	
SLP-BC-F719	BMP Conversion	Versar	0.8	2	6	8	4	20	
SLP-BC-F746	BMP Conversion	Versar	0.7	2	6	8	4	20	
SLP-BC-F760	BMP Conversion	Versar	0.2	2	6	8	4	20	
SLP-BC-F761	BMP Conversion	Versar	0.7	2	6	8	4	20	
SLP-OF-F701	Outfall	Versar	0.3	2	0	10	8	20	
SLP-OF-F734	Outfall	Versar	0.2	2	0	10	8	20	
SLP-OF-F768	Outfall	Versar	0.8	2	0	10	8	20	
SLP-OF-F862	Outfall	Versar	1.5	4	0	10	6	20	
SMP-BC-F316	BMP Conversion	Biohabitats	0.6	2	6	8	4	20	
SMP-OF-F314	Outfall	Biohabitats	0.8	2	0	10	8	20	
DOR-BC-D946	BMP Conversion	Versar	8.8	8	3	2	6	19	
DOR-BC-F918	BMP Conversion	McCormick Taylor	6.7	8	3	2	6	19	
DOR-BC-F922	BMP Conversion	McCormick Taylor	13.0	10	3	2	4	19	

Rankings and Scores for Little Patuxent Watershed Project Recommendations

Site ID	Type	Contractor	Acres of Impervious Treated	Acres of Impervious Treated Score	Pollutant Load Reduction Score	Cost Per Acre Score	Biological uplift - Programmatic Benefit - Feasibility Proportional Score	Total Score Combined Metrics	Concept 2015
DOR-BC-F930	BMP Conversion	McCormick Taylor	11.0	10	3	2	4	19	
DOR-NB-F920C	BMP New Footprint	McCormick Taylor	12.0	10	3	2	4	19	
NLP-BC-D539	BMP Conversion	KCI	9.8	8	3	2	6	19	
NLP-SR-F507B	Stream	KCI	2.6	4	3	8	4	19	
SLP-BC-F712	BMP Conversion	Versar	4.9	6	3	2	8	19	
SLP-BC-F744	BMP Conversion	Versar	0.4	2	3	10	4	19	
SLP-BC-F747	BMP Conversion	Versar	0.4	2	3	10	4	19	
SLP-BC-F755	BMP Conversion	Versar	4.9	6	3	2	8	19	
SLP-BC-F852	BMP Conversion	Versar	8.3	8	3	2	6	19	
SLP-SR-F746A	Stream	Versar	0.8	2	3	8	6	19	
SLP-SR-F758	Stream	Versar	0.9	2	3	8	6	19	
SMP-BC-F309	BMP Conversion	Biohabitats	1.0	2	3	10	4	19	
SMP-SR-F326	Stream	Biohabitats	2.3	4	3	8	4	19	
DOR-BC-F908	BMP Conversion	McCormick Taylor	0.1	2	6	8	2	18	
DOR-BC-F912	BMP Conversion	McCormick Taylor	0.3	2	10	2	4	18	
DOR-BC-F925	BMP Conversion	McCormick Taylor	1.6	4	6	2	6	18	
DOR-NB-F920A	BMP New Footprint	McCormick Taylor	3.6	6	3	5	4	18	

Rankings and Scores for Little Patuxent Watershed Project Recommendations

Site ID	Type	Contractor	Acres of Impervious Treated	Acres of Impervious Treated Score	Pollutant Load Reduction Score	Cost Per Acre Score	Biological uplift - Programmatic Benefit - Feasibility Proportional Score	Total Score Combined Metrics	Concept 2015
DOR-NB-F921A	BMP New Footprint	McCormick Taylor	3.4	6	6	2	4	18	
DOR-OF-F916	Outfall	McCormick Taylor	0.1	2	0	10	6	18	
NLP-OF-F506	Outfall	KCI	2.0	4	0	10	4	18	
NLP-OF-F514	Outfall	KCI	2.0	4	0	10	4	18	
NLP-OF-F537	Outfall	KCI	0.8	2	0	10	6	18	
NLP-OF-F655	Outfall	KCI	0.5	2	0	10	6	18	
NLP-OF-F658	Outfall	KCI	0.3	2	0	10	6	18	
SLP-BC-F715	BMP Conversion	Versar	0.4	2	3	5	8	18	
SLP-BC-F721	BMP Conversion	Versar	0.6	2	10	2	4	18	
SLP-BC-F771	BMP Conversion	Versar	1.2	4	3	5	6	18	
SLP-OF-F783	Outfall	Versar	1.1	4	0	10	4	18	
SLP-OF-F854	Outfall	Versar	0.5	2	0	10	6	18	
SLP-OF-F863	Outfall	Versar	1.1	4	0	10	4	18	
DOR-BC-F921	BMP Conversion	McCormick Taylor	3.7	6	3	2	6	17	
DOR-BC-F924	BMP Conversion	McCormick Taylor	5.9	8	3	2	4	17	
DOR-BC-F928	BMP Conversion	McCormick Taylor	6.1	8	3	2	4	17	
DOR-BC-F932	BMP Conversion	McCormick Taylor	3.7	6	3	2	6	17	
DOR-BC-F937	BMP Conversion	McCormick Taylor	6.1	8	3	2	4	17	
NLP-BC-D527	BMP Conversion	KCI	4.7	6	3	2	6	17	

Rankings and Scores for Little Patuxent Watershed Project Recommendations

Site ID	Type	Contractor	Acres of Impervious Treated	Acres of Impervious Treated Score	Pollutant Load Reduction Score	Cost Per Acre Score	Biological uplift - Programmatic Benefit - Feasibility Proportional Score	Total Score Combined Metrics	Concept 2015
NLP-BC-F502	BMP Conversion	KCI	3.0	6	3	2	6	17	
NLP-BC-F651	BMP Conversion	KCI	4.0	6	3	2	6	17	
NLP-SR-F528A	Stream	KCI	2.1	4	3	8	2	17	
SLP-BC-D782	BMP Conversion	Versar	4.1	6	3	2	6	17	
SLP-BC-F764	BMP Conversion	Versar	5.0	6	3	2	6	17	
DOR-BC-D945	BMP Conversion	Versar	0.0	2	3	5	6	16	
DOR-BC-F906	BMP Conversion	McCormick Taylor	0.6	2	3	5	6	16	
DOR-BC-F913	BMP Conversion	McCormick Taylor	1.0	2	3	5	6	16	
DOR-NB-F929A	BMP New Footprint	McCormick Taylor	2.2	4	3	5	4	16	
DOR-OF-F907	Outfall	McCormick Taylor	0.2	2	0	10	4	16	
DOR-OF-F911	Outfall	McCormick Taylor	0.8	2	0	10	4	16	
NLP-BC-D517	BMP Conversion	KCI	1.1	4	3	5	4	16	
NLP-OF-F522	Outfall	KCI	0.4	2	0	10	4	16	
NLP-OF-F656	Outfall	KCI	1.0	4	0	10	2	16	
NLP-OF-F660	Outfall	KCI	0.2	2	0	10	4	16	
SLP-NB-F764A	BMP New Footprint	Versar	2.5	4	3	5	4	16	
SLP-NB-F765A	BMP New Footprint	Versar	2.2	4	3	5	4	16	

Rankings and Scores for Little Patuxent Watershed Project Recommendations

Site ID	Type	Contractor	Acres of Impervious Treated	Acres of Impervious Treated Score	Pollutant Load Reduction Score	Cost Per Acre Score	Biological uplift - Programmatic Benefit - Feasibility Proportional Score	Total Score Combined Metrics	Concept 2015
SLP-OF-F752	Outfall	Versar	0.2	2	0	10	4	16	
DOR-BC-F905	BMP Conversion	McCormick Taylor	1.8	4	3	2	6	15	
DOR-BC-F911	BMP Conversion	McCormick Taylor	1.8	4	3	2	6	15	
DOR-BC-F914	BMP Conversion	McCormick Taylor	1.0	4	3	2	6	15	
DOR-BC-F916	BMP Conversion	McCormick Taylor	4.7	6	3	2	4	15	
DOR-BC-F919	BMP Conversion	McCormick Taylor	4.1	6	3	2	4	15	
DOR-BC-F929	BMP Conversion	McCormick Taylor	3.4	6	3	2	4	15	
DOR-BC-F938	BMP Conversion	McCormick Taylor	3.4	6	3	2	4	15	
DOR-NB-F911B	BMP New Footprint	McCormick Taylor	2.3	4	3	2	6	15	
NLP-BC-D515	BMP Conversion	KCI	1.5	4	3	2	6	15	
NLP-BC-D516	BMP Conversion	KCI	1.3	4	3	2	6	15	
NLP-BC-D525	BMP Conversion	KCI	3.2	6	3	2	4	15	
NLP-BC-D532	BMP Conversion	KCI	2.4	4	3	2	6	15	
NLP-BC-F503	BMP Conversion	KCI	1.8	4	3	2	6	15	
NLP-BC-F507	BMP Conversion	KCI	2.0	4	3	2	6	15	
NLP-BC-F509	BMP Conversion	KCI	2.8	4	3	2	6	15	

Rankings and Scores for Little Patuxent Watershed Project Recommendations

Site ID	Type	Contractor	Acres of Impervious Treated	Acres of Impervious Treated Score	Pollutant Load Reduction Score	Cost Per Acre Score	Biological uplift - Programmatic Benefit - Feasibility Proportional Score	Total Score Combined Metrics	Concept 2015
NLP-BC-F511	BMP Conversion	KCI	0.8	2	3	2	8	15	
SLP-BC-F705	BMP Conversion	Versar	1.5	4	3	2	6	15	
SLP-BC-F731	BMP Conversion	Versar	0.5	2	3	2	8	15	
SLP-BC-F748	BMP Conversion	Versar	3.4	6	3	2	4	15	
SLP-BC-F770	BMP Conversion	Versar	4.9	6	3	2	4	15	
SMP-BC-D322	BMP Conversion	Versar	1.7	4	3	2	6	15	
SLP-BC-F708	BMP Conversion	Versar	0.1	2	3	5	4	14	
SLP-BC-F751	BMP Conversion	Versar	0.3	2	3	5	4	14	
SLP-BC-F773	BMP Conversion	Versar	0.4	2	3	5	4	14	
DOR-BC-F907	BMP Conversion	McCormick Taylor	2.9	4	3	2	4	13	
DOR-NB-F938A	BMP New Footprint	McCormick Taylor	4.3	6	3	2	2	13	
NLP-BC-D523	BMP Conversion	KCI	1.9	4	3	2	4	13	
NLP-BC-D526	BMP Conversion	KCI	2.0	4	3	2	4	13	
NLP-BC-D529	BMP Conversion	KCI	1.4	4	3	2	4	13	
NLP-BC-D533	BMP Conversion	KCI	1.3	4	3	2	4	13	
NLP-BC-F501	BMP Conversion	KCI	1.1	4	3	2	4	13	

Rankings and Scores for Little Patuxent Watershed Project Recommendations

Site ID	Type	Contractor	Acres of Impervious Treated	Acres of Impervious Treated Score	Pollutant Load Reduction Score	Cost Per Acre Score	Biological uplift - Programmatic Benefit - Feasibility Proportional Score	Total Score Combined Metrics	Concept 2015
SLP-BC-F716	BMP Conversion	Versar	0.8	2	3	2	6	13	
SLP-BC-F718	BMP Conversion	Versar	1.3	4	3	2	4	13	
SLP-BC-F737	BMP Conversion	Versar	1.2	4	3	2	4	13	
SLP-BC-F753	BMP Conversion	Versar	0.8	2	3	2	6	13	
SLP-BC-F762	BMP Conversion	Versar	1.2	4	3	2	4	13	
SLP-BC-F768	BMP Conversion	Versar	1.4	4	3	2	4	13	
SLP-BC-F851	BMP Conversion	Versar	2.2	4	3	2	4	13	
DOR-BC-F901	BMP Conversion	McCormick Taylor	2.6	4	3	2	2	11	
NLP-BC-F510	BMP Conversion	KCI	0.8	2	3	2	4	11	
SLP-BC-D776	BMP Conversion	Versar	0.3	2	3	2	4	11	
SLP-BC-F752	BMP Conversion	Versar	0.4	2	3	2	4	11	

H. Individual Concept Plans for Top-Ranked Opportunities

List of Concept Plans in Little Patuxent River Watershed

Site ID	Site Name	Project Type
DOR-BC-F942	Iron Mountain	BMP Conversion
DOR-BC-F943	Gatewood Drive	BMP Conversion
DOR-NB-F912a	Capitol Express	New BMP
DOR-SR-F904c	Dorsey Run Road	Tree Planting
DOR-TP-F901b	Pepsi Delivery	Tree Planting
DOR-TP-F905g	Lee Deforest Drive	Tree Planting
NLP-OF-F508	Lilac Lane	Outfall Stabilization
NLP-OF-F516	Rumsey Road	Outfall Stabilization
NLP-OF-F536	Soccer Association of Columbia	Outfall Stabilization
NLP-OF-F654	Waverly Woods	Outfall Stabilization
NLP-OF-F661	Little Brick House Court	Outfall Stabilization
NLP-OF-F662	Waterloo Road	Outfall Stabilization
NLP-SR-F504a	Turf Valley (a)	Stream Restoration
NLP-SR-F509a	Turf Valley (b)	Stream Restoration
NLP-SR-F520b	Turf Valley (c)	Stream Restoration
NLP-SR-F551a	Enchanted Forest 3	Stream Restoration
NLP-SR-F552a	Boones Lane (a)	Stream Restoration
NLP-SR-F555a	Enchanted Forest (a)	Stream Restoration
NLP-SR-F555b	Enchanted Forest (b)	Stream Restoration
NLP-SR-F557a	Boones Lane (b)	Stream Restoration
NLP-SR-F571a	Red Hill Branch at Santa Fe Court	Stream Restoration
NLP-SR-F583a	Tributaries to Plumtree Branch, North	Stream Restoration
NLP-SR-F587d	Lutheran Village North	Stream Restoration
NLP-SR-F590a	Turf Valley (d)	Stream Restoration
NLP-SR-F599a	Plumtree Branch	Stream Restoration
NLP-TP-D519	Forest Hill	Tree Planting
NLP-TP-F511	Breconshire	Tree Planting
NLP-TP-F514	Thomas B. Dorsey Building	Tree Planting
NLP-TP-F653	Turf Valley (e)	Tree Planting
NLP-TP-F654	Bethany Lane	Tree Planting
NLP-TP-F655	David W Force Park	Tree Planting
SLP-BC-D774	End of Durham Road East	BMP Conversion - Previous Study
SLP-BC-D780	Tree Swallow Court	BMP Conversion - Previous Study
SLP-BC-D792	Dobbin Road Commercial Business Center	BMP Conversion - Previous Study
SLP-BC-D798	Golden Coin Court	BMP Conversion - Previous Study
SLP-BC-D802	Old Annapolis Road	BMP Conversion - Previous Study
SLP-BC-F701	Wesleigh and Seneca Drive	BMP Conversion
SLP-BC-F728	Columbia Medical Campus	BMP Conversion
SLP-BC-F734	9265 Berger Road Business Complex	BMP Conversion
SLP-BC-F758	Elliott & Franz Inc. Heavy Equipment Rentals	BMP Conversion
SLP-BC-F772	Thrift Store Dry Pond	BMP Conversion
SLP-NB-F711a	Maine: Paper and Food Service, Inc. - Truck Parking Lot	New BMP
SLP-NB-F711b	Maine: Paper and Food Service, Inc. - Employee Parking Lot	New BMP
SLP-NB-F712a	Coastal Sunbelt Produce - Employee Parking Lot	New BMP
SLP-NB-F712c	Coastal Sunbelt Produce - Truck Parking Lot	New BMP

Site ID	Site Name	Project Type
SLP-NB-F715b	JFC International, Inc.	New BMP
SLP-NB-F722d	Weis Market	New BMP
SLP-NB-F731a	Rivers Technology Park	New BMP
SLP-NB-F739b	Lincoln Technology Institute	New BMP
SLP-NB-F740a	Nielsen Company Parking Lot	New BMP
SLP-OF-F706	8928 McGaw Court	Outfall Stabilization
SLP-OF-F710	South of Phelps Luck and Tamar Drives Intersection	Outfall Stabilization
SLP-OF-F711	Cradlerock Way and Homespun Drive	Outfall Stabilization
SLP-OF-F740	Cheshire Court	Outfall Stabilization
SLP-OF-F753	9053 Guilford Road	Outfall Stabilization
SLP-OF-F754	9790 Patuxent Woods Drive	Outfall Stabilization
SLP-OF-F773	Lightning View Road	Outfall Stabilization
SLP-OF-F792	7363-7351 Hickory Log Circle	Outfall Stabilization
SLP-OF-F851	5377 Racegate Run	Outfall Stabilization
SLP-OF-F852	Wolf River Lane and Lightning View Road	Outfall Stabilization
SLP-OF-F855	6029 Majors Lane	Outfall Stabilization
SLP-OF-F859	Lake Circle West	Outfall Stabilization
SLP-SR-F735	Wilde Lake Headwaters Stream Restoration	Stream Restoration
SLP-SR-F737A	Oakland Mills	Stream Restoration
SLP-SR-F740a	Lightning View Road	Stream Restoration
SLP-SR-F753I	North Laurel Industrial Park	Stream Restoration
SLP-SR-F754	Lake Elkhorn Receiving Channel	Stream Restoration
SLP-SR-F852	Oakland Ridge Industrial Park	Stream Restoration
SLP-SR-F853	Hopewell Park	Stream Restoration
SLP-TP-F701	Forest Ridge Elementary School	Tree Planting
SLP-TP-F703	Howard Community College	Tree Planting
SLP-TP-F704	Sand Chain Road	Tree Planting
SLP-TP-F851	Marsh Hawk Way	Tree Planting
SLP-TP-F852	Crossroads Business Park	Tree Planting
SMP-BC-D332	Jaclyn Court	BMP Conversion - Previous Study
SMP-BC-D333	Crest Drive at Route 216	BMP Conversion - Previous Study
SMP-BC-F314	9525 Chaton Road	BMP Conversion
SMP-NB-F325	BGE Substation	Stream Restoration
SMP-OF-F317	End of Queens Guard Court	Outfall Stabilization
SMP-OF-F324	End of Elsie's Way	Outfall Stabilization
SMP-SR-F324	BGE ROW Washington Boulevard	Stream Restoration
SMP-TP-F307	Temple Isaiah	Tree Planting
SMP-TP-F309	Eternal Rings Road	Tree Planting
SMP-TP-F311	Northern Lakes	Tree Planting
SMP-TP-F405	Hammond Branch at Hammond Drive	Tree Planting
SMP-TP-F406	Hammond Branch at Maple Lawn	Tree Planting
SR-29	Emerson Community Association	Stream Restoration
SR-30	Sterling Drive	Stream Restoration
SR-31	BGE ROW Stephens Road	Stream Restoration
SR-32	Bowling Brook Farms	Stream Restoration
SR-33	Hammond Branch (a)	Stream Restoration
SR-34	Hammond Branch (b)	Stream Restoration
SR-35	Maple Lawn Farms	Stream Restoration
SR-36	Hammond Branch (c)	Stream Restoration

Site ID	Site Name	Project Type
SR-37	Hammond Branch (d) - Reservoir High School	Stream Restoration
SR-38	Hammond Branch (e) - The Home Farm LLC	Stream Restoration
SR-43	Ashleigh Knolls Homeowners Association	Stream Restoration
SR-45	Boones Lane Tributary and Little Patuxent River	Stream Restoration
SR-46	Boones Lane, Tributaries and Little Patuxent River	Stream Restoration
SR-47	Font Hill, Tributary to Little Patuxent River	Stream Restoration
SR-48	Font Hill, Tributary to Little Patuxent River, Upstream Centennial Lake	Stream Restoration
SR-49	Dunloggin Middle School	Stream Restoration
SR-50	Lutheran Village South, tributary to Plumtree Branch	Stream Restoration
SR-51	North Chatham Road	Stream Restoration
SR-52	Gray Sea Way	Stream Restoration
SR-53	Broken Wing Court	Stream Restoration
SR-54	Distant Rock Path	Stream Restoration
SR-55	Summer Cloud Way	Stream Restoration
SR-59	Jessup Correctional	Stream Restoration

Howard County Watershed Assessment Concept Plan: BMP Conversion

Site ID: DOR-BC-F942
Site Name: Iron Mountain

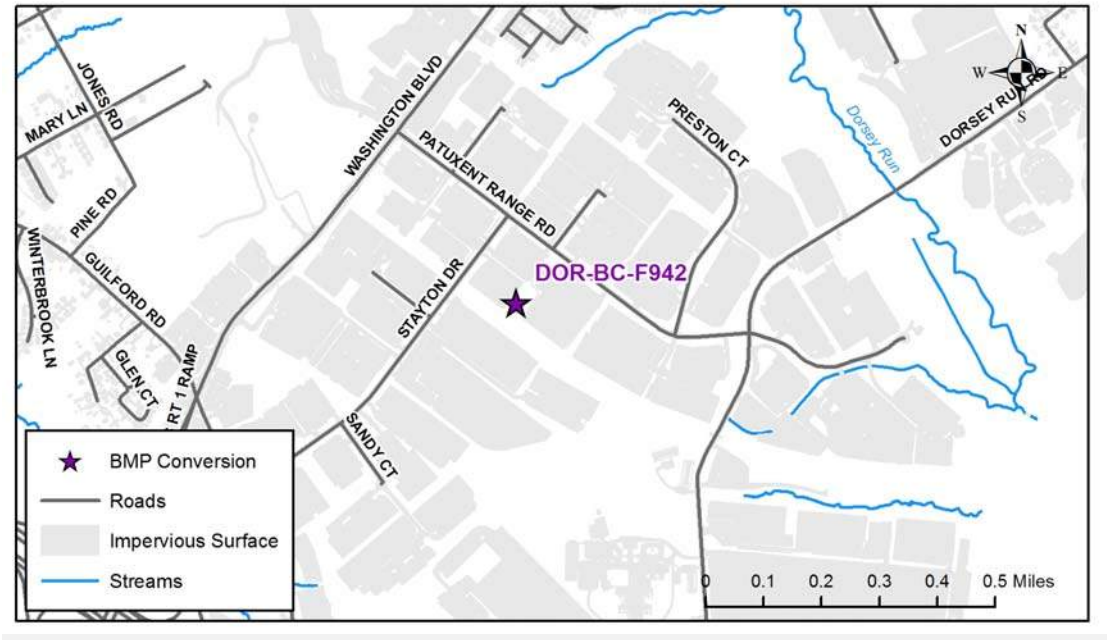
Contractor: McCormick Taylor
Watershed: Little Patuxent River

Proposed BMP Type: Shallow Marsh
Ownership: Private- Commercial/Industrial
Single Owner

BMP Structure ID: HO105455
Existing BMP Type: Dry Pond

Existing Conditions:

The site consists of a large warehouse and office building with loading docks and a parking lot. Currently, 8.99 ac. of runoff from the parking lot and rooftop discharges into an extended detention dry pond on the western side of the property. Based on a field visit and the as-built plan set, there is one 30 in. HDPE inflow at elevation 248.00, one 15 in. HDPE inflow, and one small riprap swale inflow. A 30 in. RCP inflow pipe was abandoned with new construction in 2000. There are riprap channels at the inflows and 15-20 trees in the pond and on the side slopes; the embankment is approximately 8 ft. high. The storm drain manhole on the north side of the pond which diverts the large inflow pipe is failing and a sinkhole is forming. The riser structure has an HDPE low flow pipe, a weir in the front, and an open top with an inlet grate. The structure has been patched and the principal spillway is a 21 in. CMP that flows to a manhole north of the CSX railroad. The ultimate outfall of the pond is on the southern side of the CSX railroad tracks. A second manhole just south of the embankment and north of the CSX railroad tracks which receives the barrel from the riser is also failing.



Howard County Watershed Assessment Concept Plan: BMP Conversion

Site ID: DOR-BC-F942
Site Name: Iron Mountain

Contractor: McCormick Taylor
Watershed: Little Patuxent River

Looking south toward the facility from the asphalt access path. Failing manhole at bottom right of photo.

Looking north toward the facility from the embankment.

Howard County Watershed Assessment Concept Plan: BMP Conversion

Site ID: DOR-BC-F942
Site Name: Iron Mountain

Contractor: McCormick Taylor
Watershed: Little Patuxent River

Constraints/Utilities:

Constraints for this project include the property ownership, available surface area, and proximity to CSX railroad. The pond is on private property and the outfall is on CSX property. There is no room to expand the current pond footprint. No utilities were observed in the pond vicinity during the initial site assessment.

Concept Description:

A shallow marsh is proposed within the existing footprint of the dry pond. The permanent pool elevation will be 248.00 with a 2 ft. deep forebay to provide the required 2,476 cf. of pretreatment. The small HDPE inflow near the riser will be stabilized with riprap. Excluding the forebay, the facility will provide approximately 13,900 cf. of wet storage in the permanent pool with 65% of the ponded surface area 18 in. or less, as per the Maryland Department of the Environment Design Manual (2000). A bottom elevation of 243.00 is proposed in a pool near the riser. With approximately 1.25 ft. of extended detention volume, the entire WQv (23,913 cf.) is treated. If a maintenance bench is required, the treatment potential of the facility will be significantly reduced. The failing manholes are to be replaced and sinkholes stabilized. The riser and barrel will be replaced and designed for maximum treatment while providing sufficient freeboard in the pond. A clay core will be required at the barrel and a clay liner is proposed along the length of the embankment under the facility to maintain the permanent pool. The current outfall on the south side of the CSX railroad is a CMP with a concrete pad. There is erosion around the concrete pad where it meets the side slope of the downstream channel. This outfall could be improved and stabilized as part of this conversion if the property owner gives consent. Access to the pond will be along the existing 12 ft. wide asphalt path from the parking lot on the north side of the building.

Nearby Opportunities:

None recommended

Proposed Project Credit	
Drainage Area (ac.):	8.99
Impervious Area within Drainage (ac.):	6.82
Impervious Area Treated (ac.):	6.82
Impervious Area Treated Credit (ac.):	6.9

Water Quality Volume	
WQVolume Target (cft.):	23,913
Max Treated (cft.):	25,101
Percent Treated:	105%
Rainfall Depth Treated (in.):	1.05

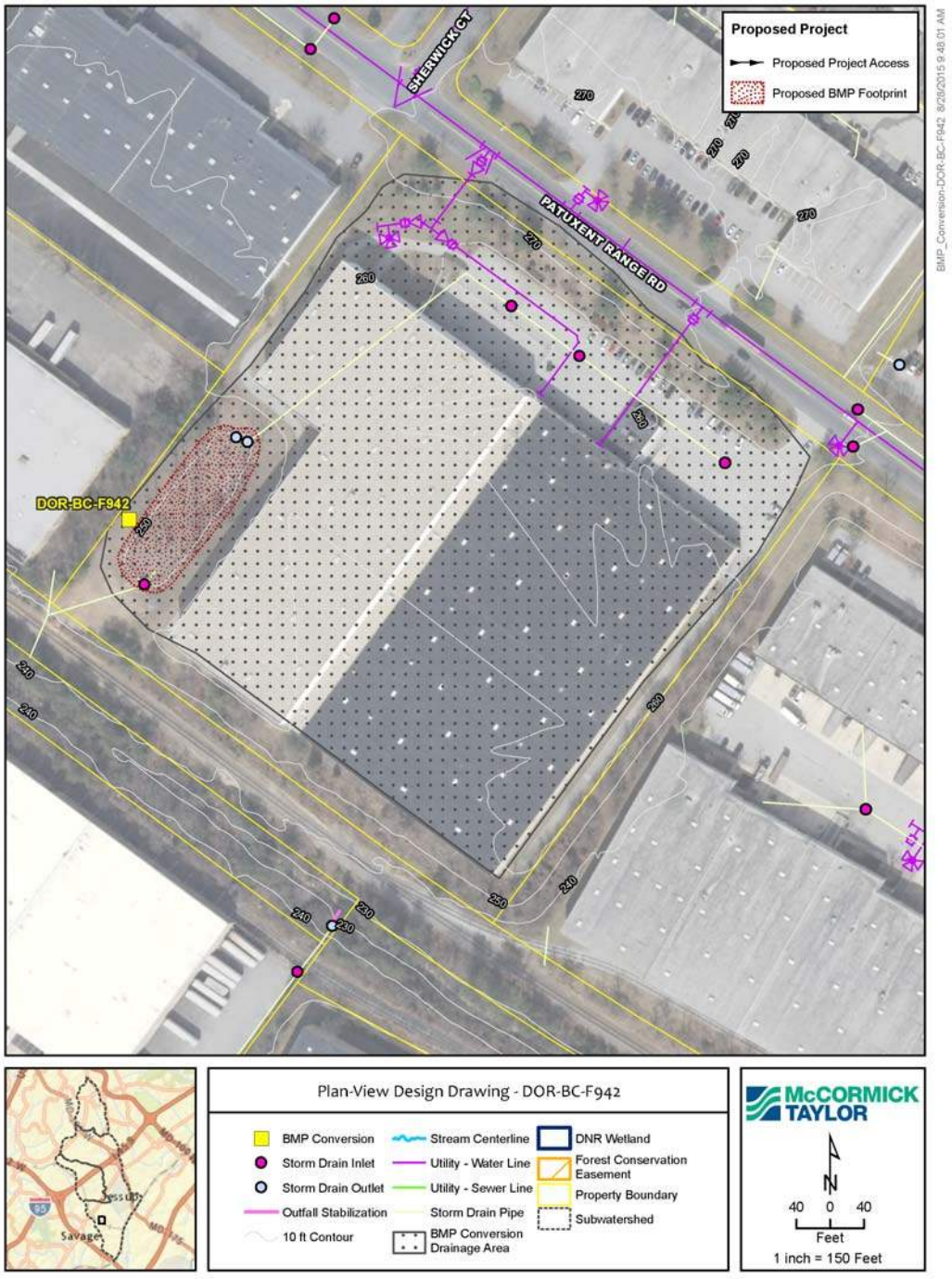
Costs

Estimated Design Cost:	$120,000.00
Estimated Construction Cost:	$177,294.00
30% Contingency:	$53,188.20
Estimated Total Cost	$350,482.20
Cost per Impervious Credit Acre:	$50,794.52

Howard County Watershed Assessment Concept Plan: BMP Conversion

Site ID: DOR-BC-F942
Site Name: Iron Mountain

Contractor: McCormick Taylor
Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: BMP Conversion

Site ID: DOR-BC-F943
Site Name: Gatewood Drive

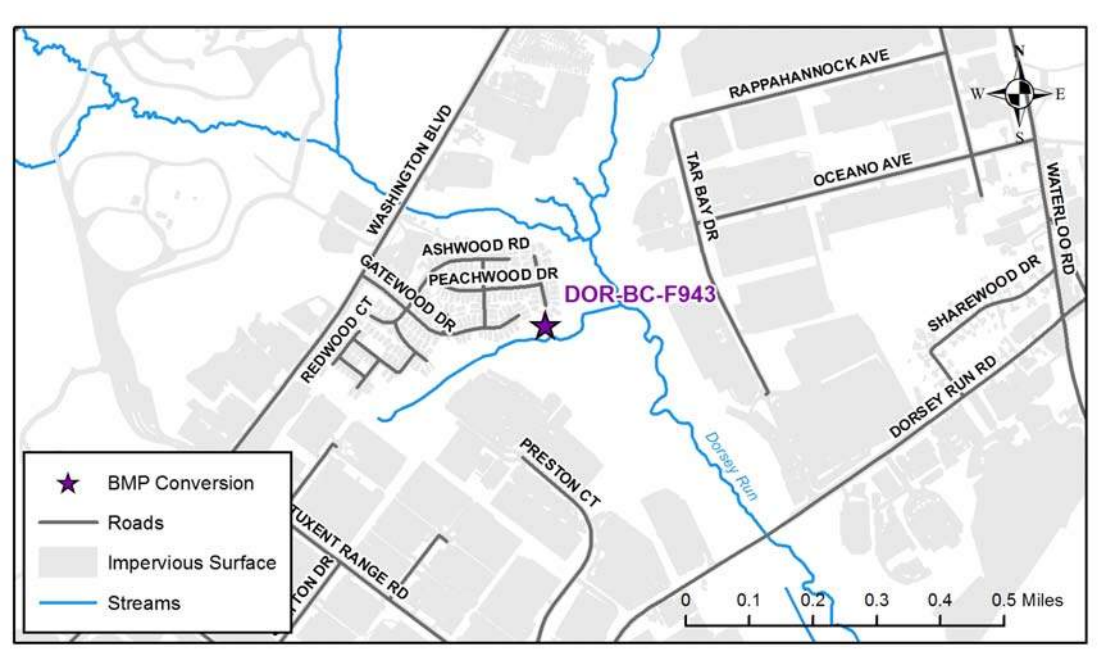
Contractor: McCormick Taylor
Watershed: Little Patuxent River

Proposed BMP Type: Sand Filter
Ownership: Private- Residential
Multiple Owners

BMP Structure ID: HO100795
Existing BMP Type: Extended Detention

Existing Conditions:

The existing extended detention dry pond receives runoff from a high density residential neighborhood. There are two CMP inflows from the neighborhood storm drain network that appear to have inverts above the current pond bottom. Minor ponding was observed during the field assessment and sewer and electric were observed along the top of the pond. The existing riser structure is a concrete structure with a brick bottom, a low flow orifice, and multiple weirs. It has been repaired or modified as there is evidence of concrete patching or grout at the weirs. The barrel is a 42 in. RCP and the embankment is approximately 6 ft. high. The immediate outfall of the pond is stable, but there is erosion at the downstream end of the outfall channel where it meets the stream. At this location, the stream banks are eroding and there is an abrupt drop in elevation of approximately one to two ft. from the outfall channel to the stream.



Howard County Watershed Assessment Concept Plan: BMP Conversion

Site ID: DOR-BC-F943
Site Name: Gatewood Drive

Contractor: McCormick Taylor
Watershed: Little Patuxent River

Looking east toward the facility and riser from near Gatewood Drive.

Looking west toward the riser structure and 24” CMP inflow from the pond embankment.

Howard County Watershed Assessment Concept Plan: BMP Conversion

Site ID: DOR-BC-F943
Site Name: Gatewood Drive

Contractor: McCormick Taylor
Watershed: Little Patuxent River

Constraints/Utilities:

Constraints for this project include the property ownership, available surface area, and utilities. The pond is on private property in close proximity to a number of homes and the existing footprint does not allow the entire WQv to be treated. The elevation between the pond bottom and outfall is minimal and a facility with an underdrain is not feasible unless the outfall is lowered and the outfall channel is graded to tie into the stream. Grading the outfall channel will require a large number of trees to be removed. Sewer and electric run along the northern edge of the pond and should not affect the facility, but their exact locations and elevations will need to be verified.

Concept Description:

The proposed facility is a sand filter with forebays at each of the inflows, a new riser structure and spillway through the embankment, and an approximately 6,400 sf. sand filter area. The forebays will be sized appropriately for the contributing area to each inflow, providing a total of 0.11 ac-ft. of storage. With 2 ft. of media, the sand filter area provides 0.12 ac-ft. of subsurface treatment and an additional 0.16 ac-ft. of storage to be treated in 1 ft. of temporary ponding. The sand filter has potential to treat approximately 0.28 ac-ft. or 66% of the required WQv. The riser structure will be replaced to lower the principal spillway and allow underdrain connections from the sand filter. Weirs will be sized for 1 ft. of ponding in addition to the larger rainfall events. The outfall channel will also require significant grading to lower the elevation of the channel and improve the confluence with the stream. A clay liner is proposed over the entire embankment. Access to the pond is from Gatewood Drive but will disrupt the parking lot use and the homeowners' yards.

Nearby Opportunities:

DOR-OF-F923, DOR-SR-F907

Proposed Project Credit	
Drainage Area (ac.):	11.09
Impervious Area within Drainage (ac.):	4.99
Impervious Area Treated (ac.):	4.99
Impervious Area Treated Credit (ac.):	3.28

Water Quality Volume	
WQVolume Target (cft.):	18,315
Max Treated (cft.):	12,053
Percent Treated:	66%
Rainfall Depth Treated (in.):	0.66

Costs

Estimated Design Cost:	$120,000.00
Estimated Construction Cost:	$188,409.52
30% Contingency:	$56,522.86
Estimated Total Cost	$364,932.38
Cost per Impervious Credit Acre:	$111,259.87

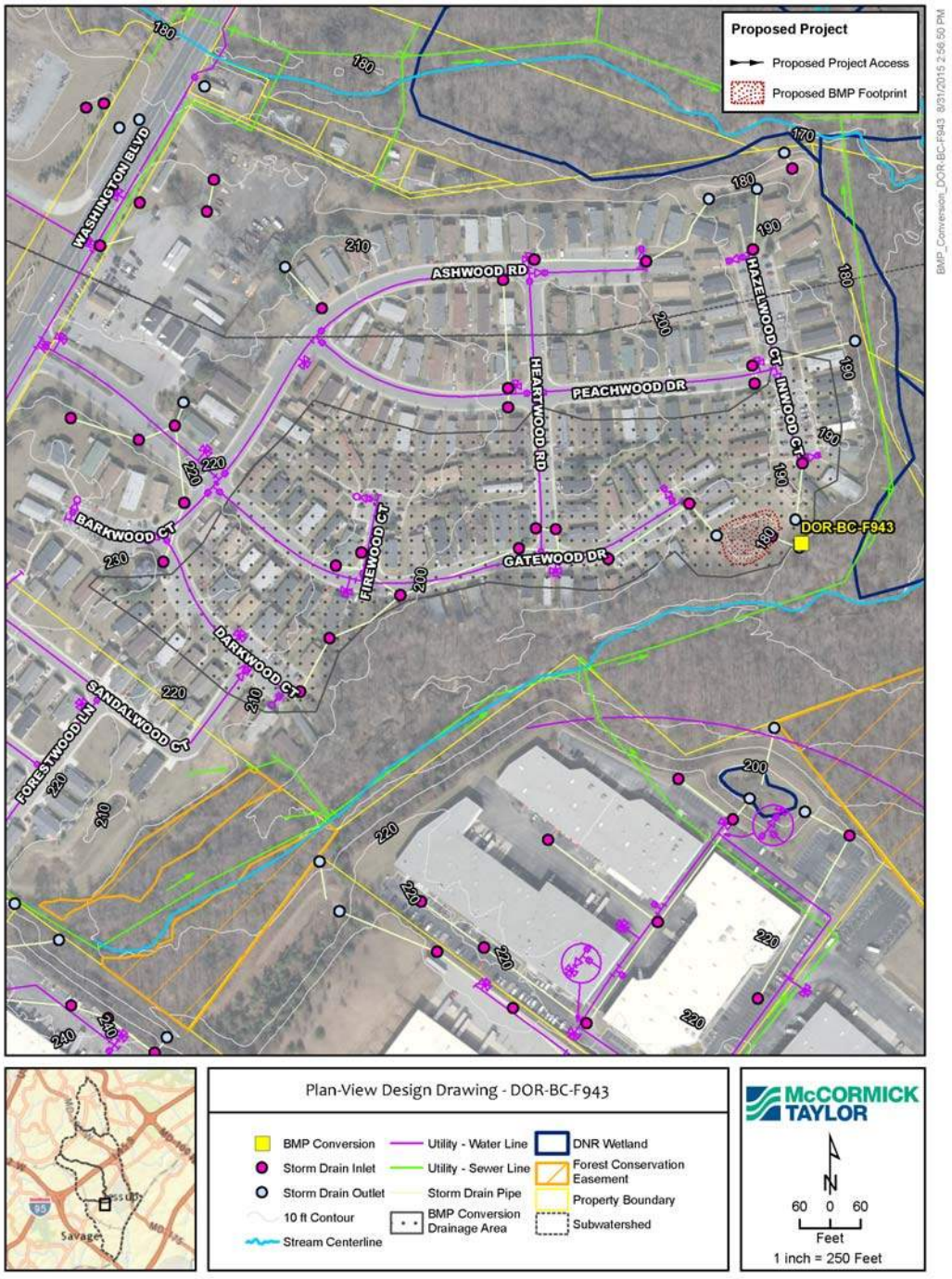
Howard County Watershed Assessment Concept Plan: BMP Conversion

Site ID: DOR-BC-F943

Site Name: Gatewood Drive

Contractor: McCormick Taylor

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: BMP Conversion

Site ID: SLP-BC-F701
Site Name: Wesleigh and Seneca Drive

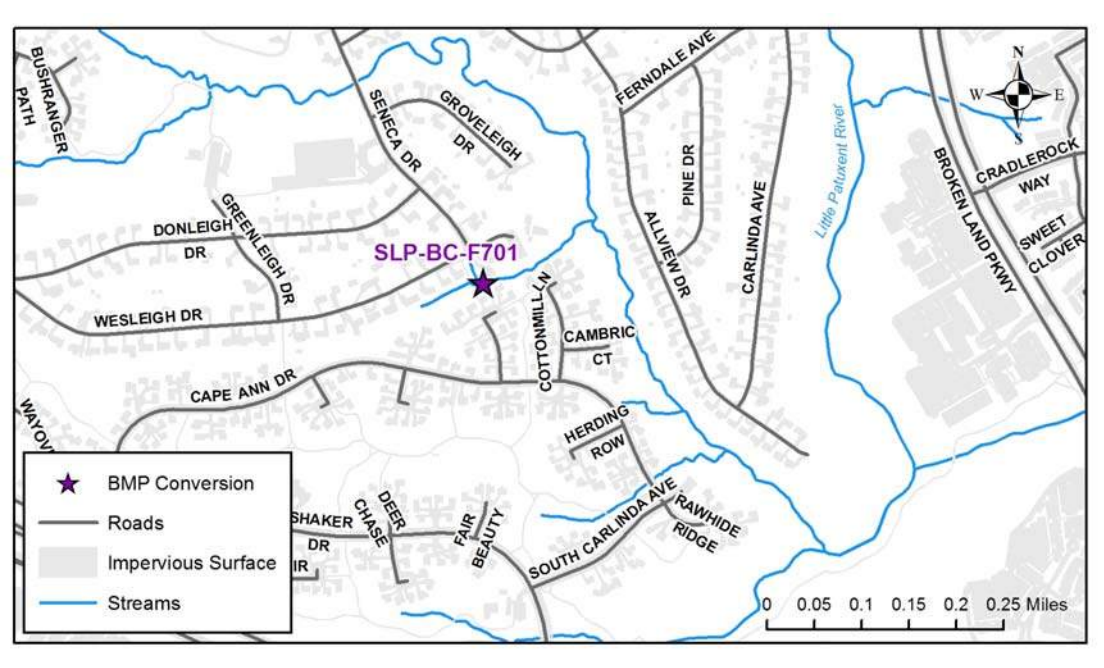
Contractor: Versar
Watershed: Little Patuxent River

Proposed BMP Type: Submerged Gravel Wetlands
Ownership: Private- Residential
Single Owner

BMP Structure ID: HO100148
Existing BMP Type: Dry Pond

Existing Conditions:

A small amount of water flows from the north inlet (30 in. RCP), through wetland vegetation to the south outfall (18 in. RCP) of the existing facility at the time of the field investigation. There is a pedestrian trail along the west and south side of the facility. The south end of the facility has an outfall with headwall and paved emergency spillway, which discharges east onto private property. In addition to the principal outfall there is an asphalt emergency spillway at this facility. An unconnected stormwater system is located at the south end of the facility which bypasses this facility.



Howard County Watershed Assessment Concept Plan: BMP Conversion

Site ID: SLP-BC-F701
Site Name: Wesleigh and Seneca Drive
Contractor: Versar
Watershed: Little Patuxent River

Standing on outlet headwall looking upstream.

Standing at south end looking downstream.

Howard County Watershed Assessment Concept Plan: BMP Conversion

Site ID: SLP-BC-F701
Site Name: Wesleigh and Seneca Drive
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:

The approval of the adjacent landowners and possible HOA. The facility is possibly in the Waters of the United States (WUS) and a wetland.

Concept Description:

Either a submerged gravel wetland (SGW) or a wet pond can be constructed within the facility. The SGW will require a new outlet weir to be constructed upstream of the existing outlet. The site currently has an access route from Wesleigh Drive into the bottom of the basin.

Nearby Opportunities:

None recommended

Proposed Project Credit	
Drainage Area (ac.):	14.59
Impervious Area within Drainage (ac.):	3.91
Impervious Area Treated (ac.):	3.91
Impervious Area Treated Credit (ac.):	3.91

Water Quality Volume	
WQVolume Target (cft.):	15,422
Max Treated (cft.):	16,964
Percent Treated:	110%
Rainfall Depth Treated (in.):	1.1

Costs

Estimated Design Cost:	$120,000.00
Estimated Construction Cost:	$100,000.00
30% Contingency:	$30,000.00
Estimated Total Cost	$250,000.00
Cost per Impervious Credit Acre:	$63,938.62

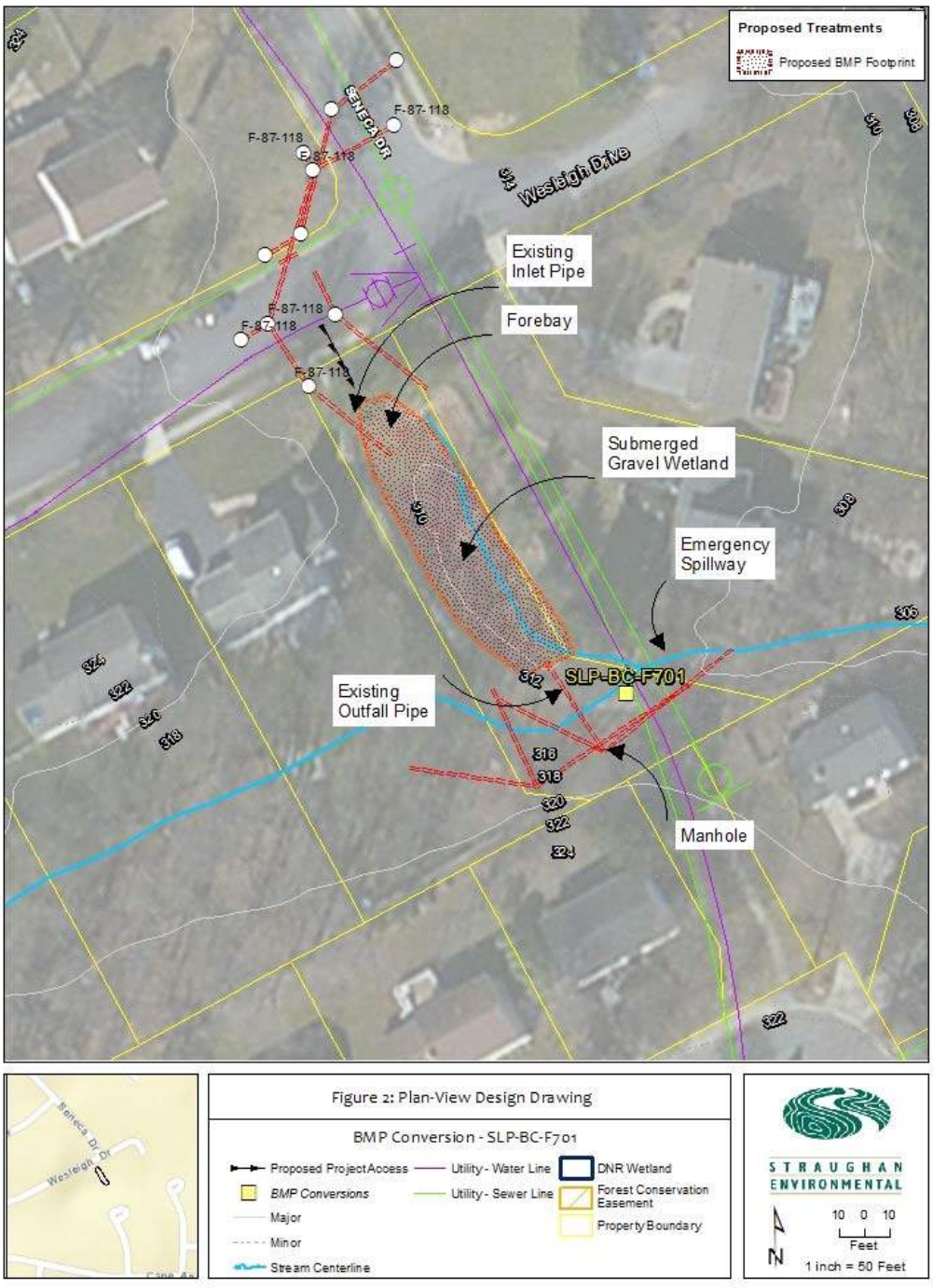
Howard County Watershed Assessment Concept Plan: BMP Conversion

Site ID: SLP-BC-F701

Site Name: Wesleigh and Seneca Drive

Contractor: Versar

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: BMP Conversion

Site ID: SLP-BC-F728
Site Name: Columbia Medical Campus

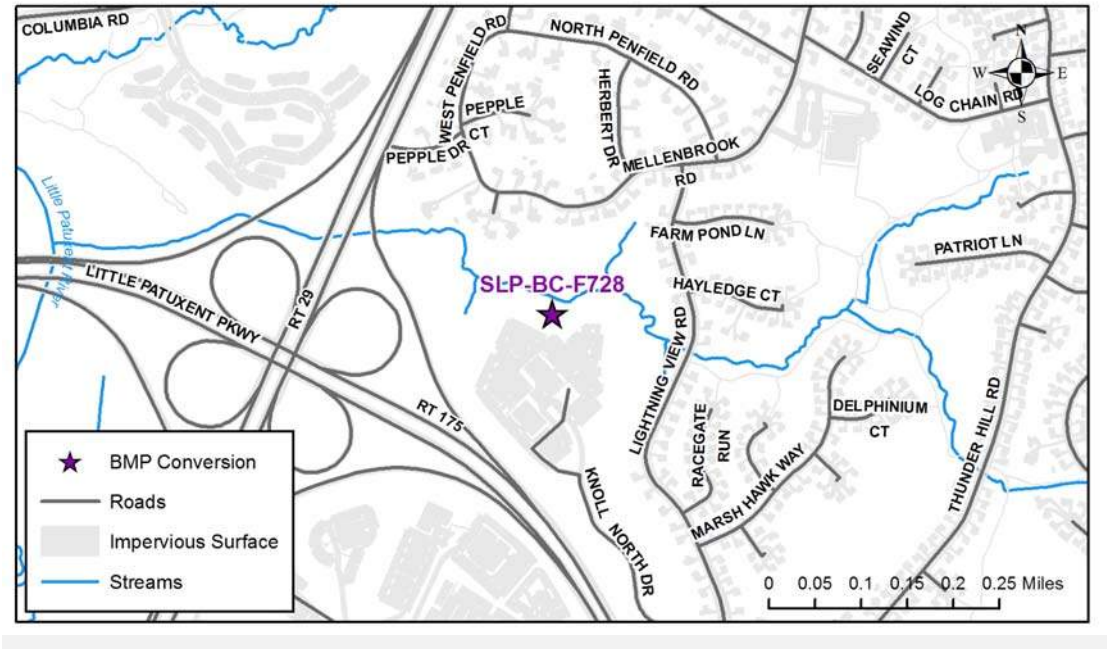
Contractor: Versar
Watershed: Little Patuxent River

Proposed BMP Type: Submerged Gravel Wetlands
Ownership: Private- Commercial/Industrial
Single Owner

BMP Structure ID: HO101106
Existing BMP Type: Extended Detention

Existing Conditions:

This facility is currently a dry extended detention facility with three surface inflows and two subsurface inflows. The surface inflows are in the east, west and center south sides of the facility. The two subsurface inflows come into the bottom center of the facility at a Type K inlet with a metal orifice plate that controls the discharge out, which is functioning as a low flow device. This junction box connects to concrete riser set in an embankment along the north side of the facility. The outfall from the facility is through a 36 in. CMP into a tributary. In walking the entire site, it appears all of the surrounding parking lots and main building drain into this facility. There appears to be an area along the northwest side that, if not for the fiber optic line, could be converted into a new second stormwater management facility. The source for one of the subsurface inlets could not be located, but it may coming from the main building. During the site visit, water was flowing through the subsurface system.



Howard County Watershed Assessment Concept Plan: BMP Conversion

Site ID: SLP-BC-F728
Site Name: Columbia Medical Campus
Contractor: Versar
Watershed: Little Patuxent River

View south from embankment behind riser.

Facility looking west from embankment.

Howard County Watershed Assessment Concept Plan: BMP Conversion

Site ID: SLP-BC-F728
Site Name: Columbia Medical Campus
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:

No known constraints.

Concept Description:

This facility can be converted into a submerged gravel wetland. As part of this conversion, the existing "low-flow" device may need to be altered.

Nearby Opportunities:

None recommended

Proposed Project Credit	
Drainage Area (ac.):	12.31
Impervious Area within Drainage (ac.):	7.96
Impervious Area Treated (ac.):	7.96
Impervious Area Treated Credit (ac.):	7.96

Water Quality Volume	
WQVolume Target (cft.):	28,239
Max Treated (cft.):	31,063
Percent Treated:	110%
Rainfall Depth Treated (in.):	1.1

Costs

Estimated Design Cost:	$120,000.00
Estimated Construction Cost:	$159,630.00
30% Contingency:	$47,889.00
Estimated Total Cost	$327,519.00
Cost per Impervious Credit Acre:	$41,145.60

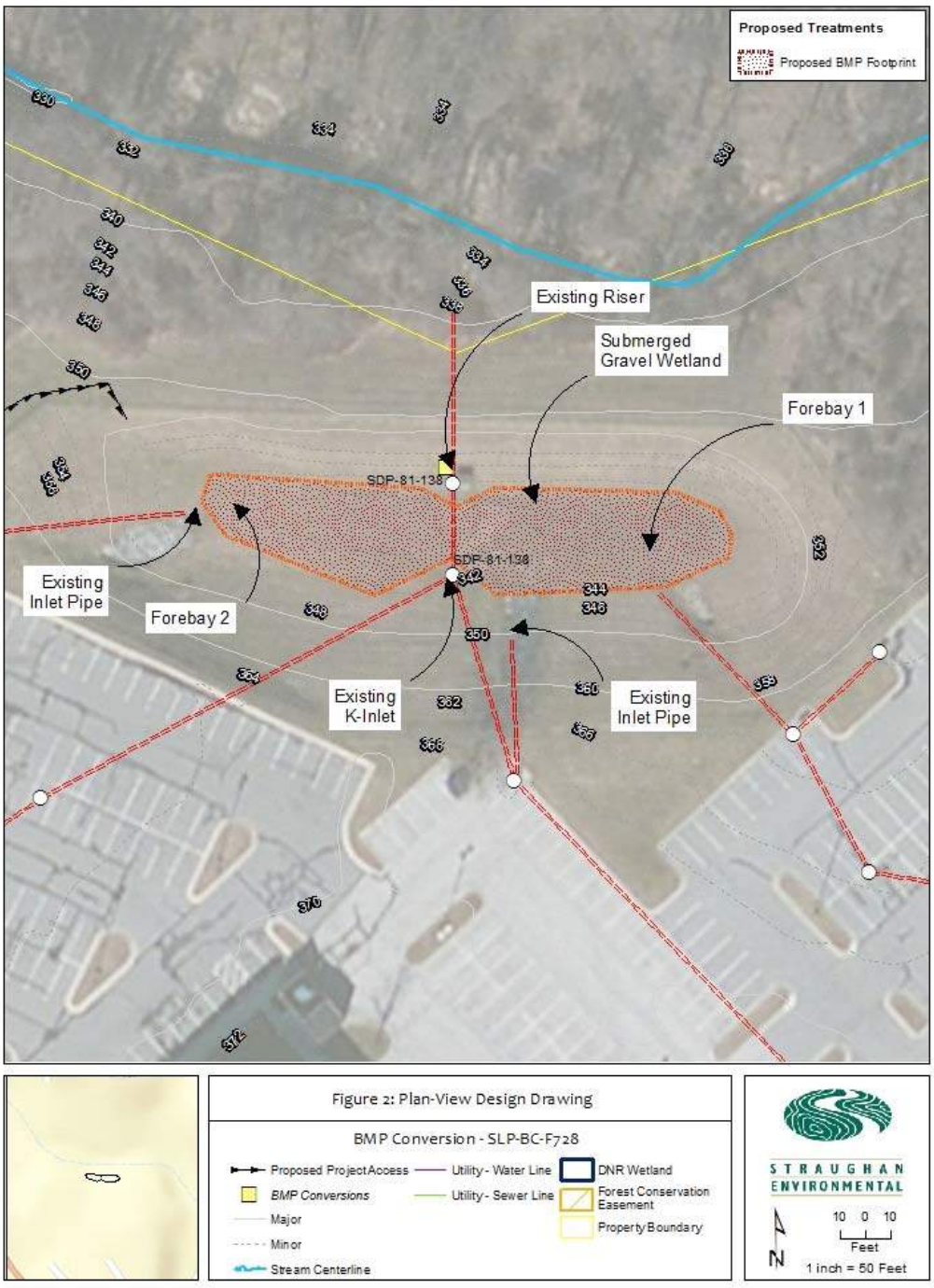
Howard County Watershed Assessment Concept Plan: BMP Conversion

Site ID: SLP-BC-F728

Site Name: Columbia Medical Campus

Contractor: Versar

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: BMP Conversion

Site ID: SLP-BC-F734
Site Name: 9265 Berger Road Business Complex

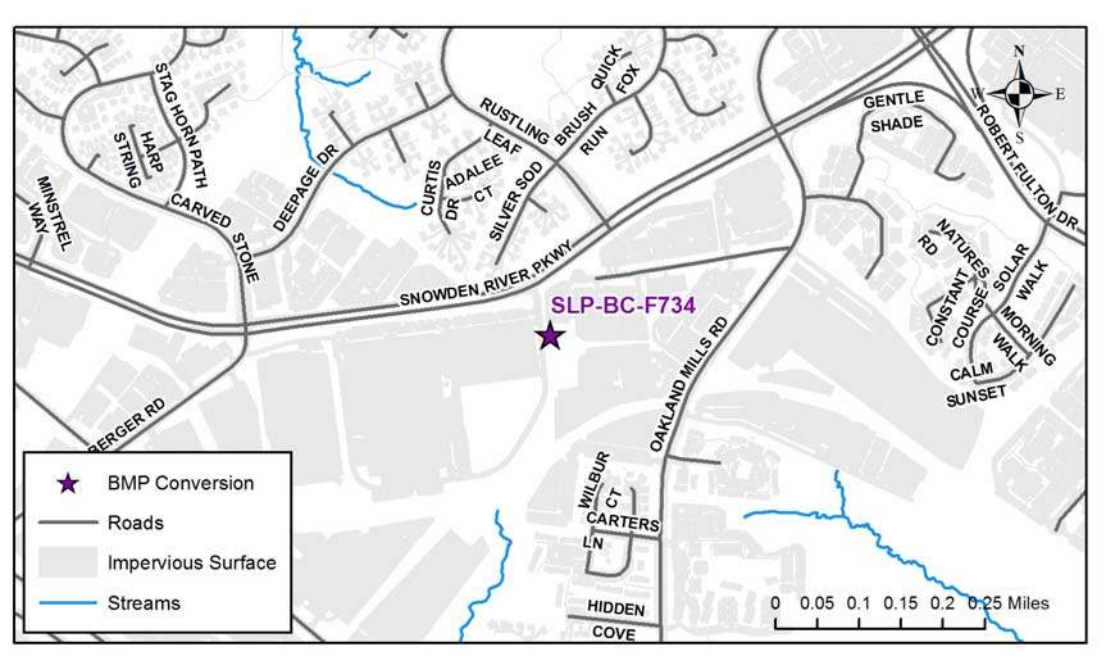
Contractor: Versar
Watershed: Little Patuxent River

Proposed BMP Type: Extended Detention Structure, Wet
Ownership: Private- Commercial/Industrial
Multiple Owners

BMP Structure ID: HO101392
Existing BMP Type: Dry Pond

Existing Conditions:

Discharges into roadway. A total of five buildings and much of the surrounding impervious parking area drain into this facility. Three of the five buildings are currently occupied by auto repair businesses, the forth building is currently vacant, and the fifth building is self-storage. The four buildings east of the self-storage facility are connected to a stormwater system that runs along the south and east side of the site property. The existing facility has three inflows (two in the northeast corner and one in the southeast corner) and a single 36 in. CMP riser outfall in the southwest corner. The outfall discharges into a double at-grade inlet in the northwest corner of the adjacent property. The existing riser and embankments are in good condition. The roof for the self-storage building is collected into a stormwater pipe along the north side of the facility before entering through one of the northeast inlets.



Howard County Watershed Assessment Concept Plan: BMP Conversion

Site ID: SLP-BC-F734

Site Name: 9265 Berger Road Business Complex

Contractor: Versar

Watershed: Little Patuxent River

East side of BMP looking north.

Over principal spillway looking northeast.

Howard County Watershed Assessment Concept Plan: BMP Conversion

Site ID: SLP-BC-F734
Site Name: 9265 Berger Road Business Complex
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:

The site may be declared a "hotspot" due to automotive repair shops at this location.

Concept Description:

Convert the existing dry extended detention facility into a wet extended detention pond with a liner and install two oil interceptors (one for each storm drain system). Construction of an access road into the facility is not possible without reducing pond storage capacity.

It is also recommended that a direct connection be made between the outfall and the double inlet in the adjacent property. Plans were not readily regarding the construction of the embankment available while developing this concept, and it may need to be upgraded.

Nearby Opportunities:

None recommended

Proposed Project Credit	
Drainage Area (ac.):	4.72
Impervious Area within Drainage (ac.):	3.77
Impervious Area Treated (ac.):	3.77
Impervious Area Treated Credit (ac.):	3.77

Water Quality Volume	
WQVolume Target (cft.):	13,173
Max Treated (cft.):	14,491
Percent Treated:	110%
Rainfall Depth Treated (in.):	1.1

Costs

Estimated Design Cost:	$120,000.00
Estimated Construction Cost:	$100,000.00
30% Contingency:	$30,000.00
Estimated Total Cost	$250,000.00
Cost per Impervious Credit Acre:	$66,313.00

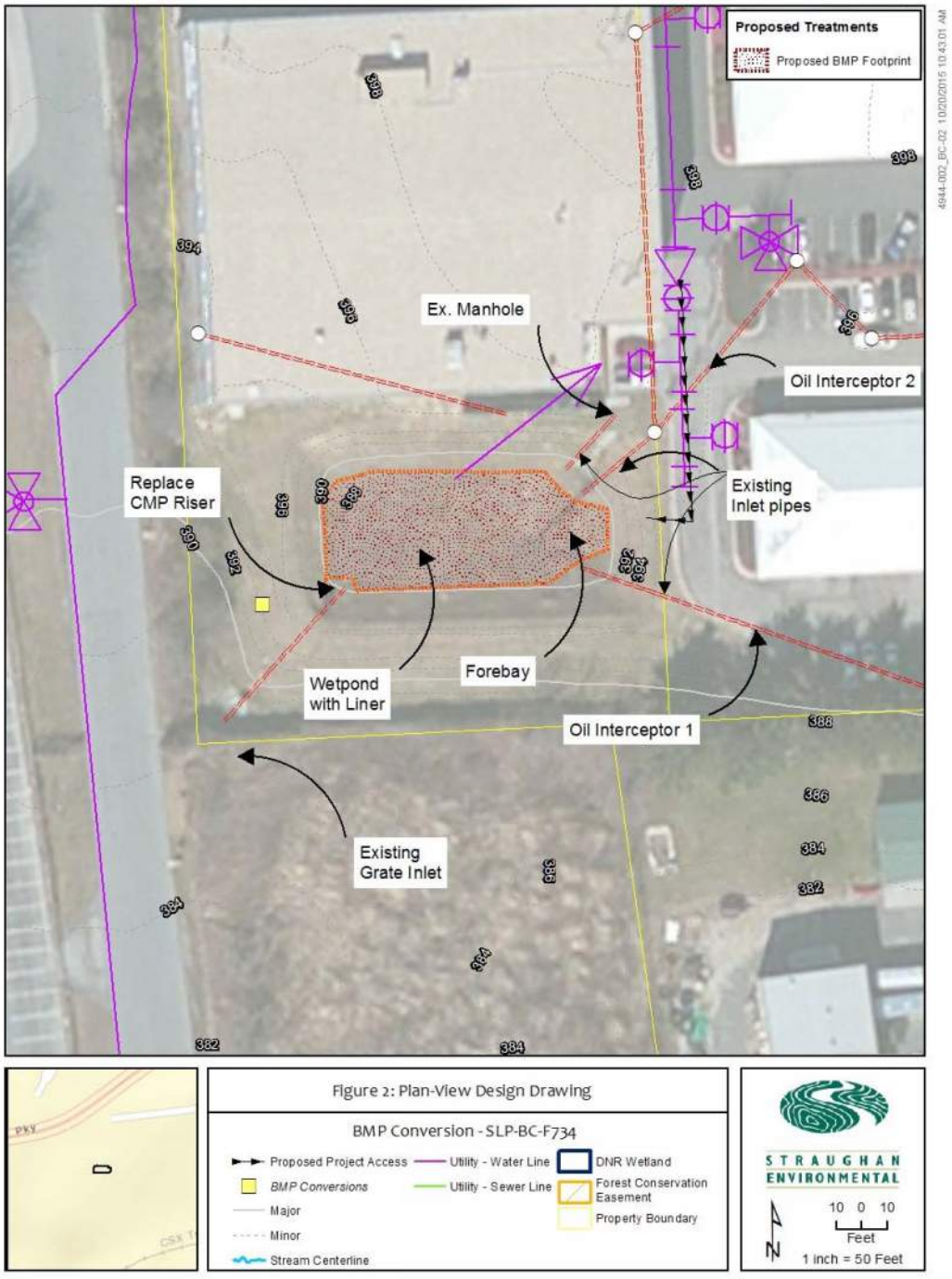
Howard County Watershed Assessment Concept Plan: BMP Conversion

Site ID: SLP-BC-F734

Site Name: 9265 Berger Road Business Complex

Contractor: Versar

Watershed: Little Patuxent River



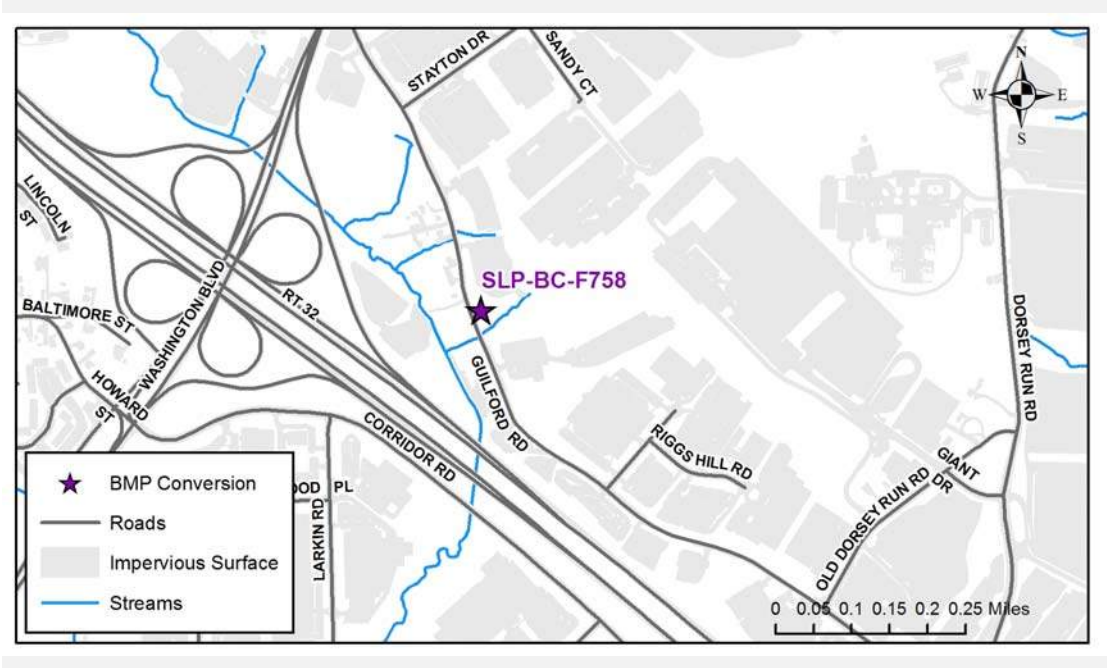
Howard County Watershed Assessment Concept Plan: BMP Conversion

Site ID: SLP-BC-F758
Site Name: Elliott & Franz Inc. Heavy Equipment Rentals
Contractor: Versar
Watershed: Little Patuxent River

Proposed BMP Type: Retention Pond (Wet Pond)
Ownership: Private- Commercial/Industrial
Single Owner
BMP Structure ID: HO102072
Existing BMP Type: Dry Pond

Existing Conditions:

The basin has a single inflow receiving sediment containing asphalt material from the adjacent industrial parking lot. The facility bottom is about one quarter covered with sediment from the inlet. The facility's embankments are mowed, free of woody vegetation and in good condition. The pond bottom is free of wetland vegetation, indicating the facility may infiltrate. The outlet structure is a composite of concrete and brick but is intact with no signs of breaks or cracks. The discharge from the facility spills directly onto the downstream roadway. The nearest downstream collection point is a double (at-grade) inlet about 200 ft. downstream



Howard County Watershed Assessment Concept Plan: BMP Conversion

Site ID: SLP-BC-F758
Site Name: Elliott & Franz Inc. Heavy Equipment Rentals
Contractor: Versar
Watershed: Little Patuxent River

The erosion of the inflow swale.

The facility bottom and outlet riser from the access.

Howard County Watershed Assessment Concept Plan: BMP Conversion

Site ID: SLP-BC-F758
Site Name: Elliott & Franz Inc. Heavy Equipment Rentals
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:

Downstream of the facility are a road, overhead power lines, and a cemetery. Upstream is a private industrial parking lot which has a building containing two repair bays for large construction equipment. Water balance calculations will be needed to prove that facility soils can support a wet pond and that the downstream channel is Use I or II.

Concept Description:

A wet pond with liner is proposed if downstream channel is Use I or II or submerged gravel wetland (SGW) is proposed if the stream is Use III or IV. The inflow channel needs to be stabilized with riprap, and a new forebay constructed. The forebay is strongly recommended due to the large amount of sediment and bituminous materials from the upstream property. The forebay needs to be accessible for regular maintenance.

It is also recommended that a swale be constructed downstream of the outfall pipe that will convey discharge to the double (at-grade) inlets and minimize water ponding on the street.

Nearby Opportunities:

None recommended

Proposed Project Credit		Water Quality Volume	
Drainage Area (ac.):	2.52	WQVolume Target (cft.):	5,097
Impervious Area within Drainage (ac.):	1.418	Max Treated (cft.):	5,606
Impervious Area Treated (ac.):	1.42	Percent Treated:	110%
Impervious Area Treated Credit (ac.):	1.42	Rainfall Depth Treated (in.):	1.1

Costs

Estimated Design Cost:	$120,000.00
Estimated Construction Cost:	$100,000.00
30% Contingency:	$30,000.00
Estimated Total Cost	$250,000.00
Cost per Impervious Credit Acre:	$176,056.34

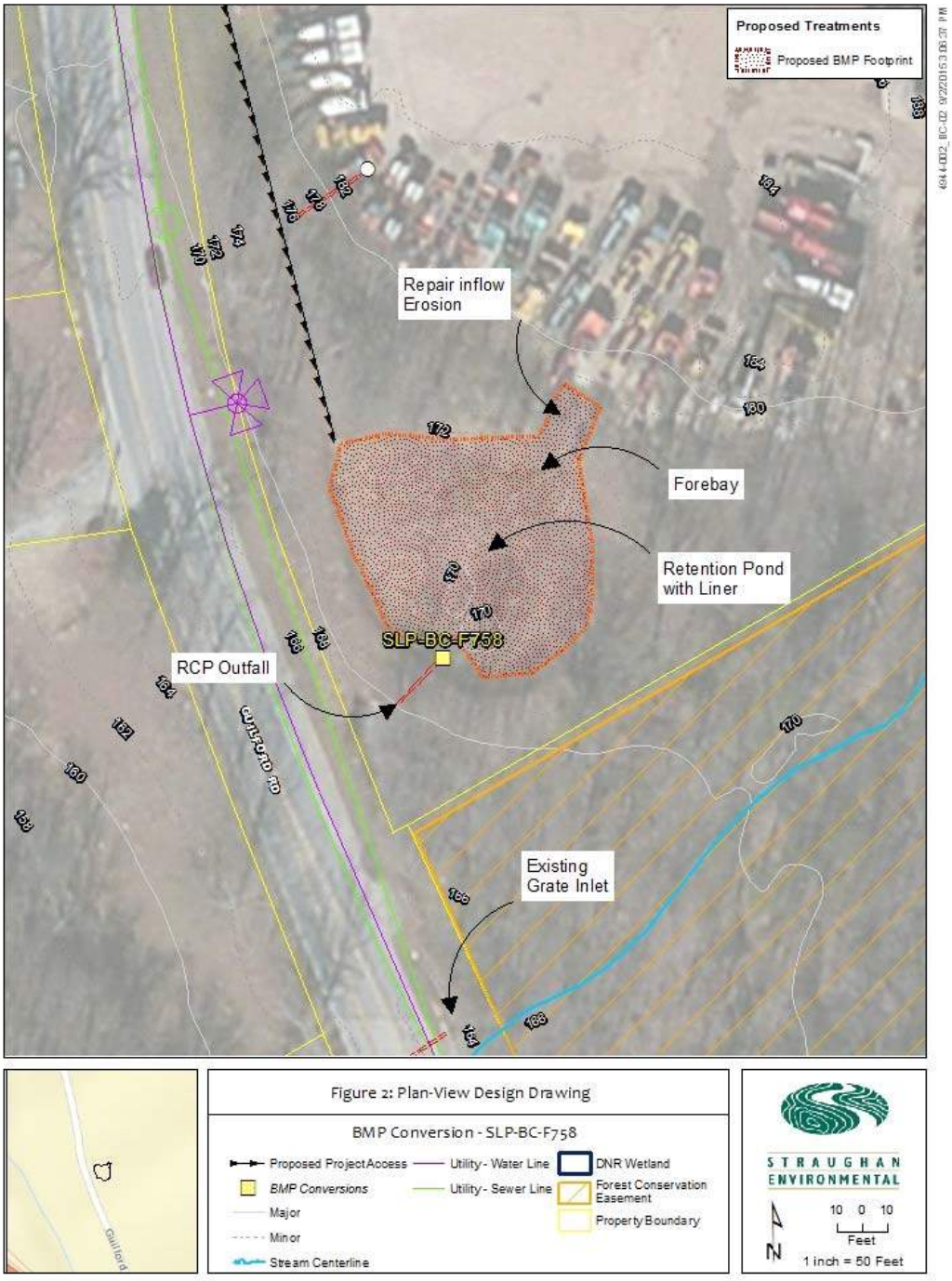
Howard County Watershed Assessment Concept Plan: BMP Conversion

Site ID: SLP-BC-F758

Site Name: Elliott & Franz Inc. Heavy Equipment Rentals

Contractor: Versar

Watershed: Little Patuxent River



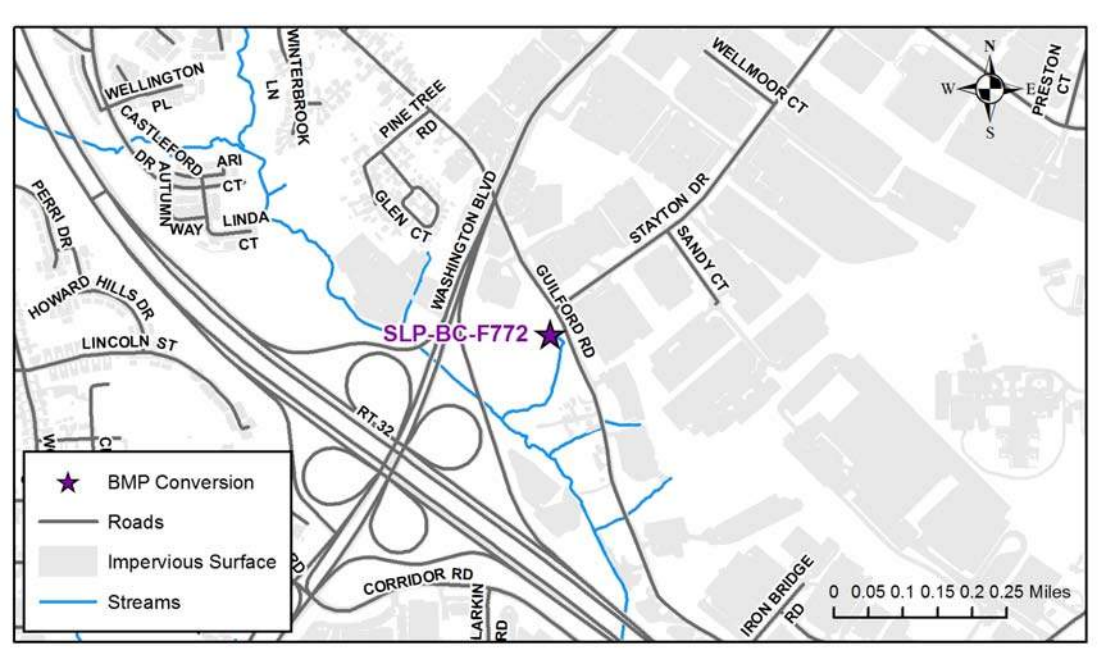
Howard County Watershed Assessment Concept Plan: BMP Conversion

Site ID: SLP-BC-F772
Site Name: Thrift Store Dry Pond
Contractor: Versar
Watershed: Little Patuxent River

Proposed BMP Type: Submerged Gravel Wetlands
Ownership: Private- Commercial/Industrial
Single Owner
BMP Structure ID: HO101856
Existing BMP Type: Extended Detention

Existing Conditions:

Existing facility lacks proper access. The existing inflow is a storm drain pipe with a concrete end section. The inflow is surrounded by a large amount of trash and tall reeds. At the time of site visit, no standing water was found at the inlet or in the tall reeds. The bottom of the pond is extremely dry with areas of cracking soil. Except for around the inflow the vegetation in the pond is low (30 in. or less). At the concrete riser structure (6 ft. by 7 ft.) a riprap depression was found, indicating the possibility of a low flow inlet pipe, but the pipe could not be found. The concrete riser is in good condition with no cracks, and the four trash racks are free of rust. The reinforced concrete outfall pipe appears to be in good condition. The outfall riprap channel is also in good condition. The facility has an earth embankment with non-woody vegetation on the inside and 1 in. to 4 in. diameter woody vegetation on the outside. No emergency spillway was found and the embankment inspection was limited due to thick vegetative cover.



Howard County Watershed Assessment Concept Plan: BMP Conversion

Site ID: SLP-BC-F772
Site Name: Thrift Store Dry Pond

Contractor: Versar
Watershed: Little Patuxent River

Standing on manhole upstream of inlet looking over the facility (outlet riser left of photo area).

Inlet with trash and tall reeds.

Howard County Watershed Assessment Concept Plan: BMP Conversion

Site ID: SLP-BC-F772
Site Name: Thrift Store Dry Pond
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:

Construction of access road will require cutting into the existing roadside 2:1 slope.

Concept Description:

A submerged gravel wetland (SGW) is proposed as the stream is Use IV. A forebay is recommended, as well as an access road to the inflow.

Nearby Opportunities:

None recommended

Proposed Project Credit	
Drainage Area (ac.):	5.527
Impervious Area within Drainage (ac.):	1.9
Impervious Area Treated (ac.):	1.9
Impervious Area Treated Credit (ac.):	1.9

Water Quality Volume	
WQVolume Target (cft.):	7,211
Max Treated (cft.):	7,932
Percent Treated:	110%
Rainfall Depth Treated (in.):	1.1

Costs

Estimated Design Cost:	$120,000.00
Estimated Construction Cost:	$100,000.00
30% Contingency:	$30,000.00
Estimated Total Cost	$250,000.00
Cost per Impervious Credit Acre:	$131,578.95

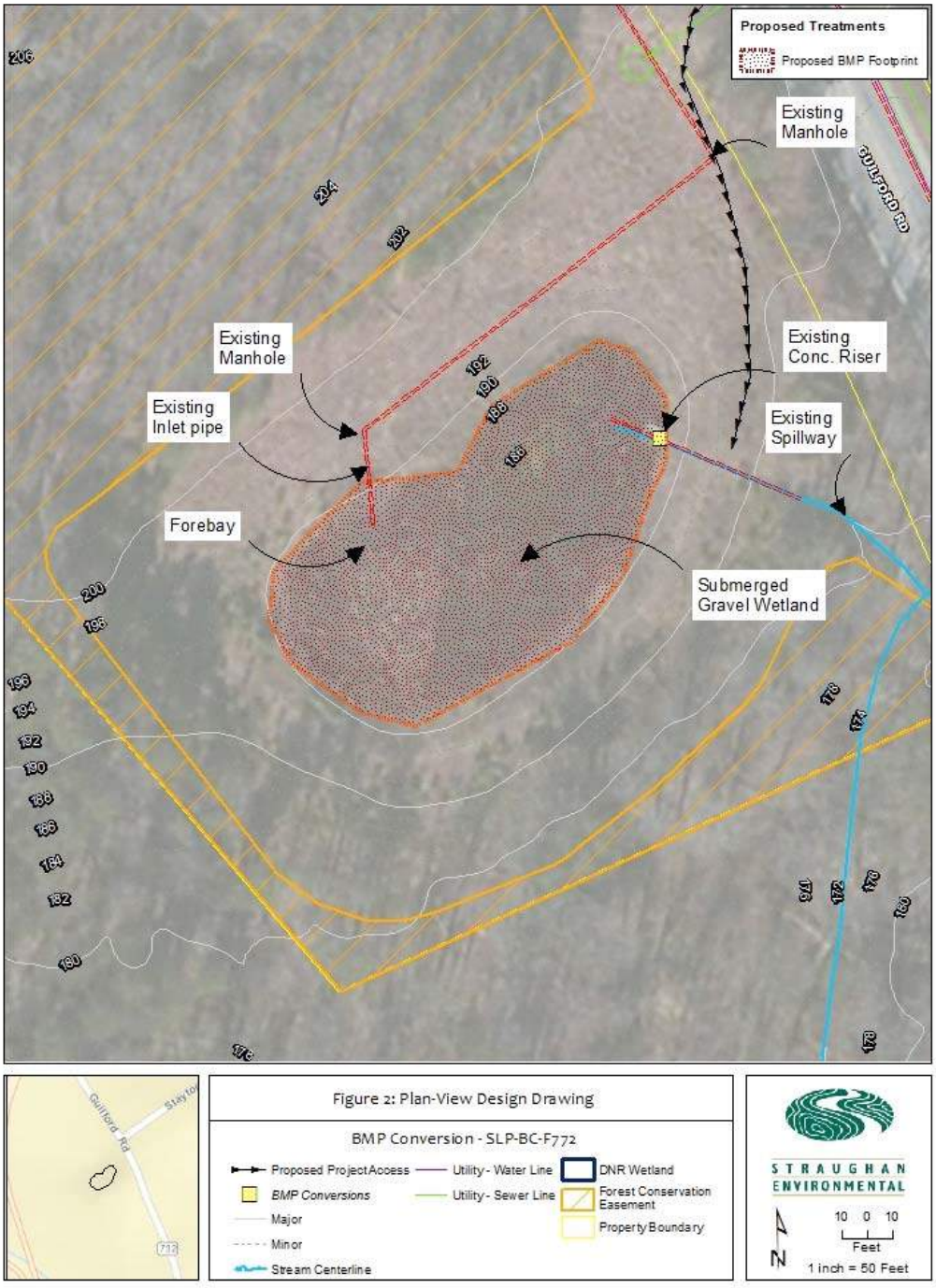
Howard County Watershed Assessment Concept Plan: BMP Conversion

Site ID: SLP-BC-F772

Site Name: Thrift Store Dry Pond

Contractor: Versar

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: BMP Conversion

Site ID: SMP-BC-F314
Site Name: 9525 Chaton Road

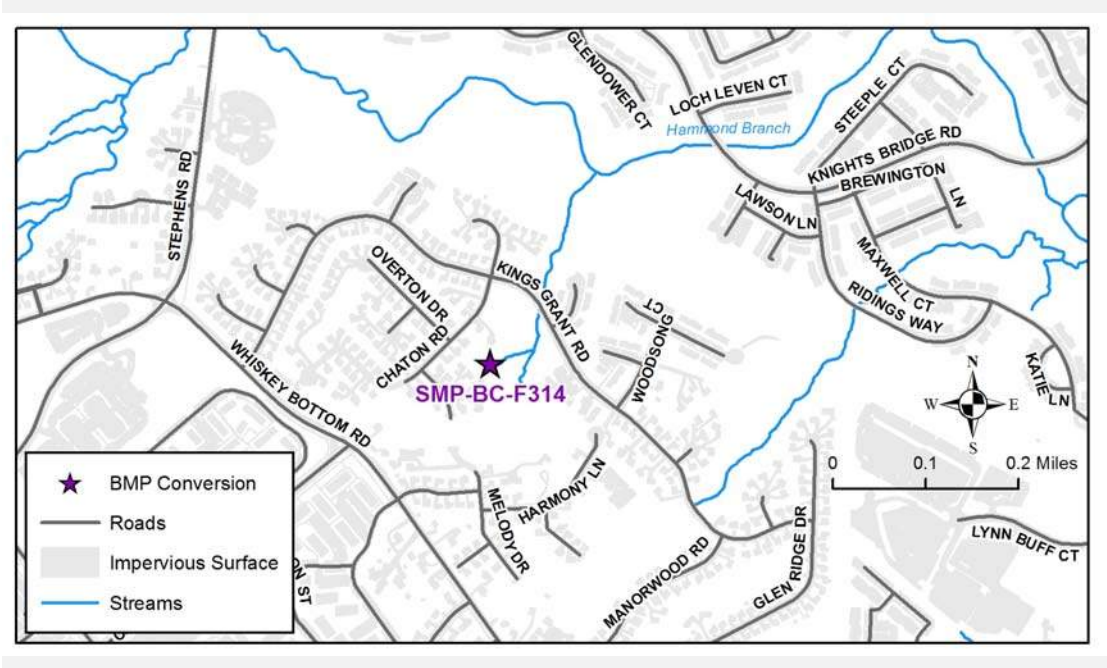
Contractor: Biohabitats
Watershed: Little Patuxent River

Proposed BMP Type: Sand Filter
Ownership: Private- Residential
Single Owner

BMP Structure ID: HO100434
Existing BMP Type: Extended Detention

Existing Conditions:

The current pond is a dry pond with one storm drain infall and manages a 8.35 ac. drainage area containing 43% impervious surfaces from a residential development. The infall discharges to a forebay in the pond and low flows discharge through a perforated pipe surrounded by stone. The pond was observed to have some aquatic vegetation, likely due to the low flow configuration. The outfall barrel is a 36 in. reinforced concrete pipe (RCP) and outfalls into a wooded area near a wetland area which is owned by Columbia Association. A 12 ft. maintenance access surrounds the pond. The pond is located on the Kings Woods HOA property.



Howard County Watershed Assessment Concept Plan: BMP Conversion

Site ID: SMP-BC-F314
Site Name: 9525 Chaton Road

Contractor: Biohabitats
Watershed: Little Patuxent River

Pond basin overview.

Riser overview.

Howard County Watershed Assessment Concept Plan: BMP Conversion

Site ID: SMP-BC-F314
Site Name: 9525 Chaton Road

Contractor: Biohabitats
Watershed: Little Patuxent River

Constraints/Utilities:

The only place to discharge the emergency spillway on original ground would be toward lot 255; all other locations for the emergency spillway would be located on fill material. The groundwater level needs to be investigated for feasibility for a sand filter. Work would require permission from the HOA.

Concept Description:

The existing dry pond could be converted to a dry pond with sand filter by lowering the pond basin by 2 ft. and by lowering the outfall by 4 ft. The upstream embankment is currently at a 3:1 slope and would be excavated to a 2:1 to increase the storage capacity of the pond. A forebay would be constructed at the facility infall using the existing excavated material. The existing stormwater pond currently has 2 ft. of freeboard without an emergency spillway. The sand filter would require 3 ft. of depth to treat 1 in. of runoff. The remaining 1 ft. of depth could be met by raising the water level in the facility by reducing the freeboard from 2 ft. to 1 ft. and constructing an emergency spillway. An alternative plan would be to convert the pond to an extended detention pond with micropool or a pocket pond by removing the western 12 ft. maintenance access.

Nearby Opportunities:

Assess stream channel near the intersection of Kings Grant Rd and Earl Le

Proposed Project Credit	
Drainage Area (ac.):	8.35
Impervious Area within Drainage (ac.):	3.58
Impervious Area Treated (ac.):	3.58
Impervious Area Treated Credit (ac.):	3.58

Water Quality Volume	
WQVolume Target (cft.):	13,211
Max Treated (cft.):	13,211
Percent Treated:	100%
Rainfall Depth Treated (in.):	1

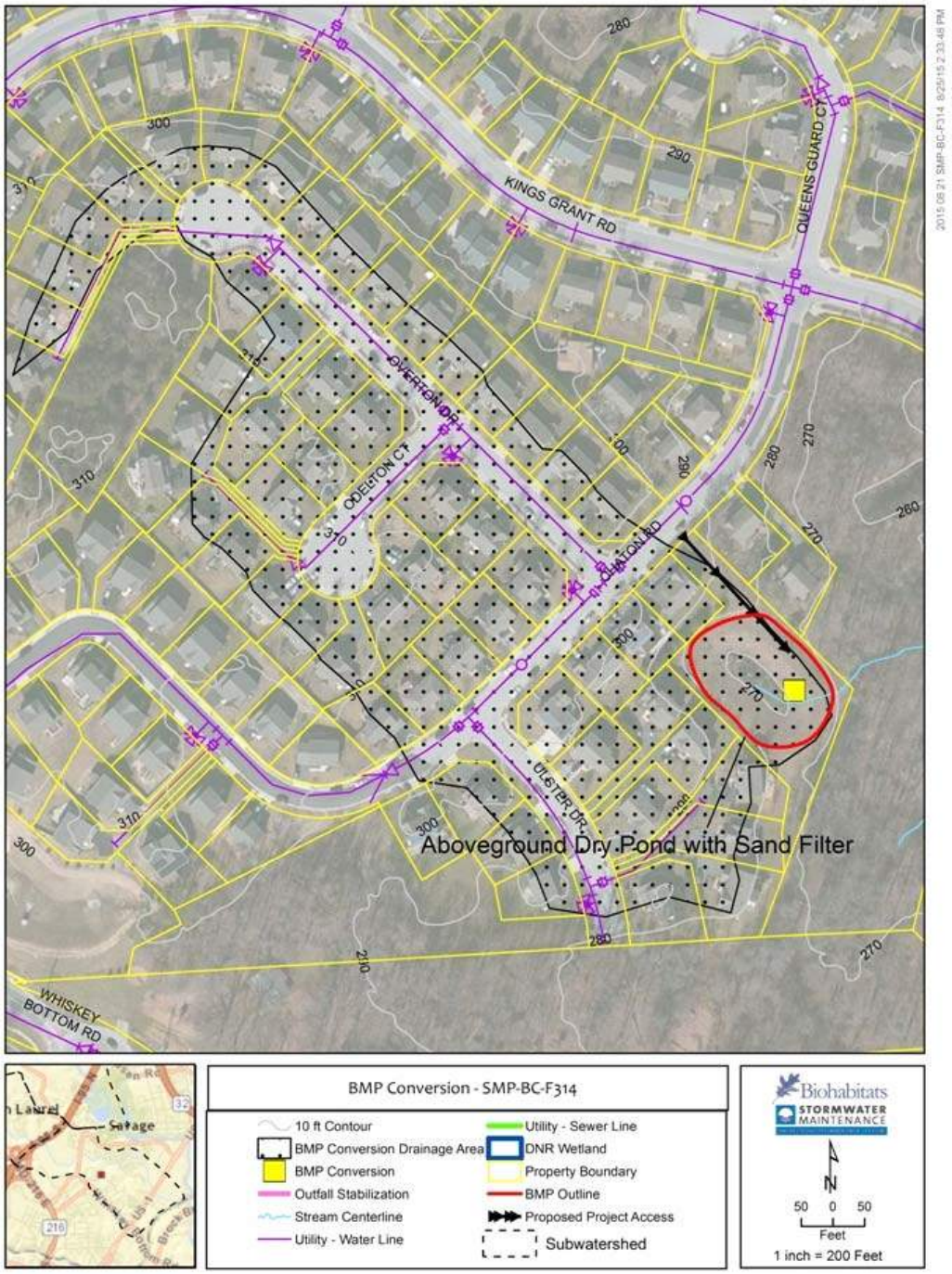
Costs

Estimated Design Cost:	$220,000.00
Estimated Construction Cost:	$355,330.00
30% Contingency:	$106,599.00
Estimated Total Cost	$681,929.00
Cost per Impervious Credit Acre:	$190,482.96

Howard County Watershed Assessment Concept Plan: BMP Conversion

Site ID: SMP-BC-F314
Site Name: 9525 Chaton Road

Contractor: Biohabitats
Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: New BMP

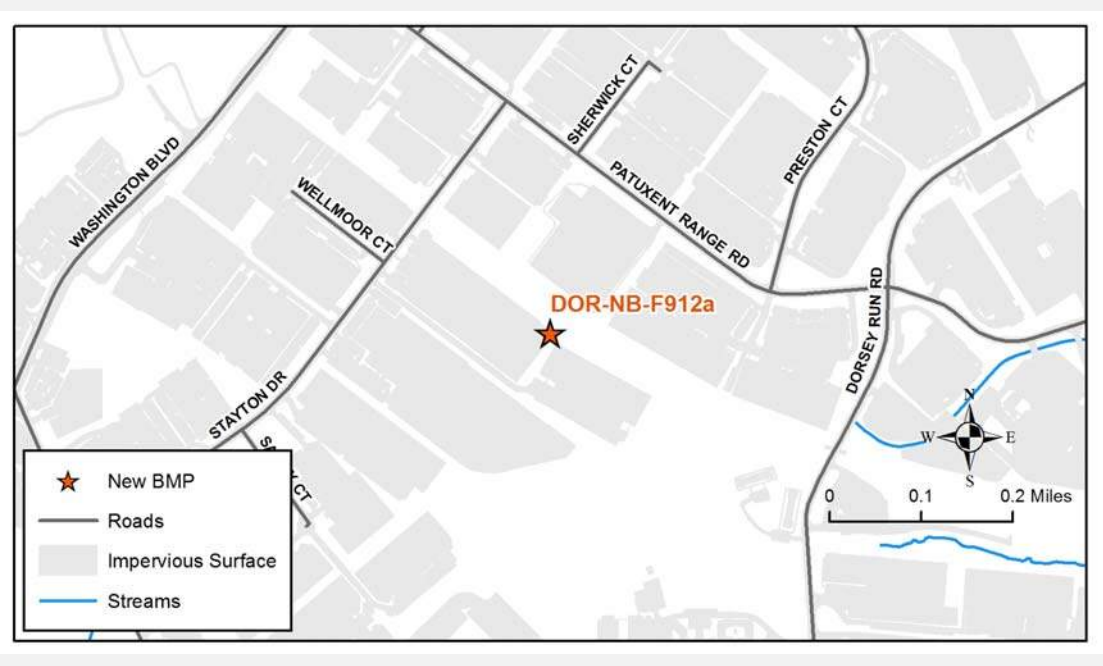
Site ID: DOR-NB-F912a
Site Name: Capitol Express

Contractor: McCormick Taylor
Watershed: Little Patuxent River

Proposed BMP Type: Underground Filter
Ownership: Private- Commercial/Industrial
Single Owner

Existing Conditions:

The site consists of a large warehouse building with loading docks and a parking lot. An existing 42 in. storm drain network along the southeast side of the parking lot carries stormwater runoff from the parking lot to an outfall and swale along the CSX Railroad tracks. The inlet in the northeastern corner of the property is approximately 12 ft. deep and no other utilities were visible during the initial assessment. The inlet is partially clogged and does not function as designed. Rooftop runoff discharges directly into the stream adjacent to the railroad via a series of PVC pipes.



Howard County Watershed Assessment Concept Plan: New BMP

Site ID: DOR-NB-F912a
Site Name: Capitol Express

Contractor: McCormick Taylor
Watershed: Little Patuxent River

Looking east toward the existing clogged inlet to be used as the facility outfall.

Looking south toward the parking lot area to be used for the underground sand filter.

Howard County Watershed Assessment Concept Plan: New BMP

Site ID: DOR-NB-F912a
Site Name: Capitol Express

Contractor: McCormick Taylor
Watershed: Little Patuxent River

Constraints/Utilities:

Constraints for this project include the property ownership and land use. It is on private property and the site has frequent truck traffic. The project may require the temporary closure of some loading docks as the proposed facility is in the parking lot. The proposed outfall may also be a constraint since the rooftop runoff does not currently enter the storm drain network at the inlet on the northeast corner of the property. No utilities were observed during the initial site assessment.

Concept Description:

An underground sand filter (USF) is proposed to treat 2.00 ac. of rooftop runoff from the warehouse. The PVC roof drains within the 2.00 ac. drainage area would be connected and routed to a flow splitter which will divert the WQv to the USF on the eastern side of the lot near the existing storm drain inlet. The existing storm drain is to be utilized as the outfall for the flow splitter bypass and the facility overflow connection. A hydraulic analysis will be required on the flow splitter, bypass, and overflow storm drain network to ensure there is capacity for larger storms. The USF would have 1,733 cf. of pretreatment in a sedimentation chamber with a surface area of approximately 578 sf. The sand filter area is 960 sf. with 2 ft. of media. An additional 4 ft. of temporary ponding over the entire facility area (1,538 sf.) is also considered to treat 100% of the WQv.

The total size of the USF would be approximately 30 ft. wide and 55 ft. long (interior dimensions) to treat the entire WQv from the 2.00 ac. drainage area. This area includes the three chambers for sedimentation, treatment, and overflow as typical per the Maryland Department of Environment Design Manual (2000). The remaining 2.5 ac. of the warehouse roof could be diverted to a second underground treatment facility if desired for additional cost. To reduce the facility footprint and cost, a smaller sand filter can be installed to treat a smaller portion of the roof or a portion of the WQv. The outfall was also assessed during the watershed study and could be considered for stabilization along with this project as the concrete apron is cracked and failing. Access to the proposed site location would be through the parking lot.

Nearby Opportunities:

DOR-OF-F907

Proposed Project Credit		Water Quality Volume	
Drainage Area (ac.):	2	WQVolume Target (cft.):	6,897
Impervious Area within Drainage (ac.):	2	Max Treated (cft.):	6,897
Impervious Area Treated (ac.):	2	Percent Treated:	100%
Impervious Area Treated Credit (ac.):	2	Rainfall Depth Treated (in.):	1

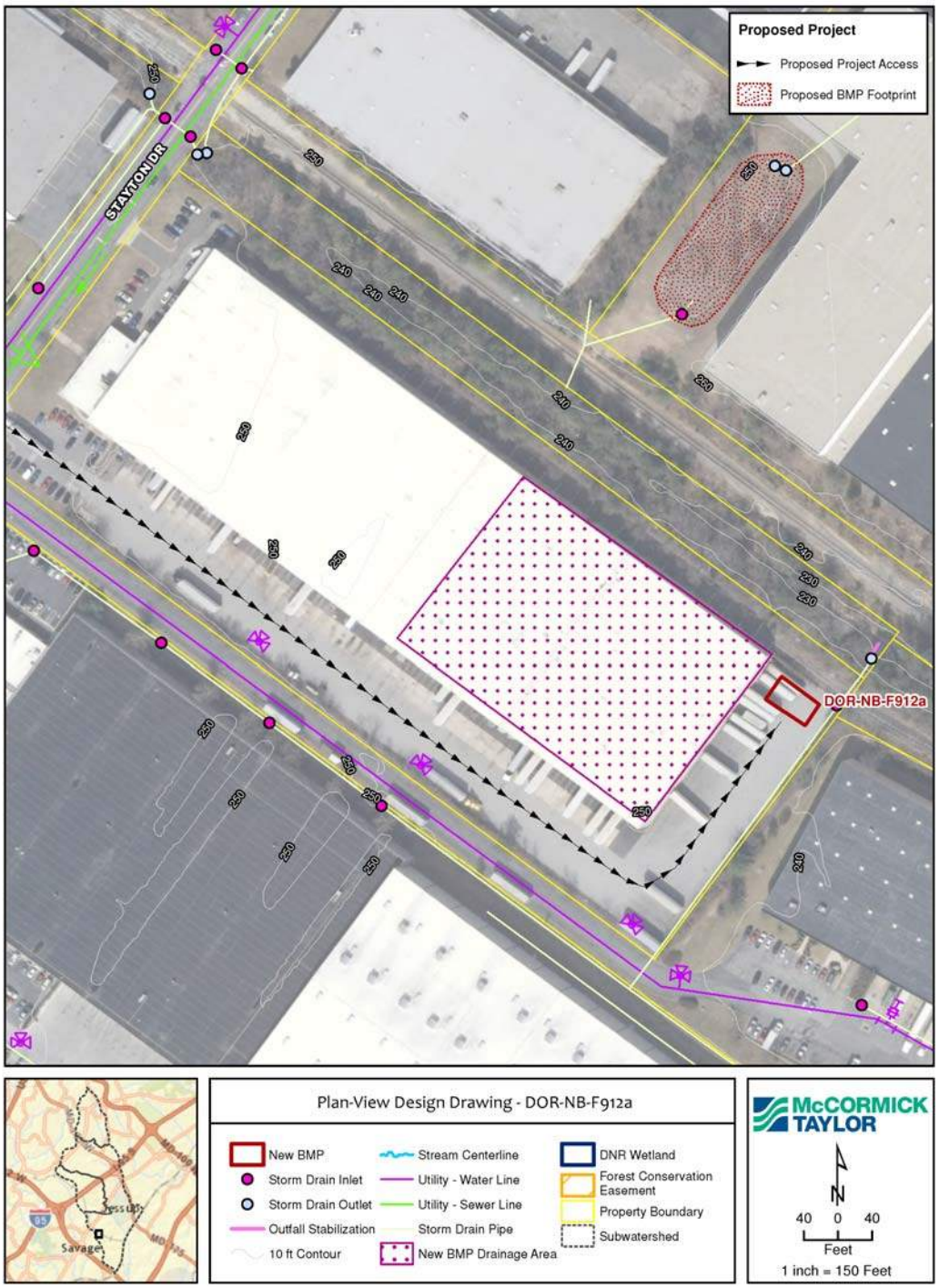
Costs

Estimated Design Cost:	$120,000.00
Estimated Construction Cost:	$142,601.56
30% Contingency:	$42,780.47
Estimated Total Cost	$305,382.03
Cost per Impervious Credit Acre:	$152,691.01

Howard County Watershed Assessment Concept Plan: New BMP

Site ID: DOR-NB-F912a
Site Name: Capitol Express

Contractor: McCormick Taylor
Watershed: Little Patuxent River



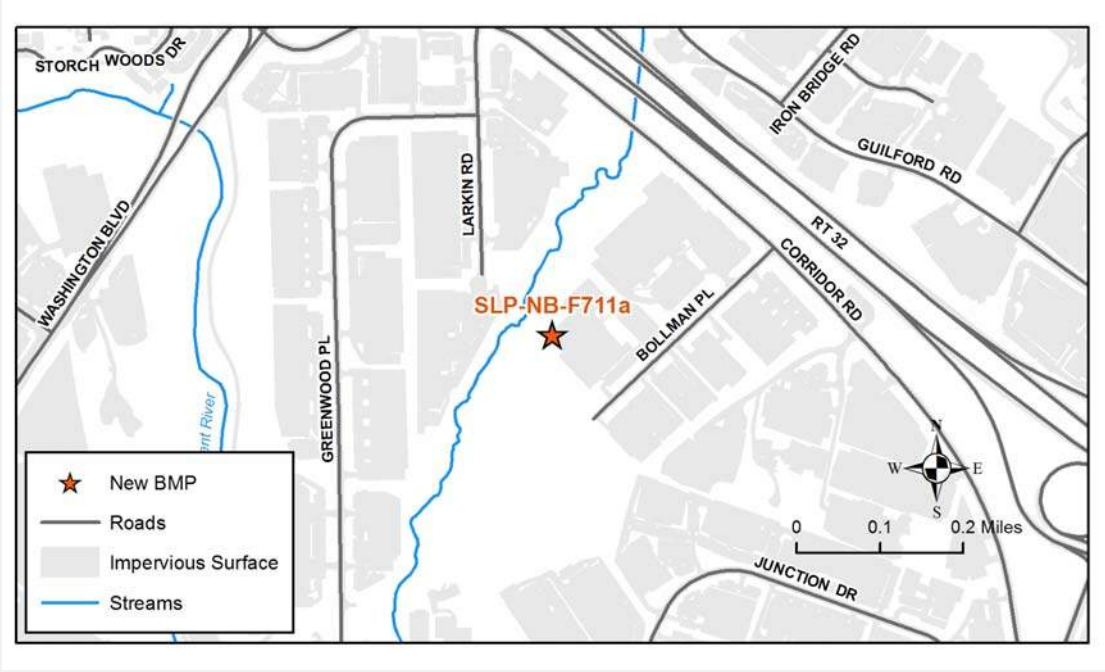
Howard County Watershed Assessment Concept Plan: New BMP

Site ID: SLP-NB-F711a
Site Name: Maine: Paper and Food Service, Inc. - Truck Parking Lot
Contractor: Versar
Watershed: Little Patuxent River

Proposed BMP Type: Retention Pond (Wet Pond)
Ownership: Private- Commercial/Industrial
Single Owner

Existing Conditions:

The site is dominated by parking for passenger cars (north and east sides) and semi-trucks (west side), and the warehouse. The runoff from the roof appears to collect to a pipe system within the warehouse and discharges into a ravine along the south side of the property. The only other possible roof discharge is into the stormwater pipe under the western parking lot. Runoff from the east parking lot discharges into the north lot. The north lot runoff discharges into the west parking lot through a stormwater pipe. The west lot runoff enters an at-grade inlet located in the center of the west lot south end. The final point of discharge for the site is into a brick junction box (Type K) located east of the railroad tracks and south of the perimeter fence. There are two inlet pipes at this junction box. The east pipe origin is unknown. It appears the outfall of this junction box is through a concrete pipe under the railroad track.



Howard County Watershed Assessment Concept Plan: New BMP

Site ID: SLP-NB-F711a
Site Name: Maine: Paper and Food Service, Inc. - Truck Parking Lot
Contractor: Versar
Watershed: Little Patuxent River

Southwest corner of warehouse (possible site for new BMP facility).

Brick junction box downstream of site.

Howard County Watershed Assessment Concept Plan: New BMP

Site ID: SLP-NB-F711a
Site Name: Maine: Paper and Food Service, Inc. - Truck Parking Lot
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:

Project will require coordination with CSX Railroad and the depth of the existing stormwater system will need to be determined.

Concept Description:

Construct a retention pond (aka wet pond) adjacent to the existing outbuilding between the parking lot to be treated and the CSX spur line. A new storm drain system and modification of the parking lot may be needed to direct runoff into the facility.

Nearby Opportunities:

None recommended

Proposed Project Credit		Water Quality Volume	
Drainage Area (ac.):	1.61	WQVolume Target (cft.):	3,984
Impervious Area within Drainage (ac.):	1.13	Max Treated (cft.):	4,382
Impervious Area Treated (ac.):	1.13	Percent Treated:	110%
Impervious Area Treated Credit (ac.):	1.13	Rainfall Depth Treated (in.):	1.1

Costs

Estimated Design Cost:	$120,000.00
Estimated Construction Cost:	$100,000.00
30% Contingency:	$30,000.00
Estimated Total Cost	$250,000.00
Cost per Impervious Credit Acre:	$221,238.94

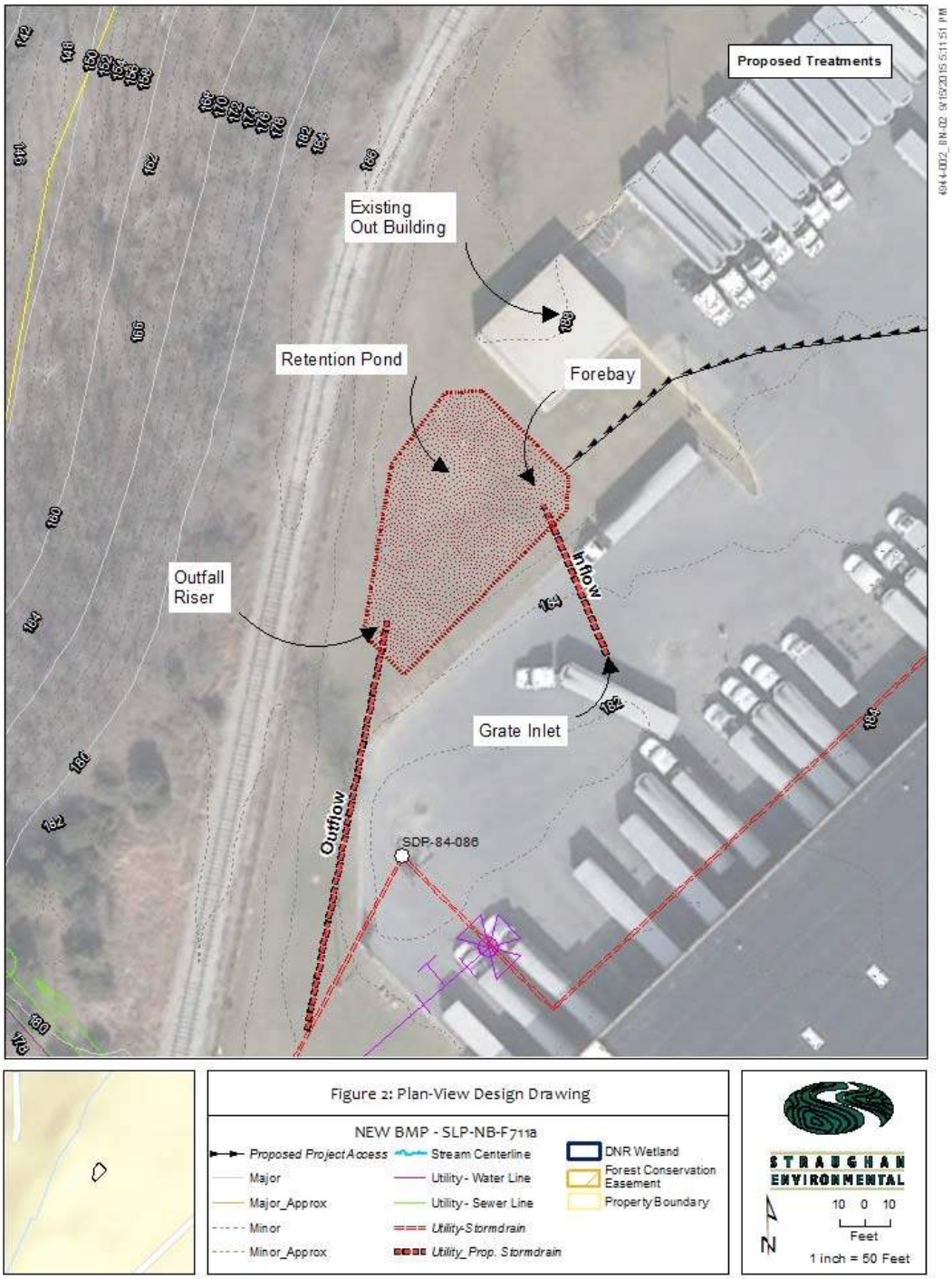
Howard County Watershed Assessment Concept Plan: New BMP

Site ID: SLP-NB-F711a

Site Name: Maine: Paper and Food Service, Inc. - Truck Parking Lot

Contractor: Versar

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: New BMP

Site ID: SLP-NB-F711b

Site Name: Maine: Paper and Food Service, Inc. - Employee Parking Lot

Contractor: Versar

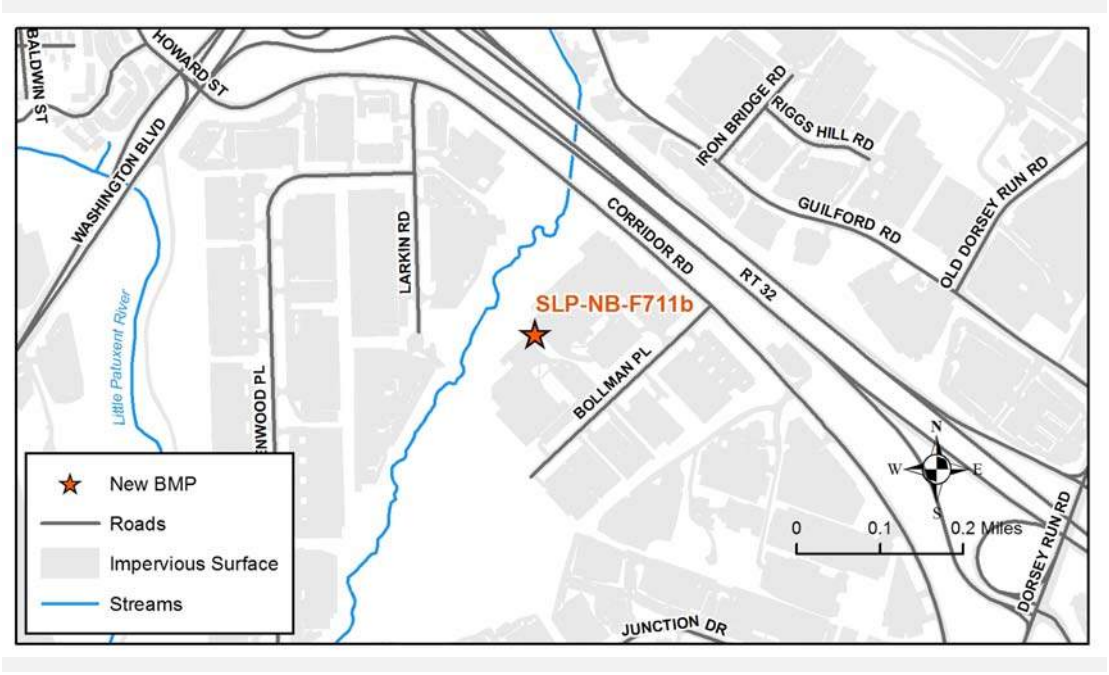
Watershed: Little Patuxent River

Proposed BMP Type: Bioretention

Ownership: Private- Commercial/Industrial
Multiple Owners

Existing Conditions:

This site is located between SLP-NB-F711a and SLP-NB-F712a. The site is mostly parking lot with a single storm drain system. Treatment in this area will be limited to the parking lot (no buildings).



Howard County Watershed Assessment Concept Plan: New BMP

Site ID: SLP-NB-F711b

Site Name: Maine: Paper and Food Service, Inc. - Employee Parking Lot

Contractor: Versar

Watershed: Little Patuxent River

Google Maps aerial image centered on proposed treatment option location.

Howard County Watershed Assessment Concept Plan: New BMP

Site ID: SLP-NB-F711b
Site Name: Maine: Paper and Food Service, Inc. - Employee Parking Lot
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:

The depth of the existing storm drain system in this site area is unknown. This information will determine if a bioretention facility can be properly graded.

Concept Description:

Maintaining the existing storm drain system, a bioretention facility is proposed at the west end of the drainage area. Downstream of the westernmost curb/grate inlet a new manhole will be constructed and a pipe installed to convey the runoff into the east end of the new bioretention facility. At the west end of the bioretention facility runoff will pass through the underdrain and a K-Type inlet into the existing large diameter storm drain pipe along the north side of the bioretention facility.

Nearby Opportunities:

None recommended

Proposed Project Credit		Water Quality Volume	
Drainage Area (ac.):	3.68	WQVolume Target (cft.):	6,483
Impervious Area within Drainage (ac.):	1.78	Max Treated (cft.):	7,131
Impervious Area Treated (ac.):	1.78	Percent Treated:	110%
Impervious Area Treated Credit (ac.):	1.78	Rainfall Depth Treated (in.):	1.1

Costs

Estimated Design Cost:	$120.000.00
Estimated Construction Cost:	$100,000.00
30% Contingency:	$30,000.00
Estimated Total Cost	$250,000.00
Cost per Impervious Credit Acre:	$140,449.44

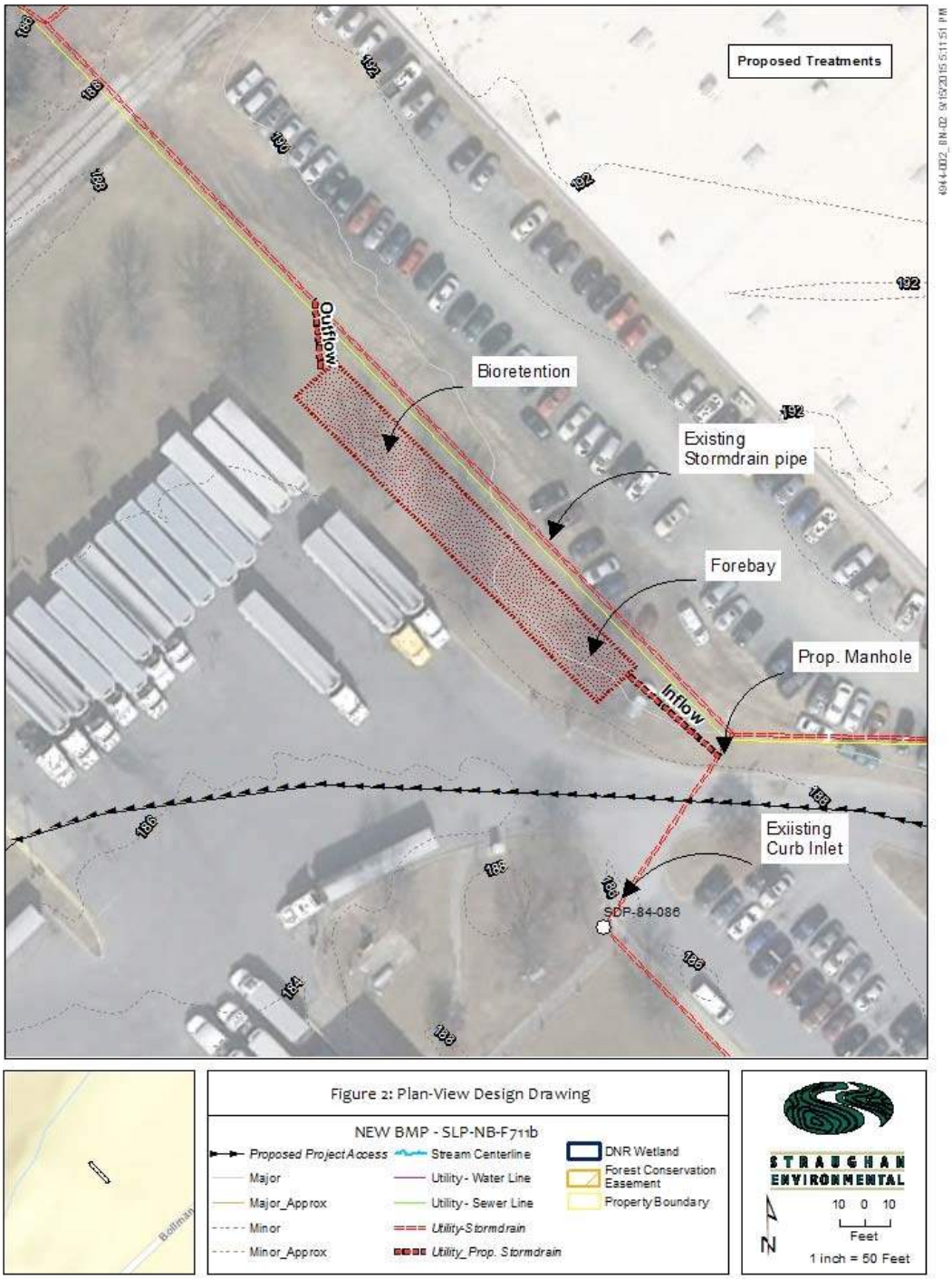
Howard County Watershed Assessment Concept Plan: New BMP

Site ID: SLP-NB-F711b

Site Name: Maine: Paper and Food Service, Inc. - Employee Parking Lot

Contractor: Versar

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: New BMP

Site ID: **SLP-NB-F712a**

Site Name: **Coastal Sunbelt Produce - Employee Parking Lot**

Contractor: Versar

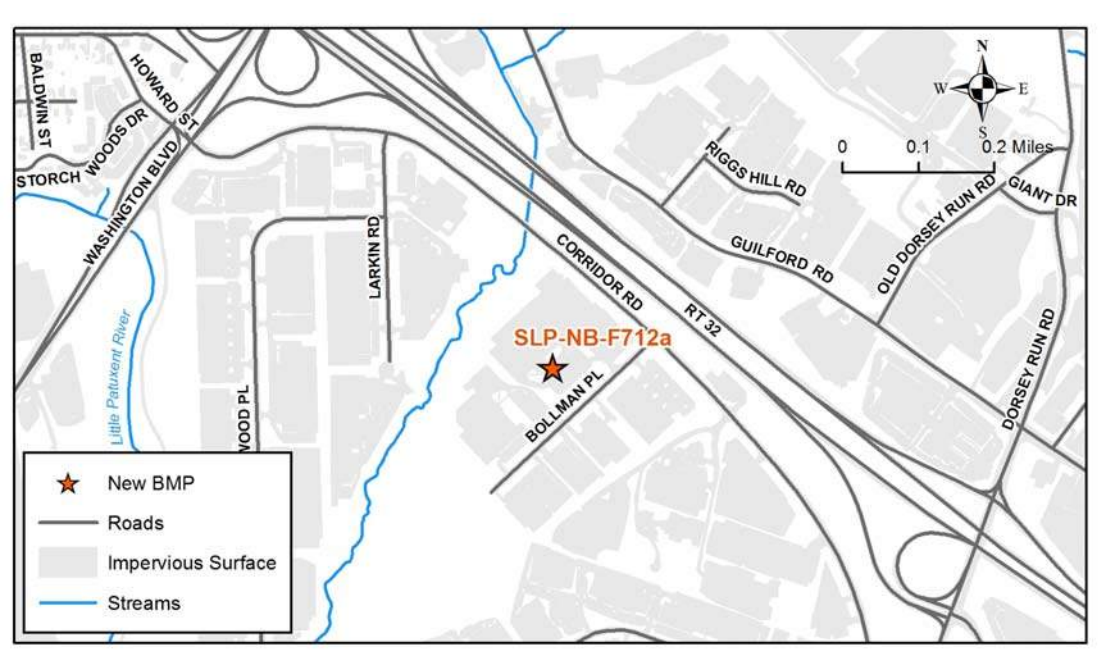
Watershed: Little Patuxent River

Proposed BMP Type: Retention Pond (Wet Pond)

Ownership: Private- Commercial/Industrial
Single Owner

Existing Conditions:

Site is an industrial food processing facility with heavy truck traffic and a large amount of employee parking. The employee parking has been expanded along the south side of the warehouse with a gravel parking laid down over existing turf and curb. The existing stormwater system in the east parking lot has at-grade inlets with brick boxes. This system discharges south into a manhole where it then is conveyed west to the outlet point at the river.



Howard County Watershed Assessment Concept Plan: New BMP

Site ID: SLP-NB-F712a
Site Name: Coastal Sunbelt Produce - Employee Parking Lot
Contractor: Versar
Watershed: Little Patuxent River

The stormwater system grates (3) in the east parking lot.

Sidewalk along west side of east parking lot (in direction of stormwater discharge).

Howard County Watershed Assessment Concept Plan: New BMP

Site ID: SLP-NB-F712a
Site Name: Coastal Sunbelt Produce - Employee Parking Lot
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:

Water line along west side of east parking lot. Electric lines for parking lights. Possible electric lines for warehouse refrigerator unit. Temporary loss of some parking during construction. Will need to notify CSX Railroad for work within 100 ft. of tracks.

Concept Description:

Construct a retention pond (wet pond) in the southeast corner of the property. This will require redirecting the stormwater in the west corner of the parking lot through a new pipe into the wet pond. A baffle will be needed to prevent short-circuit of flow to the wet pond outfall. The wet pond outfall will be near the inflow pipe, and connect the existing storm drain system to the southwest. This location will allow treatment of all impervious area within the east parking area with minimal impact to utilities.

Nearby Opportunities:

None recommended

Proposed Project Credit		Water Quality Volume	
Drainage Area (ac.):	8.96	WQVolume Target (cft.):	22,110
Impervious Area within Drainage (ac.):	6.27	Max Treated (cft.):	24,321
Impervious Area Treated (ac.):	6.27	Percent Treated:	110%
Impervious Area Treated Credit (ac.):	6.27	Rainfall Depth Treated (in.):	1.1

Costs

Estimated Design Cost:	$120,000.00
Estimated Construction Cost:	$152,314.00
30% Contingency:	$45,694.20
Estimated Total Cost	$318,008.20
Cost per Impervious Credit Acre:	$50,719.01

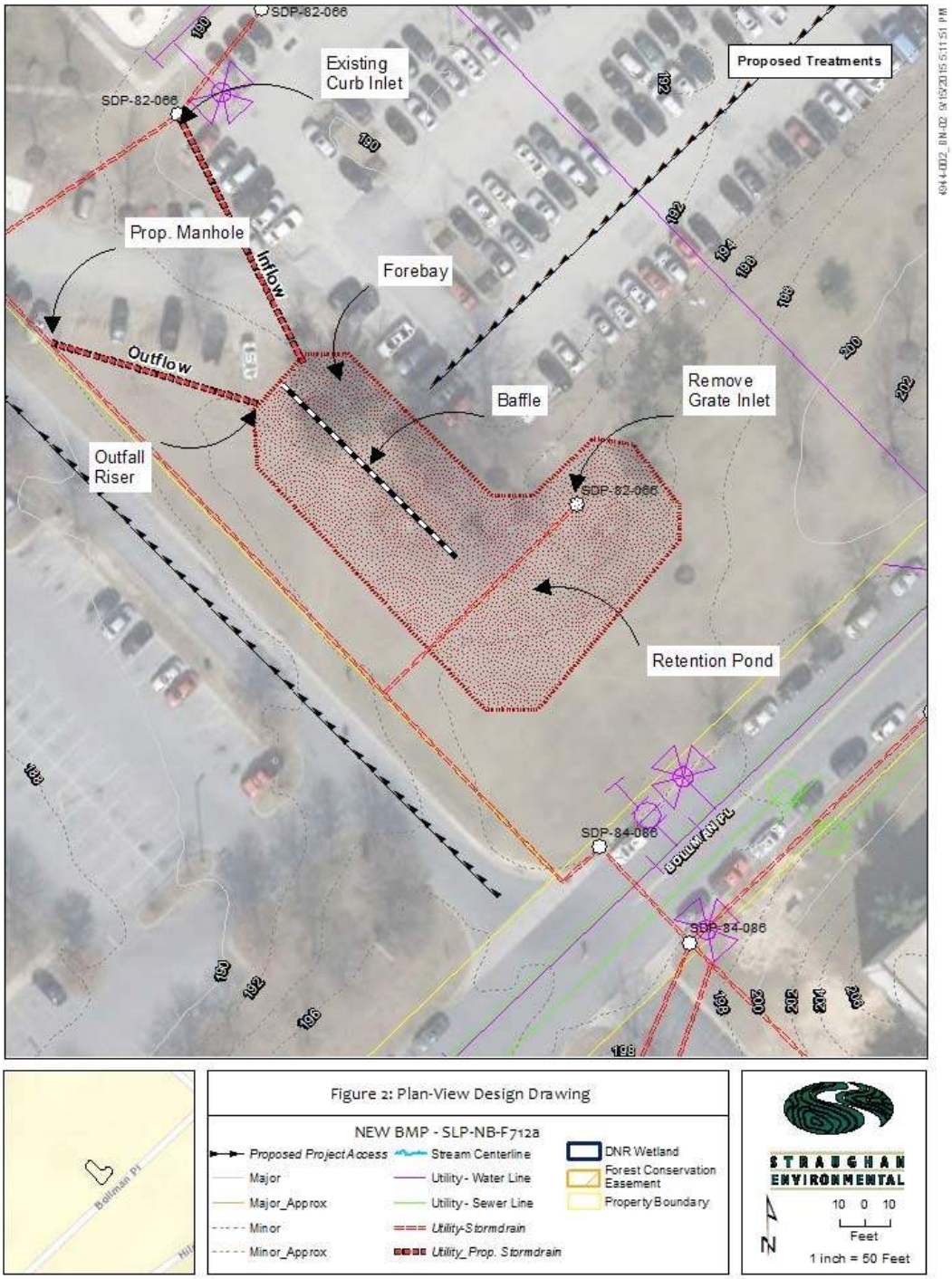
Howard County Watershed Assessment Concept Plan: New BMP

Site ID: SLP-NB-F712a

Site Name: Coastal Sunbelt Produce - Employee Parking Lot

Contractor: Versar

Watershed: Little Patuxent River



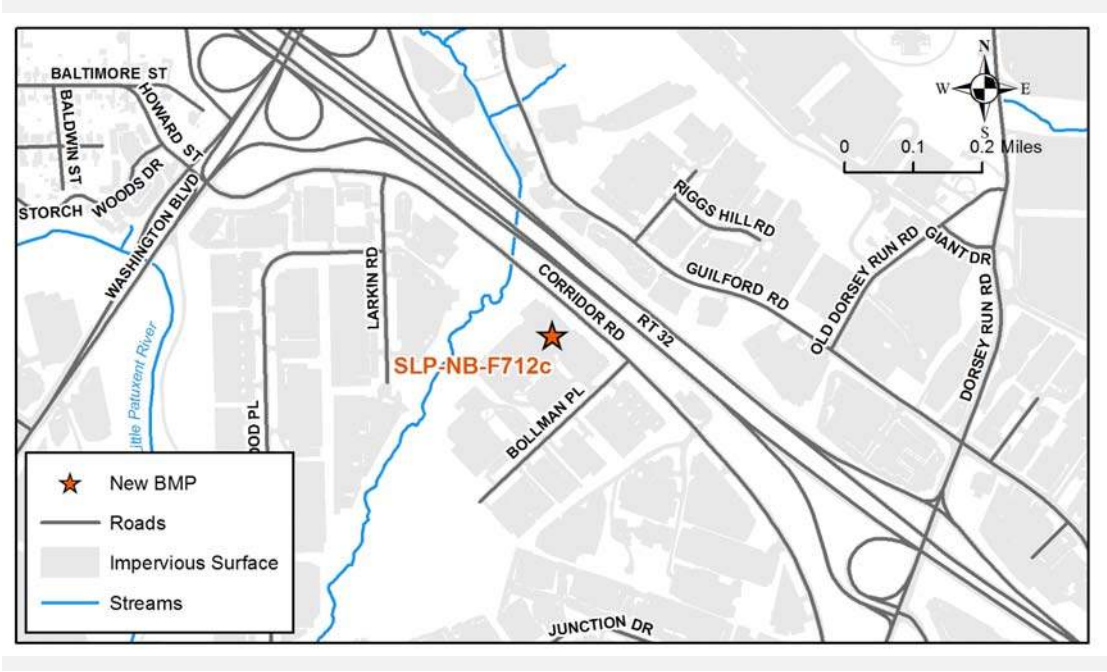
Howard County Watershed Assessment Concept Plan: New BMP

Site ID: SLP-NB-F712c
Site Name: Coastal Sunbelt Produce - Truck Parking Lot
Contractor: Versar
Watershed: Little Patuxent River

Proposed BMP Type: Bioretention
Ownership: Private- Commercial/Industrial
Single Owner

Existing Conditions:

The north parking lot (trucks only) has a stormwater system which conveys runoff west into a manhole before discharging south between a railroad spur and steep river bank. The outfall pipe connects to the same outfall point at the river for the East parking lot (SLP-NB-F712a). The outfall pipe has a large concrete box about 50 ft. upstream of a river. This outfall pipe is about 6 ft. in diameter. In the north parking lot is a third stormwater system that collects runoff from the loading dock area into an interceptor. It is believed the interceptor outlets to the stormwater system in the north parking lot.



Howard County Watershed Assessment Concept Plan: New BMP

Site ID: SLP-NB-F712c
Site Name: Coastal Sunbelt Produce - Truck Parking Lot
Contractor: Versar
Watershed: Little Patuxent River

Standing on west end of north lot looking east. First of two at-grade inlets in foreground.

Independent stormwater system for docking bays evident by concrete sloping back to slotted drain along docking bays.

Howard County Watershed Assessment Concept Plan: New BMP

Site ID: SLP-NB-F712c
Site Name: Coastal Sunbelt Produce - Truck Parking Lot
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:

Depth of existing storm drain pipe is unknown and may affect ability to design of a bioretention facility. Heavy truck traffic and truck storage area. A sewer manhole found west side of north lot with unknown pipe directions (may connect to warehouse). Loss of a few parking spaces during construction may occur. Will need to notify CSX Railroad for work within 100 ft. of tracks.

Concept Description:

The recommended location for the bioretention facility is the pervious area west of the railroad spur. The advantage here is no disturbance to parking and system will not need to accommodate H-20 Loads. The disadvantage is proximity to railroad spur, and 20 ft. tall bank.

Nearby Opportunities:

None recommended

Proposed Project Credit		Water Quality Volume	
Drainage Area (ac.):	3.17	WQVolume Target (cft.):	9,886
Impervious Area within Drainage (ac.):	2.85	Max Treated (cft.):	10,875
Impervious Area Treated (ac.):	2.85	Percent Treated:	110%
Impervious Area Treated Credit (ac.):	2.85	Rainfall Depth Treated (in.):	1.1

Costs

Estimated Design Cost:	$120.000.00
Estimated Construction Cost:	$173,515.00
30% Contingency:	$52,054.50
Estimated Total Cost	$345,569.50
Cost per Impervious Credit Acre:	$121,252.46

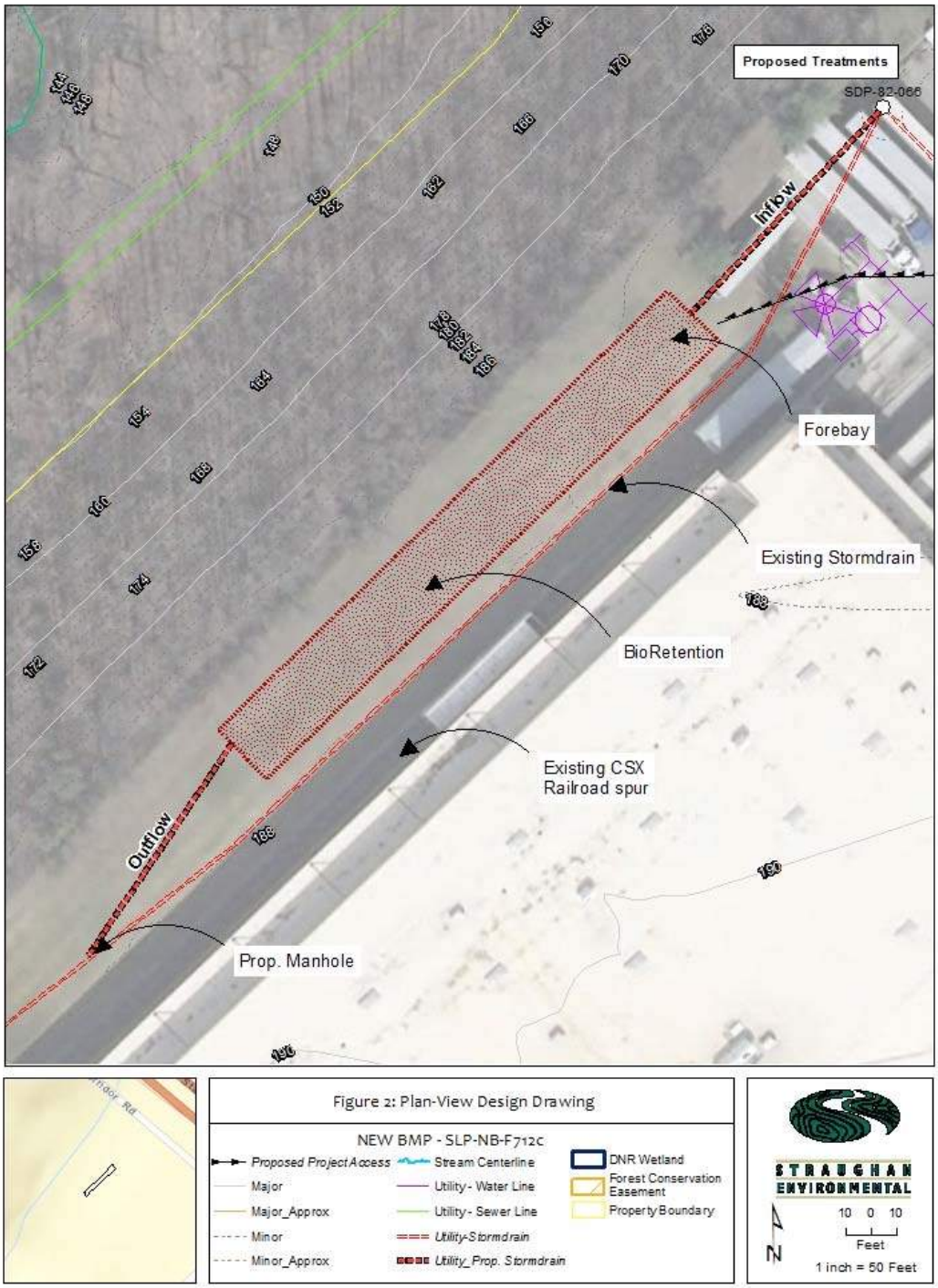
Howard County Watershed Assessment Concept Plan: New BMP

Site ID: SLP-NB-F712c

Site Name: Coastal Sunbelt Produce - Truck Parking Lot

Contractor: Versar

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: New BMP

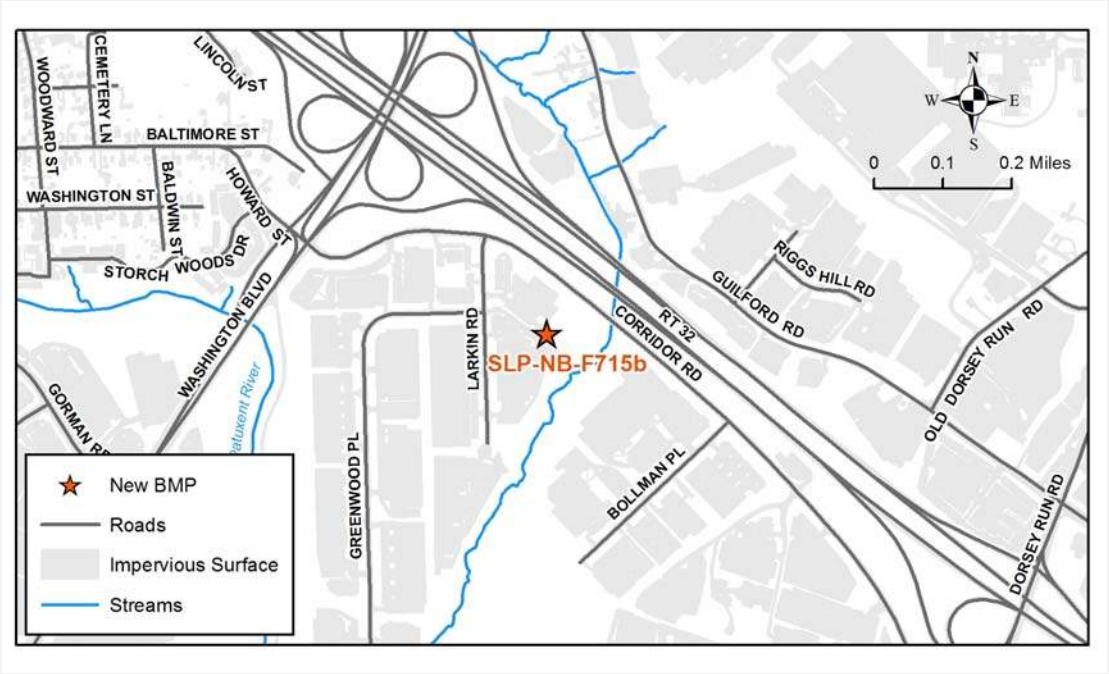
Site ID: SLP-NB-F715b
Site Name: JFC International, Inc.

Contractor: Versar
Watershed: Little Patuxent River

Proposed BMP Type: Retention Pond (Wet Pond)
Ownership: Private- Commercial/Industrial
Single Owner

Existing Conditions:

Stormwater on site all drains to the southeast corner of the property, where it is conveyed across a wooded area to a tributary of Little Patuxent River. There is a parking lot located on the east side of the building. There is also a steep (2:1) bank along the south side of the property. No downspouts on the building could be found, indicating that the rooftop runoff drains into the stormwater system.



Howard County Watershed Assessment Concept Plan: New BMP

Site ID: SLP-NB-F715b
Site Name: JFC International, Inc.

Contractor: Versar
Watershed: Little Patuxent River

Grate inlet looking into area for proposed extended detention wet pond.

Area behind grate in above photo.

Howard County Watershed Assessment Concept Plan: New BMP

Site ID: SLP-NB-F715b
Site Name: JFC International, Inc.
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:

The proposed stormwater management facility must keep a safe distance (20 to 30 ft.) from the bank along the south side of the property.

Concept Description:

Build a wet pond in the wooded area (mostly pear trees) located east of the manhole (not found) downstream of the curb/grate inlet. Use the existing storm drain pipe for both inflow to and outflow from the new facility.

Nearby Opportunities:

None recommended

Proposed Project Credit		Water Quality Volume	
Drainage Area (ac.):	4.55	WQVolume Target (cft.):	11,280
Impervious Area within Drainage (ac.):	3.2	Max Treated (cft.):	12,408
Impervious Area Treated (ac.):	3.2	Percent Treated:	110%
Impervious Area Treated Credit (ac.):	3.2	Rainfall Depth Treated (in.):	1.1

Costs

Estimated Design Cost:	$120,000.00
Estimated Construction Cost:	$104,063.00
30% Contingency:	$31,218.90
Estimated Total Cost	$255,281.90
Cost per Impervious Credit Acre:	$79,775.59

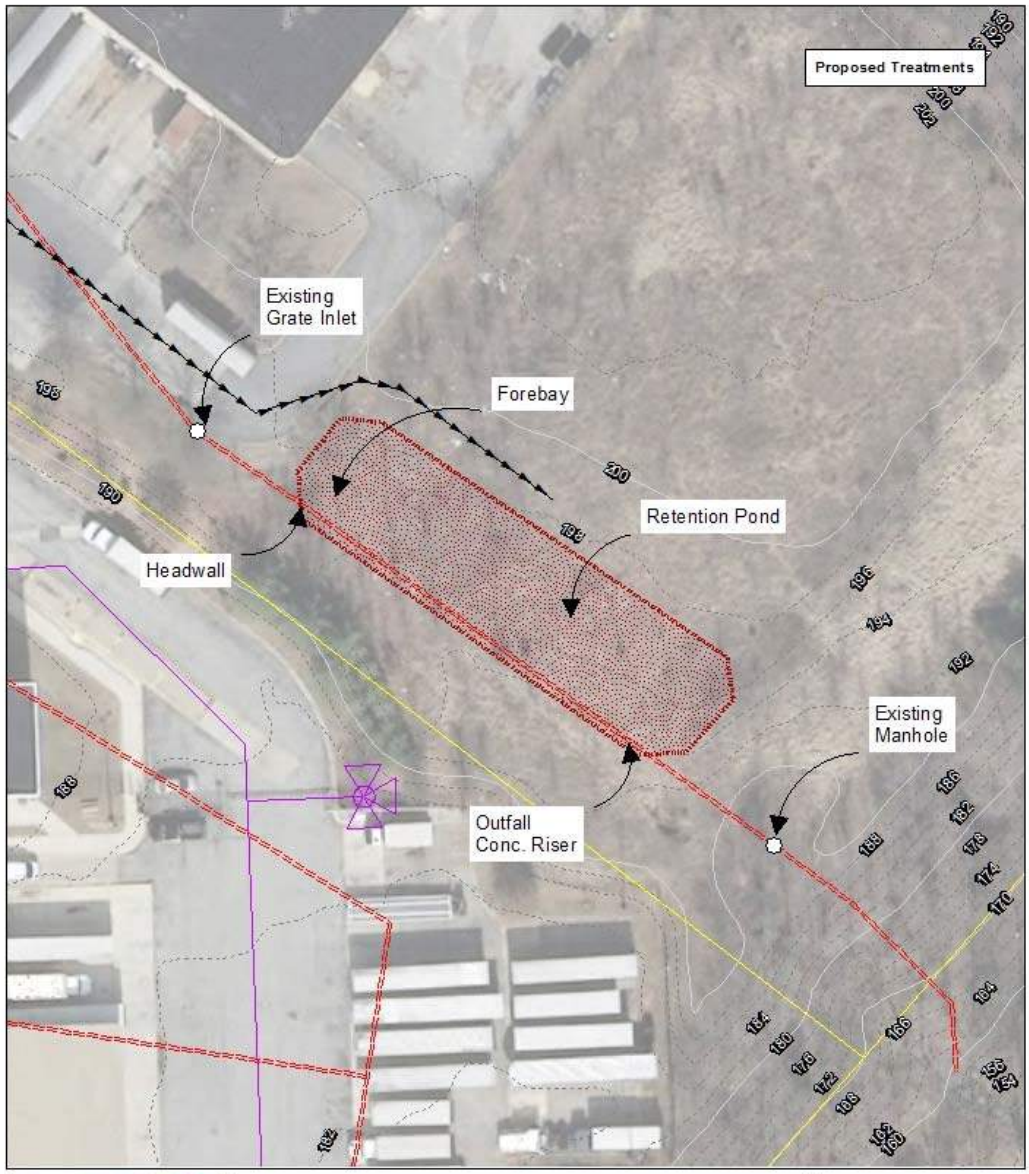
Howard County Watershed Assessment Concept Plan: New BMP

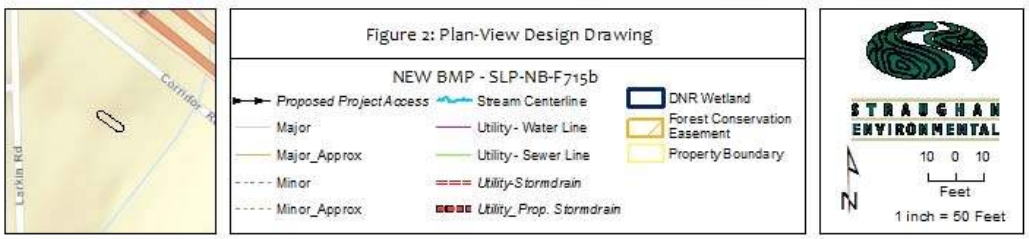
Site ID: SLP-NB-F715b

Site Name: JFC International, Inc.

Contractor: Versar

Watershed: Little Patuxent River





Howard County Watershed Assessment Concept Plan: New BMP

Site ID: **SLP-NB-F722d**

Site Name: **Weis Market**

Contractor: Versar

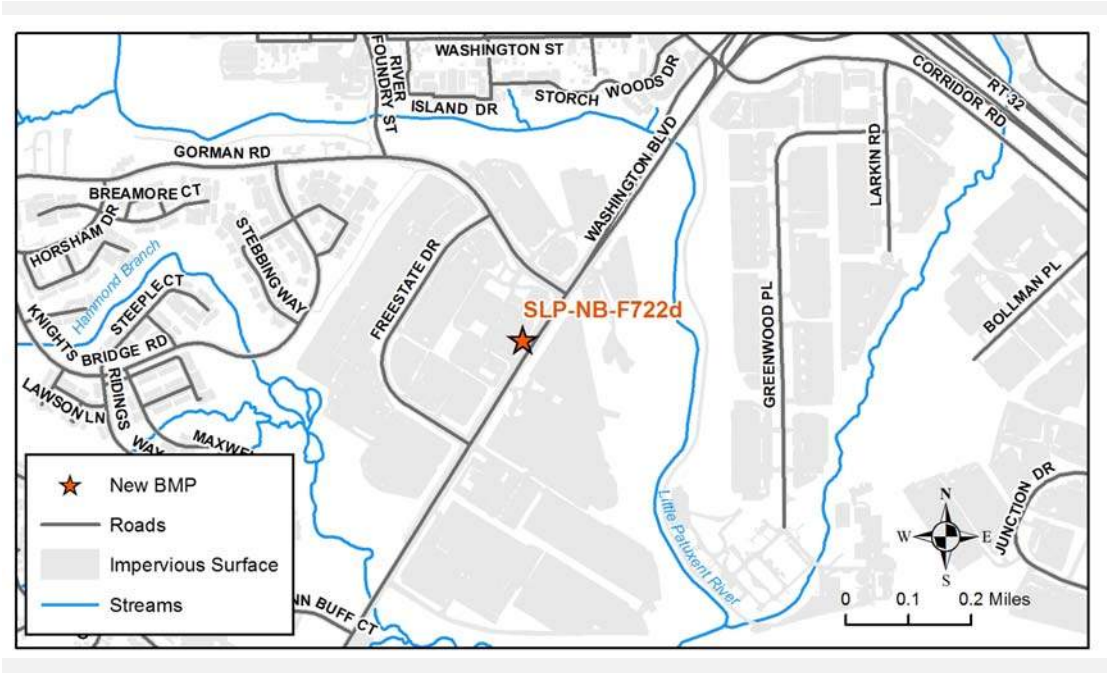
Watershed: Little Patuxent River

Proposed BMP Type: Perimeter (Sand) Filter

Ownership: Private- Commercial/Industrial
Single Owner

Existing Conditions:

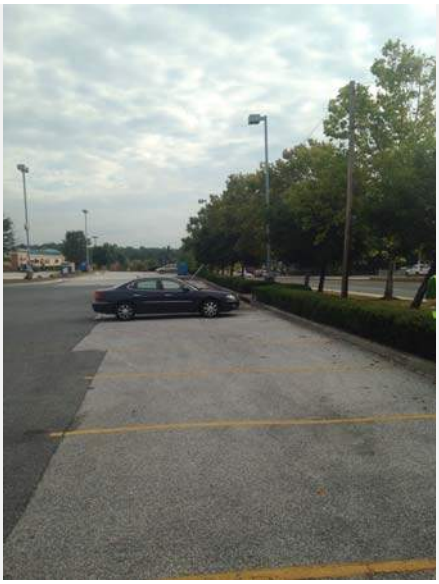
There is a single flow path in the south portion of the parking lot which conveys runoff towards an existing gas station before entering a curb/grate opening in the southeast corner of the parking lot. Along Route 1, adjacent to the parking lot, is a fiber optic line and overhead utilities. The parking lot serving the multi-unit commercial building north of the main parking lot drains to the north. It appears the roof of Weis Market drains into a storm drain system at the back of the building.



Howard County Watershed Assessment Concept Plan: New BMP

Site ID: SLP-NB-F722d
Site Name: Weis Market

Contractor: Versar
Watershed: Little Patuxent River



Proposed treatment option area for perimeter sand filter.

Existing principal inlet structure.

Howard County Watershed Assessment Concept Plan: New BMP

Site ID: SLP-NB-F722d
Site Name: Weis Market
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:

An existing gas station in the southeast corner of the parking lot. Maintaining the existing storm drain system under the proposed perimeter sand filter. A utility pole/guy wire will need to be relocated or removed.

Concept Description:

Construct a perimeter sand filter (underground) along the southeast side of the parking lot. The standard underground perimeter sand filter will need to be modified so that the sand filter is in front of (under parking spaces) and the grates will be against the concrete curb. It will also need to avoid conflict with the existing storm drain system. Perthe Maryland Department of Environment Stormwater Manual (2000) Section 4.1, Table 4.1 filtration systems such as underground sand filters are acceptable in hotspots, such as gas stations, so long as there is no exfiltration. Since the underground sand filter is contained no discharge will result in percolation or absorption into the surrounding soil.

Nearby Opportunities:

None recommended

Proposed Project Credit		Water Quality Volume	
Drainage Area (ac.):	2.56	WQVolume Target (cft.):	7,946
Impervious Area within Drainage (ac.):	2.29	Max Treated (cft.):	8,741
Impervious Area Treated (ac.):	2.29	Percent Treated:	110%
Impervious Area Treated Credit (ac.):	2.29	Rainfall Depth Treated (in.):	1.1

Costs

Estimated Design Cost:	$120,000.00
Estimated Construction Cost:	$145,955.00
30% Contingency:	$43,786.50
Estimated Total Cost	$309,741.50
Cost per Impervious Credit Acre:	$135,258.30

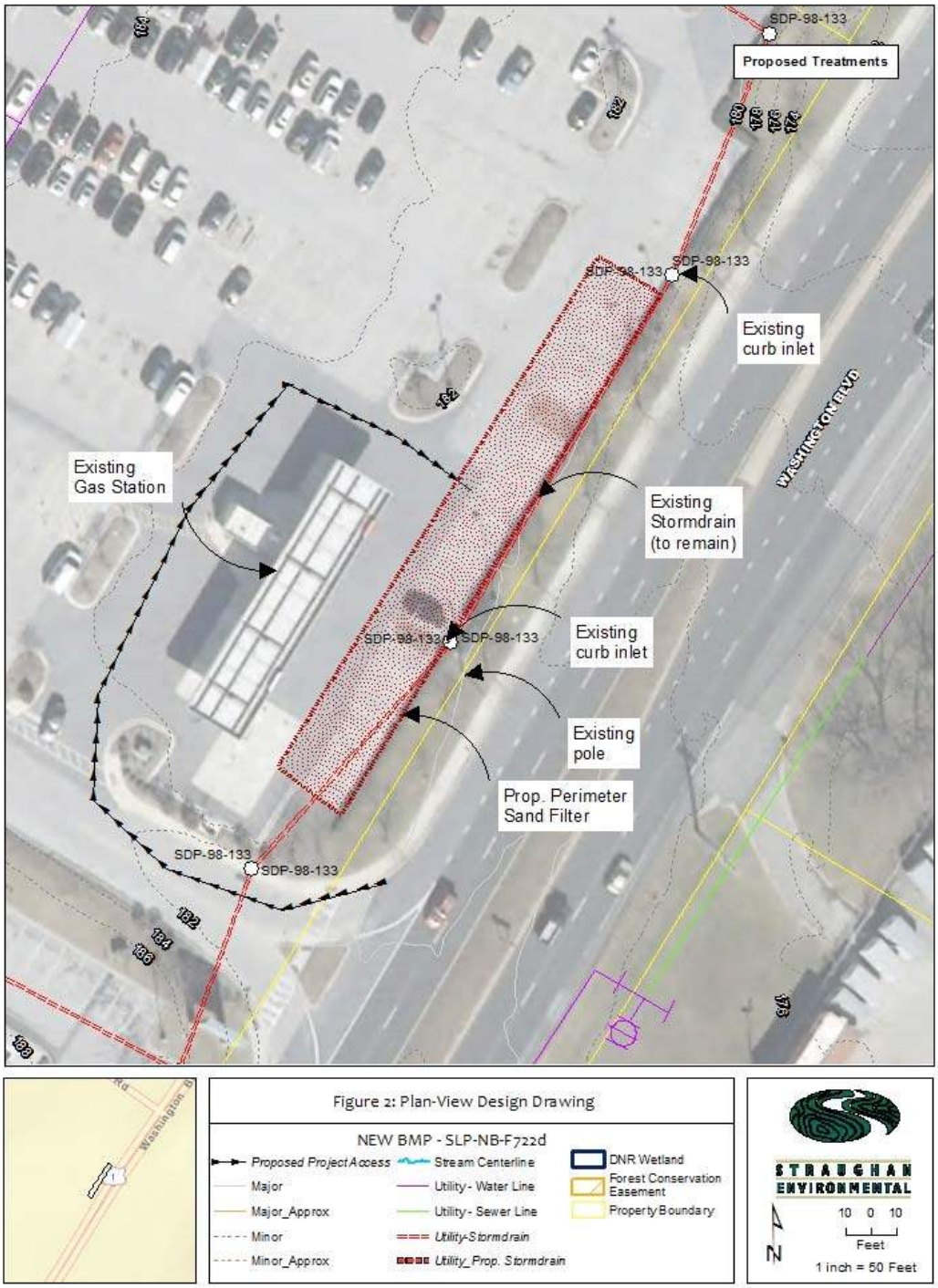
Howard County Watershed Assessment Concept Plan: New BMP

Site ID: **SLP-NB-F722d**

Site Name: **Weis Market**

Contractor: Versar

Watershed: Little Patuxent River



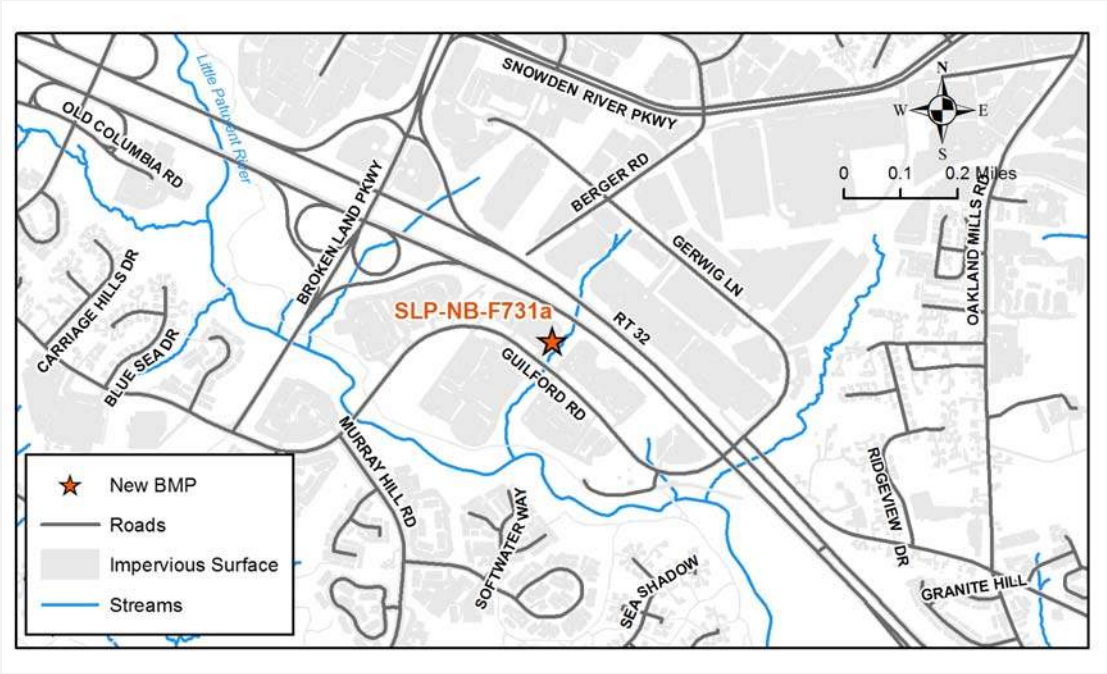
Howard County Watershed Assessment Concept Plan: New BMP

Site ID: SLP-NB-F731a
Site Name: Rivers Technology Park
Contractor: Versar
Watershed: Little Patuxent River

Proposed BMP Type: Perimeter (Sand) Filter
Ownership: Private- Commercial/Industrial
Single Owner

Existing Conditions:

The runoff from this site flows from the northwest parking area and building into two independent sub-areas (north and south) toward a tributary along the southeast side of the site. All three buildings for this site have rain spouts that discharge directly into the parking lot. The existing inlet structures at the southeast side of the building discharge directly into the adjacent tributary.



Howard County Watershed Assessment Concept Plan: New BMP

Site ID: SLP-NB-F731a
Site Name: Rivers Technology Park

Contractor: Versar
Watershed: Little Patuxent River

Proposed treatment option area for underground filtration.

Proposed treatment area for BMP pond facility.

Howard County Watershed Assessment Concept Plan: New BMP

Site ID: SLP-NB-F731a
Site Name: Rivers Technology Park
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:

The main constraints to this opportunity are the potential lack of elevation difference needed to discharge the filtration underdrains and possible high groundwater.

Concept Description:

Construct an underground perimeter sand filter to treat the southeast portion of the existing impervious area. Due to possible high groundwater and lack of elevation drop it is unlikely the impervious area along the northeast side of the property can be treated without substantial regrading of the parking lot (east end). As part of the proposed improvements the existing southeast grate inlet would be removed and some regrading of the parking spaces may be needed.

Nearby Opportunities:

None recommended

Proposed Project Credit		Water Quality Volume	
Drainage Area (ac.):	1.43	WQVolume Target (cft.):	4,409
Impervious Area within Drainage (ac.):	1.27	Max Treated (cft.):	4,849
Impervious Area Treated (ac.):	1.27	Percent Treated:	110%
Impervious Area Treated Credit (ac.):	1.27	Rainfall Depth Treated (in.):	1.1

Costs

Estimated Design Cost:	$120.000.00
Estimated Construction Cost:	$159,770.00
30% Contingency:	$47,931.00
Estimated Total Cost	$327,701.00
Cost per Impervious Credit Acre:	$258,032.28

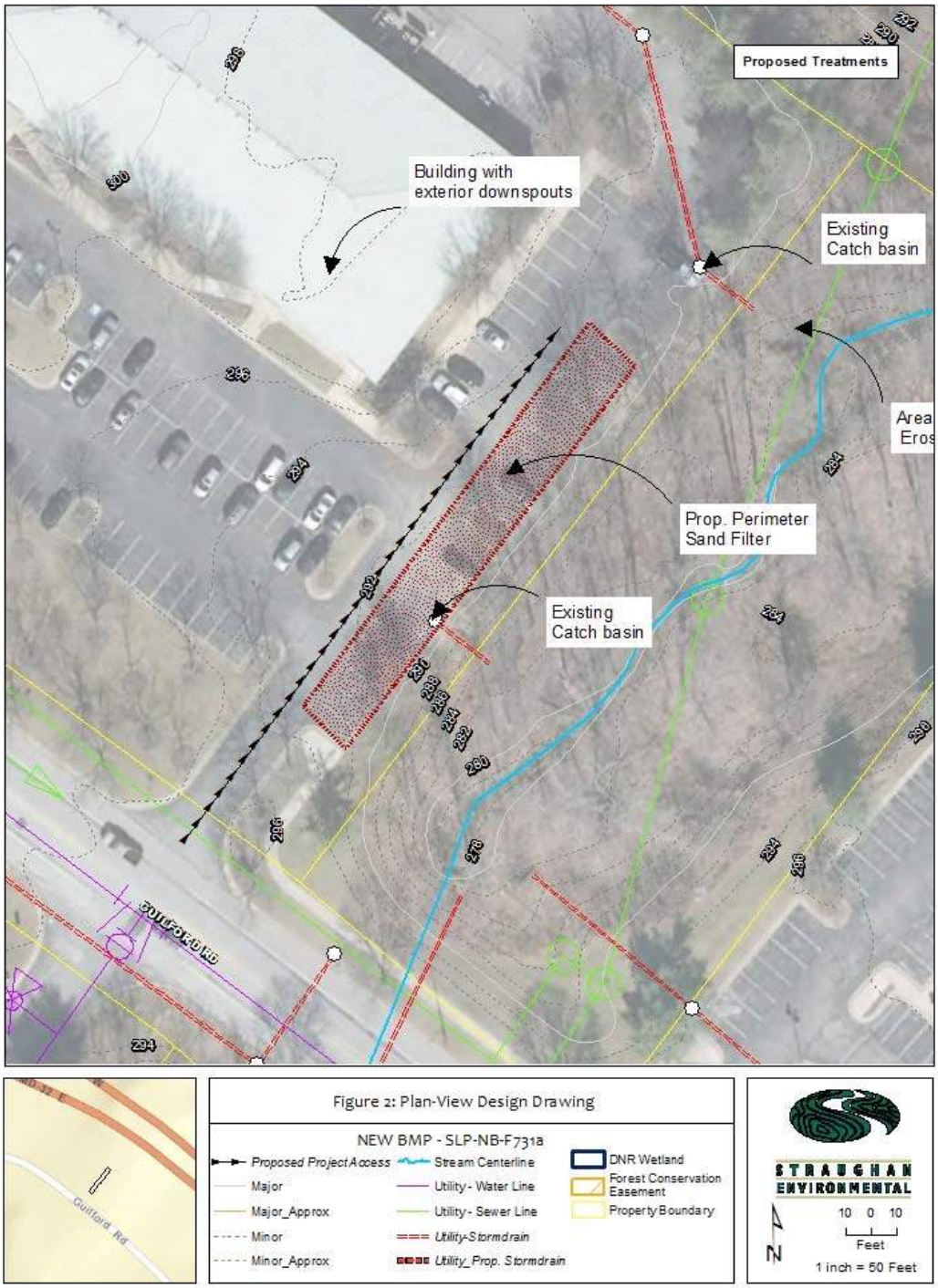
Howard County Watershed Assessment Concept Plan: New BMP

Site ID: SLP-NB-F731a

Site Name: Rivers Technology Park

Contractor: Versar

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: New BMP

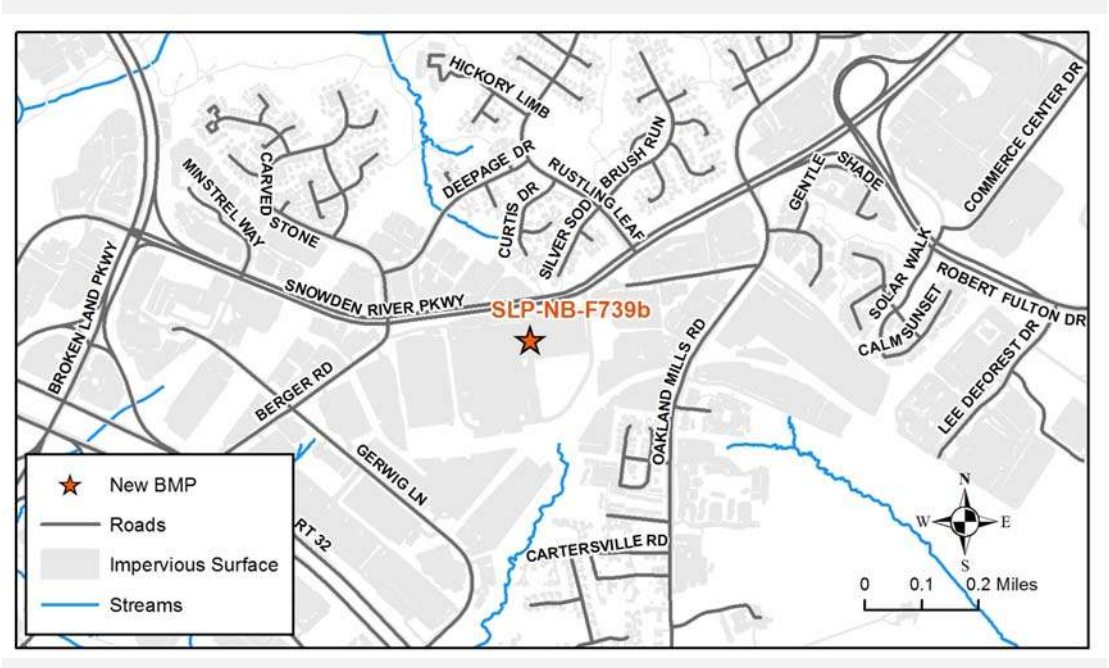
Site ID: SLP-NB-F739b
Site Name: Lincoln Technology Institute

Contractor: Versar
Watershed: Little Patuxent River

Proposed BMP Type: Underground Filter
Ownership: Private- Commercial/Industrial
Single Owner

Existing Conditions:

There are two sub-drainage areas for this property. The primary drainage area discharges through a large-diameter storm drain pipe system to the southeast corner of the property. The one important landmark for this larger drainage area is an existing cylinder tower on the east side of the building. The parking area north and east of this tower is served by two catch basins (6 sf. or less) with at-grade grates. The portion of the building north of the tower drains into the same catch basins. It will need to be determined if all of the main building roof runoff drains to the east or if only the east half of the building does. A secondary drainage area is the strip of parking along the north side of the property. This drainage area lacks an adequate discharge point resulting in regular flooding (per facility manager comments).



Howard County Watershed Assessment Concept Plan: New BMP

Site ID: SLP-NB-F739b
Site Name: Lincoln Technology Institute

Contractor: Versar
Watershed: Little Patuxent River

Proposed treatment option for underground filtration.

Aerial image from Google Maps of new development southeast of the main building.

Howard County Watershed Assessment Concept Plan: New BMP

Site ID: SLP-NB-F739b
Site Name: Lincoln Technology Institute
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:

Unknown depth and size of existing storm drain. Research is needed to determine if the new stormwater management facility, downstream of the proposed filtration system, provides adequate WQv treatment for the proper drainage area. Possible parking impacts during construction.

Concept Description:

An underground filtration system is recommended for this sub-drainage area. The filtration system will be located northeast of the tower and west of the existing large diameter stormwater pipe. The discharge from the filtration system will be directed downstream back into the main stormwater pipe. This system should be able to treat all of the east parking lot and the northeast quarter of the main building.

Nearby Opportunities:

None recommended

Proposed Project Credit		Water Quality Volume	
Drainage Area (ac.):	7.88	WQVolume Target (cft.):	25,704
Impervious Area within Drainage (ac.):	7.43	Max Treated (cft.):	28,274
Impervious Area Treated (ac.):	7.43	Percent Treated:	110%
Impervious Area Treated Credit (ac.):	7.43	Rainfall Depth Treated (in.):	1.1

Costs

Estimated Design Cost:	$320.000.00
Estimated Construction Cost:	$748,475.00
30% Contingency:	$224,542.50
Estimated Total Cost	$1,293,017.50
Cost per Impervious Credit Acre:	$174,026.58

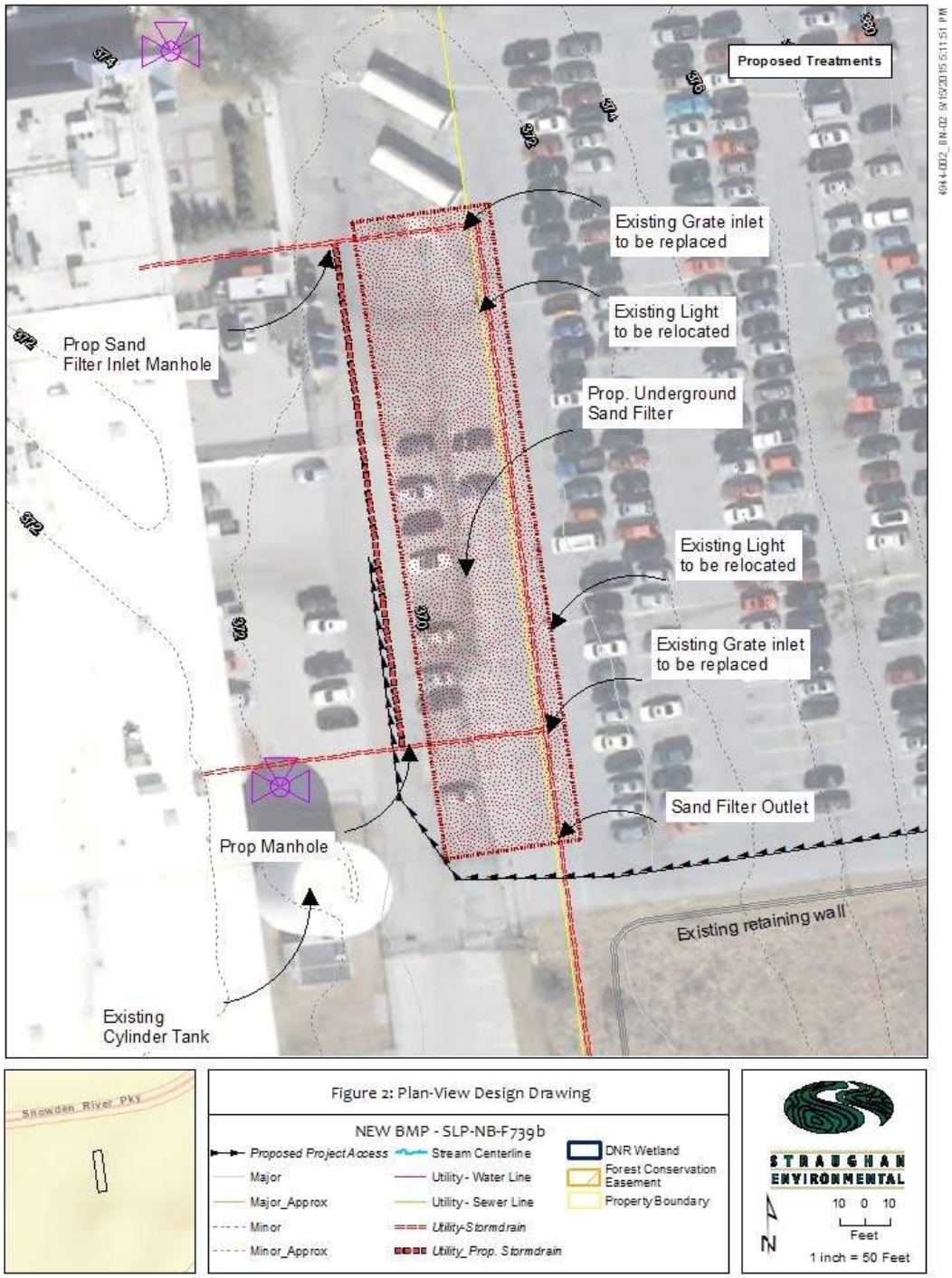
Howard County Watershed Assessment Concept Plan: New BMP

Site ID: **SLP-NB-F739b**

Site Name: **Lincoln Technology Institute**

Contractor: Versar

Watershed: Little Patuxent River



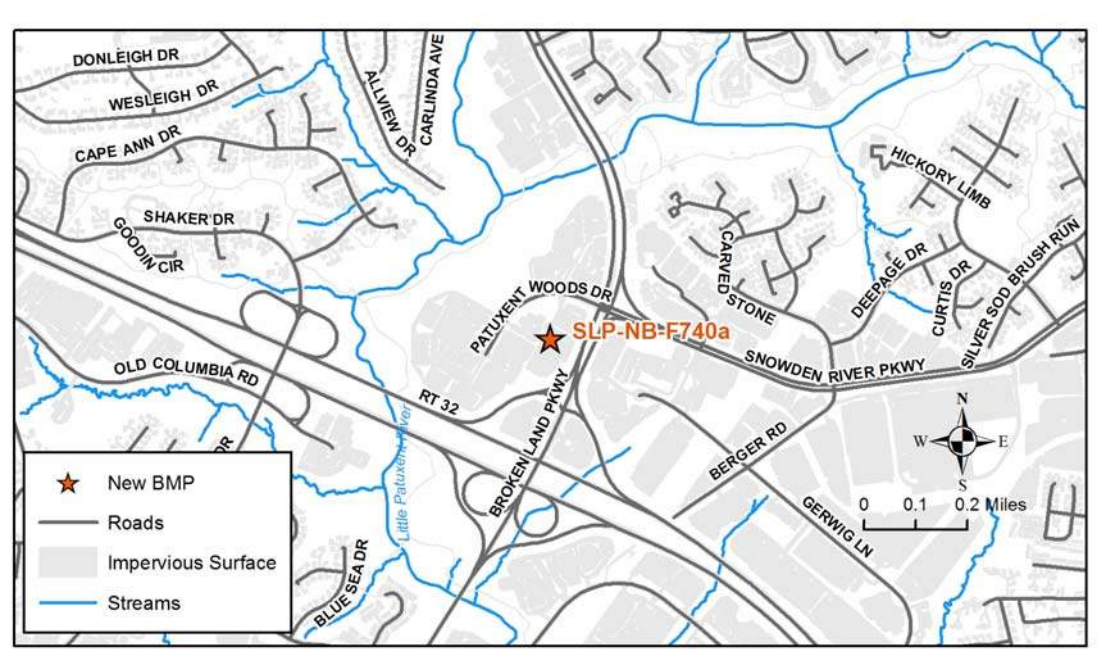
Howard County Watershed Assessment Concept Plan: New BMP

Site ID: SLP-NB-F740a
Site Name: Nielsen Company Parking Lot
Contractor: Versar
Watershed: Little Patuxent River

Proposed BMP Type: Retention Pond (Wet Pond)
Ownership: Private- Commercial/Industrial
Single Owner

Existing Conditions:

Between main building and Broken Land Parkway is a large parking area that is broken into two sub-drainage areas (north and south areas). The south area stormwater system is located in the western portion of the parking lot and conveys water from the southwest corner of the parking lot north to a junction manhole. The north area stormwater system is located in the western portion of the parking lot and conveys water from the northwest corner south to a junction manhole. The junction manhole is located in the driveway (southeast corner of main building). The discharge from this junction manhole is conveyed west to Patuxent Woods Drive in a 48 in. RCP. Plans indicate the rooftop runoff enters the storm drain system near Patuxent Woods Drive.



Howard County Watershed Assessment Concept Plan: New BMP

Site ID: SLP-NB-F740a
Site Name: Nielsen Company Parking Lot
Contractor: Versar
Watershed: Little Patuxent River

Standing on junction manhole looking south.

Standing on junction manhole looking west.

Howard County Watershed Assessment Concept Plan: New BMP

Site ID: SLP-NB-F740a
Site Name: Nielsen Company Parking Lot
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:

The only restrictions to this concept are existing inverts and crossing the existing 8 in. PVC sanitary sewer serving the main building.

Concept Description:

Construct a single retention pond (wet pond) northeast of the main building in the east portion of the lawn. A new storm drain system will be constructed starting downstream of the existing junction manhole and continue to the existing driveway northeast toward the new facility. The outfall for the new facility will be on the northwest side and consist of a new storm drain system across the lawn to Patuxent Woods Drive. From here the new storm drain system will connect into the existing system.

Nearby Opportunities:

None recommended

Proposed Project Credit		Water Quality Volume	
Drainage Area (ac.):	10.29	WQVolume Target (cft.):	19,019
Impervious Area within Drainage (ac.):	5.25	Max Treated (cft.):	20,921
Impervious Area Treated (ac.):	5.25	Percent Treated:	110%
Impervious Area Treated Credit (ac.):	5.25	Rainfall Depth Treated (in.):	1.1

Costs

Estimated Design Cost:	$220.000.00
Estimated Construction Cost:	$212,150.00
30% Contingency:	$63,645.00
Estimated Total Cost	$495,795.00
Cost per Impervious Credit Acre:	$94,437.14

Howard County Watershed Assessment Concept Plan: New BMP

Site ID: SLP-NB-F740a

Site Name: Nielsen Company Parking Lot

Contractor: Versar

Watershed: Little Patuxent River

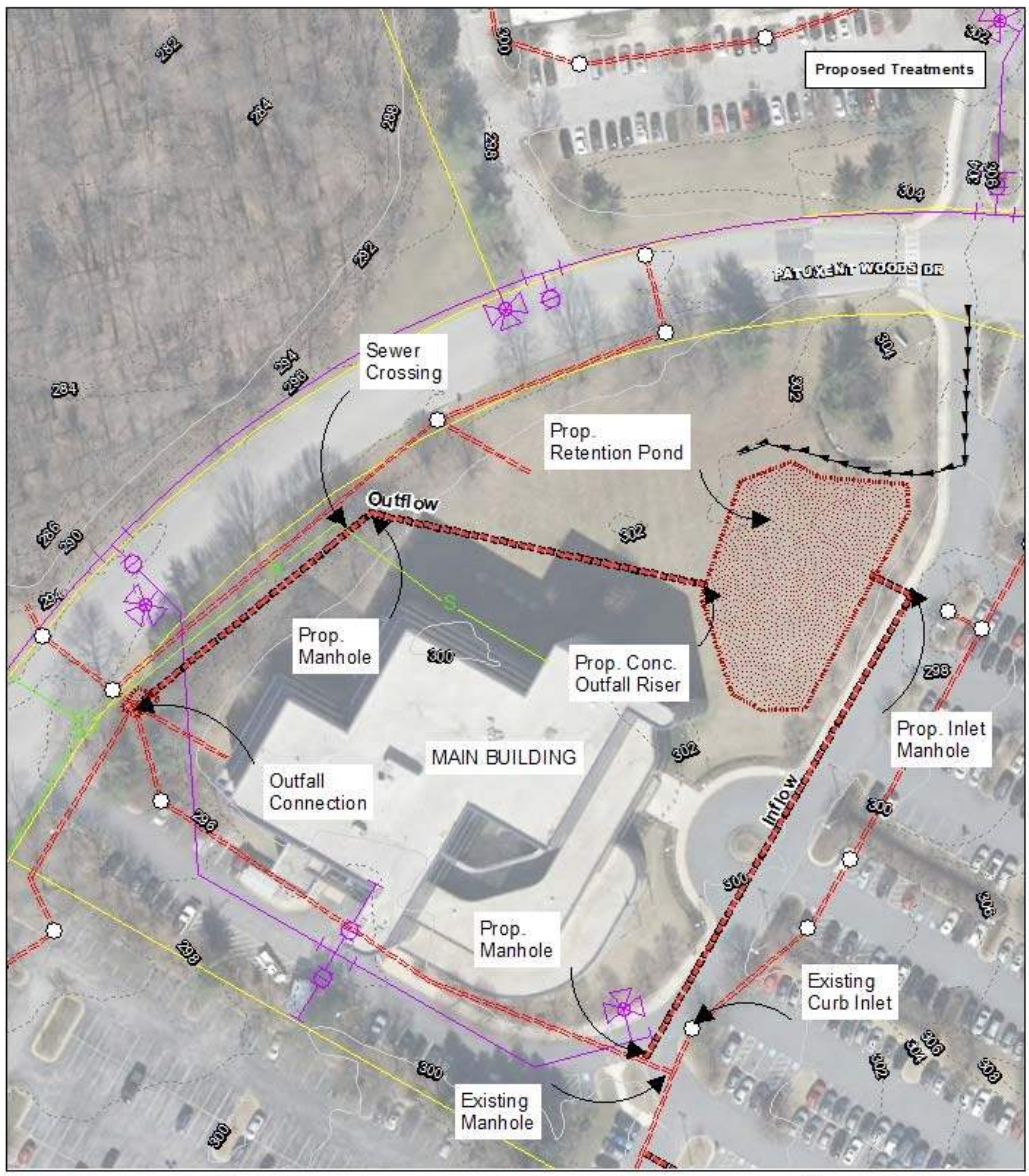


Figure 2: Plan-View Design Drawing

NEW BMP - SLP-NB-F740a

- Proposed Project Access
- Major
- Major_Approx
- Minor
- Minor_Approx
- Stream Centerline
- Utility - Water Line
- Utility - Sewer Line
- Utility-Stormdrain
- Utility_Prop. Stormdrain
- DNR Wetland
- Forest Conservation Easement
- Property Boundary

STRAUGHAN ENVIRONMENTAL

20 0 20

Feet

1 inch = 83 Feet

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F504a
Site Name: Turf Valley (a)
Contractor: KCI
Watershed: Little Patuxent River

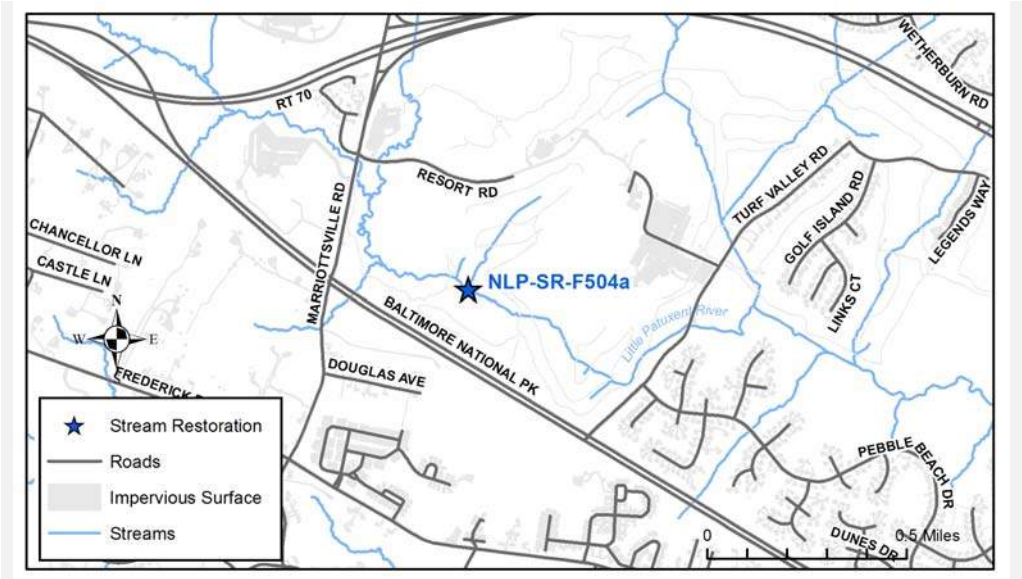
Ownership: Private- Mixed Use
Multiple Owners

Existing Conditions:

The site is a reach of the Little Patuxent River located primarily within the Turf Valley Golf Course. The reach is characterized by 3 ft. high banks that are 15 to 30 ft. in width at the top of bank. Banks are a silty material that is easily erodible due to the low root depths and lack of surface protection. Portions of the channel are located within forested sections while others are in open areas of the golf course which contain mowed turf. The stream banks are more severely eroded in the open areas that are lacking sufficient vegetation to stabilize the banks. A reach located between two forested sections of channel contains recent tree plantings.

The channel is moderately embedded with fines and the bed material is composed of mostly sand, gravel and cobble. Large amounts of sand deposition were observed in the channel. There is a moderate presence of available and good quality epifaunal substrate habitat and coverage. Two velocity/depth regimes are apparent and baseflow occupies the full channel width, reaching both banks. Riffle spacing is characterized as being approximately seven to 15 channel widths. Minor channel alterations were observed, including golf cart trail crossings.

The majority of the riparian buffer width is less than 20 ft. on both the right and left banks as the majority of stream runs through Turf Valley Golf Course, and the quality of the riparian vegetation is low, at approximately 30% cover. However, the upper portion and a section in the middle of the stream reach have a forested buffer.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F504a
Site Name: Turf Valley (a)
Contractor: KCI
Watershed: Little Patuxent River

Left bank erosion with vertical banks, poor root depth and a silty material.

Facing downstream with moderate erosion and falling trees.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F504a
Site Name: Turf Valley (a)
Contractor: KCI
Watershed: Little Patuxent River

Constraints/Utilities:

The reach runs through two private properties, the Mangione Enterprises Turf Valley property and the Turf Valley Property Owners Association. A significant amount of the reach runs through the Turf Valley Golf Course playing surface, requiring special consideration to the design and construction access. Significant coordination with Turf Valley will be needed to accomplish the project. A sewer line also parallels the channel on the right bank, approximately 8 to 65 ft. from the channel with two crossings along the reach. Given the close proximity of the reach to the golf course field of play, access and timing of construction coordination may be difficult to acquire as to not interfere with normal play.

Concept Description:

The proposed stream restoration includes widening the floodplain at the existing bankfull elevation in some areas, and other areas being stabilized in place. Stabilization will be applied to areas that are located in the golf course field of play where vegetative plantings will likely be restricted and as a result, stone bank treatments will likely be necessary to stabilize the banks. The areas of this reach containing a riparian buffer will receive a floodplain widening approach. In these areas bioengineering techniques such as coir logs and vegetative stabilization can be used to stabilize the banks. A sanitary sewer line parallels the stream channel and crosses the channel in two locations and a water line crosses the channel. Consideration will be given in the proposed design to protect the existing infrastructure. Existing bed materials are likely salvageable, but larger cobble and boulder material will be necessary to provide better riffle habitat and bank stabilization.

A planting plan will be developed for the landscape zones throughout the site that will allow for the establishment of native plant species and does not interfere with golf course field of play.

Nearby Opportunities:

None recommended

Proposed Project Credit		Costs	
Length Restored (ft):	2,662	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	26.6	Estimated Construction Cost:	$1,198,350.00
Cost per Impervious Credit Acre:	$69,791.70	30% Contingency:	$359,505.00
		Estimated Total Cost:	$1,857,855.00

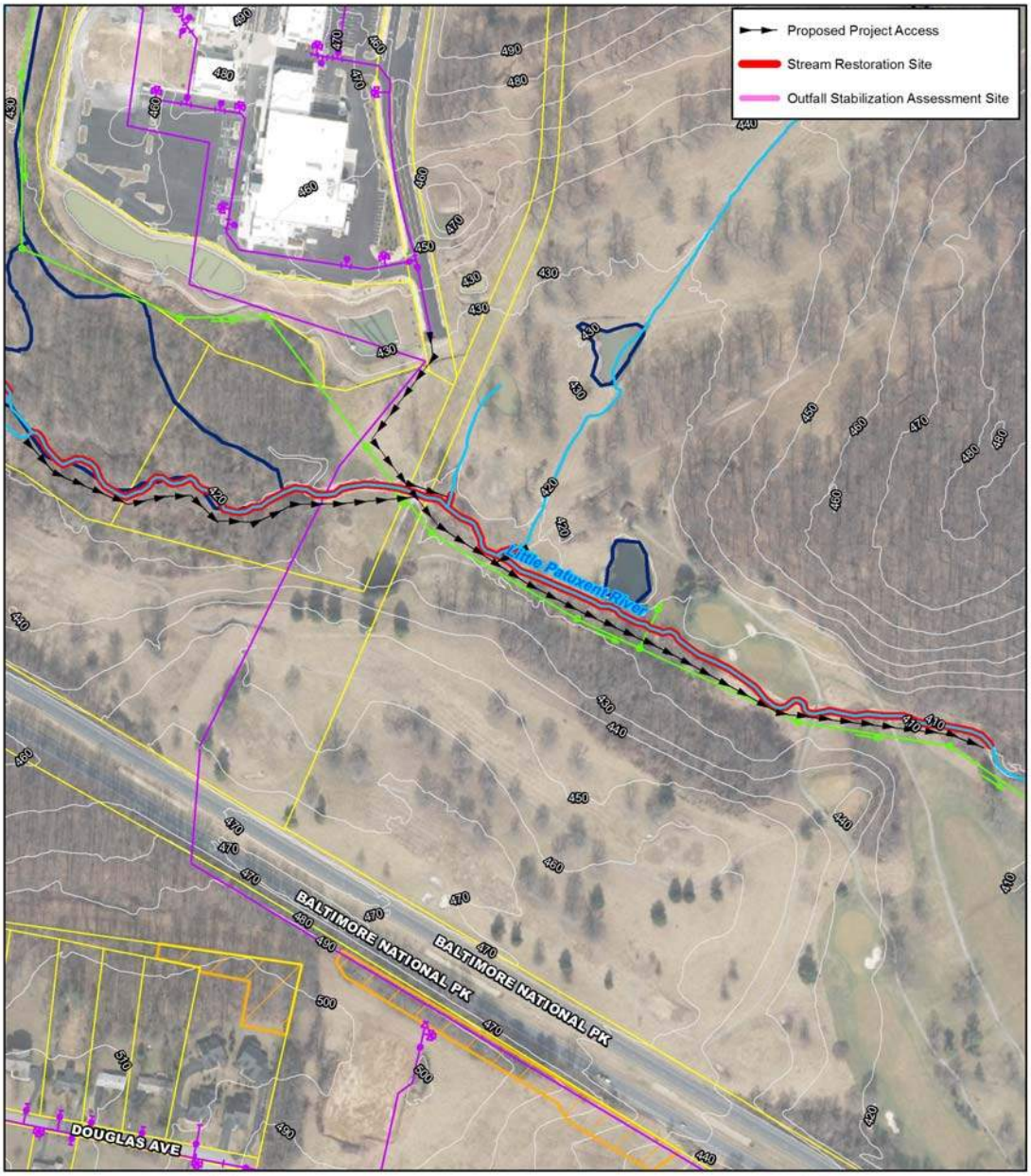
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F504a

Site Name: Turf Valley (a)

Contractor: KCI

Watershed: Little Patuxent River



Plan-View Design Drawing
Stream Restoration - NLP-SR-F504a

- Pipe Outfall
- Pipe Outfall Assessment Site
- 10 ft Contour
- Stream Centerline
- Utility - Water Line
- Utility - Sewer Line
- Utility - Storm Drain
- Tree Planting
- DNR Wetland
- Forest Conservation Easement
- Subwatershed
- Property Boundary

KCI TECHNOLOGIES

N

90 0 90

Feet

1 inch = 325 Feet

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F509a
Site Name: Turf Valley (b)
Contractor: KCI
Watershed: Little Patuxent River

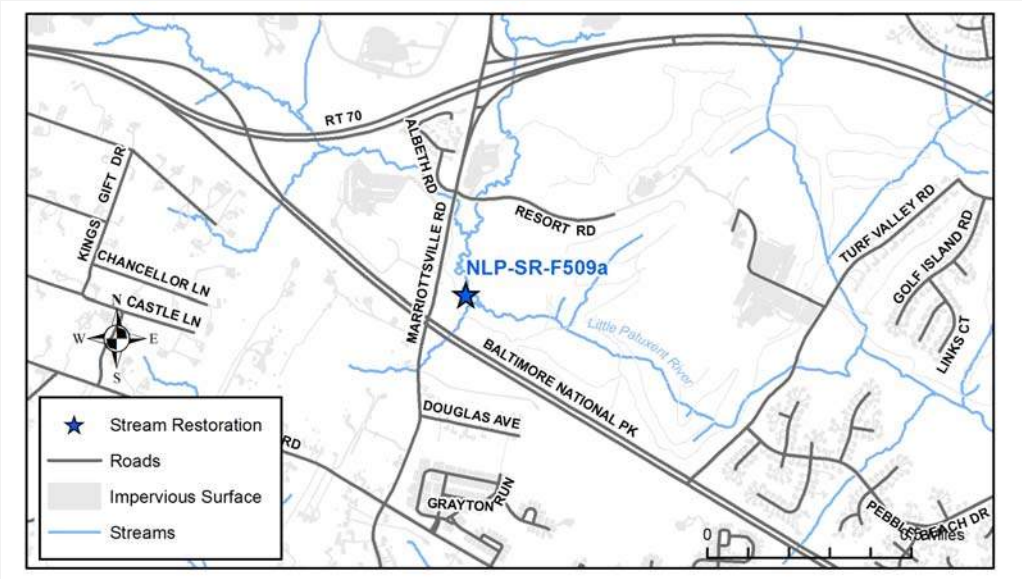
Ownership: Private- Mixed Use
Single Owner

Existing Conditions:

The site is located on a reach of the Little Patuxent River situated between Marriottsville Road to the west and shopping center development to the east. The reach is part of an abandoned golf course at Turf Valley. The reach has approximately 4 to 5 ft. high banks that are 10 to 15 ft. in width at the top of bank. Banks are a silty material that is easily erodible due to the low root depths, low surface protection and vertical angles. The reach contains a high sinuosity and compressed meander geometry.

The channel appears to be in the process of widening/aggrading in the lower portions of the reach with undercut banks and deposition in the channel bed; and downcutting/widening in the upper portions of the reach with higher banks towards the upstream extent of the site. The channel is moderately embedded with fines and the bed material is composed of mostly sand and gravel with some silt and cobble. Moderate bar formation and deposition is observed in the channel. The presence of high quality epifaunal substrate and habitat coverage is marginal, with all three velocity/depth regimes present and baseflow occupying approximately 75% of the width of the channel. Riffle spacing is characterized as being approximately 7-15 channel widths.

The riparian buffer width is narrow at 20 to 40 ft. on both the right and left bank and the quality of the riparian vegetation ranging from low to moderate, currently providing approximately 10 to 60% cover. The sparse vegetation is further contributing to the accelerated erosion as there is little to no root density available to stabilize the banks. A paved trail exists along the right overbank area, approximately 50 to 100 ft. from the top of bank. This trail leads to a stormwater management facility.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F509a
Site Name: Turf Valley (b)
Contractor: KCI
Watershed: Little Patuxent River

Facing right bank, erosion with poor root depth and stream has poor epifaunal habitat availability.

Vertical banks with falling trees. Stream has moderate deposition of silt and sand.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F509a
Site Name: Turf Valley (b)
Contractor: KCI
Watershed: Little Patuxent River

Constraints/Utilities:

The restoration reach is located exclusively on private property so property coordination will be necessary to perform the proposed project. Access will be achievable from Marriottsville Road or Resort Drive. Impacts to the existing forest will be low to moderate due to the existing sparse riparian buffer.

Concept Description:

The proposed stream restoration includes a design throughout this site where a secondary floodplain can be graded at a new, lower elevation. Channel realignment is necessary throughout the restoration reach to soften compressed meander geometry. Proposed bank protection will include bioengineering techniques such as coir logs, alternating roughness protection, and vegetative stabilization; however, stone protection and other harder bank treatments may be necessary in a few isolated locations. Existing bed materials are likely salvageable, but larger cobble material will be necessary to provide better riffle habitat.

A comprehensive planting plan will be developed for the various landscape zones throughout the site that will allow for the establishment of native plant species.

The site has potential for educational outreach, as it is across the street from Chapelgate Christian Academy.

Nearby Opportunities:

None recommended

Proposed Project Credit		Costs	
Length Restored (ft):	2,251	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	22.5	Estimated Construction Cost:	$1,012,950.00
Cost per Impervious Credit Acre:	$71,827.41	30% Contingency:	$303,885.00
		Estimated Total Cost:	$1,616,835.00

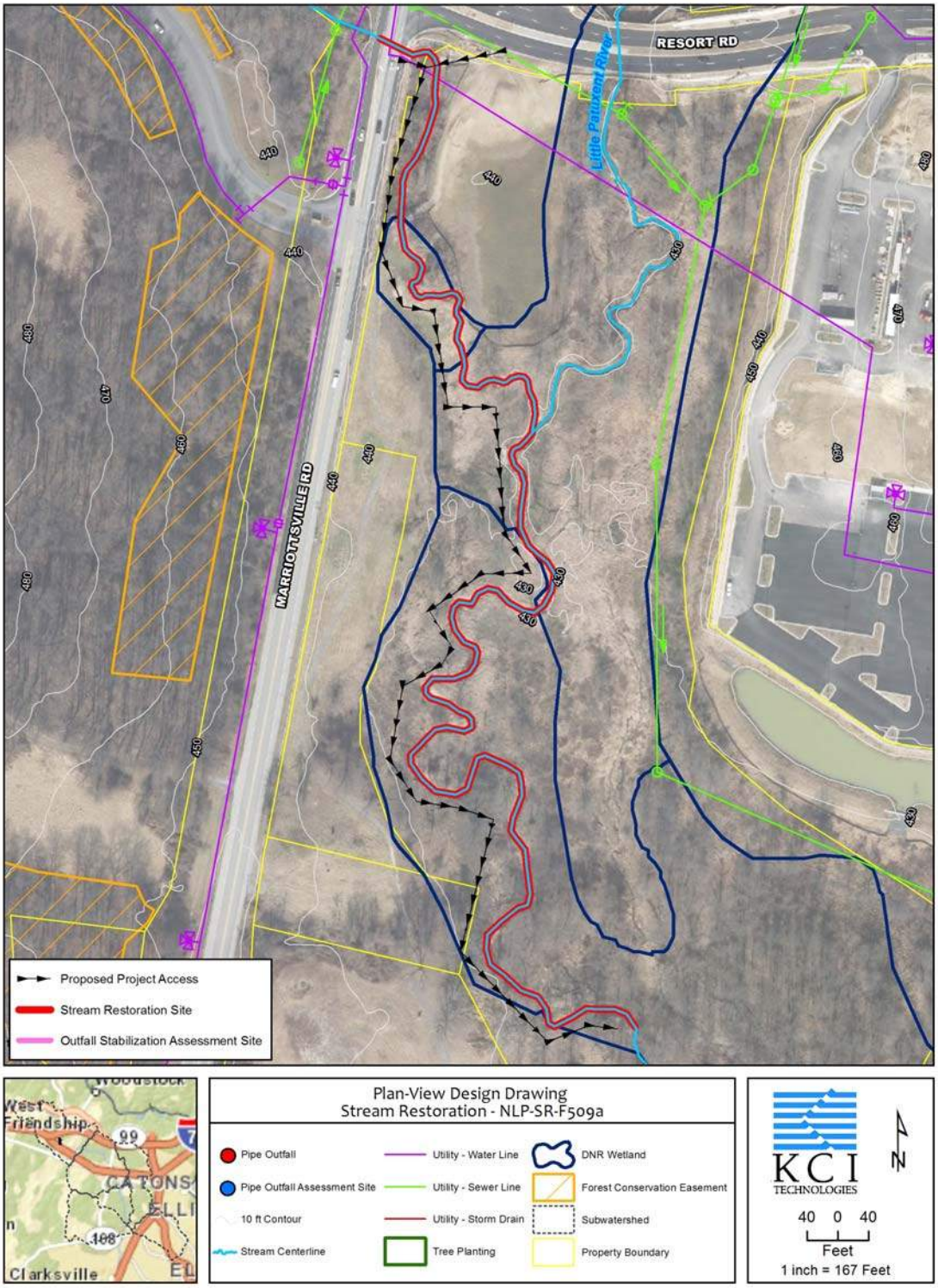
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F509a

Site Name: Turf Valley (b)

Contractor: KCI

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Stream Restoration

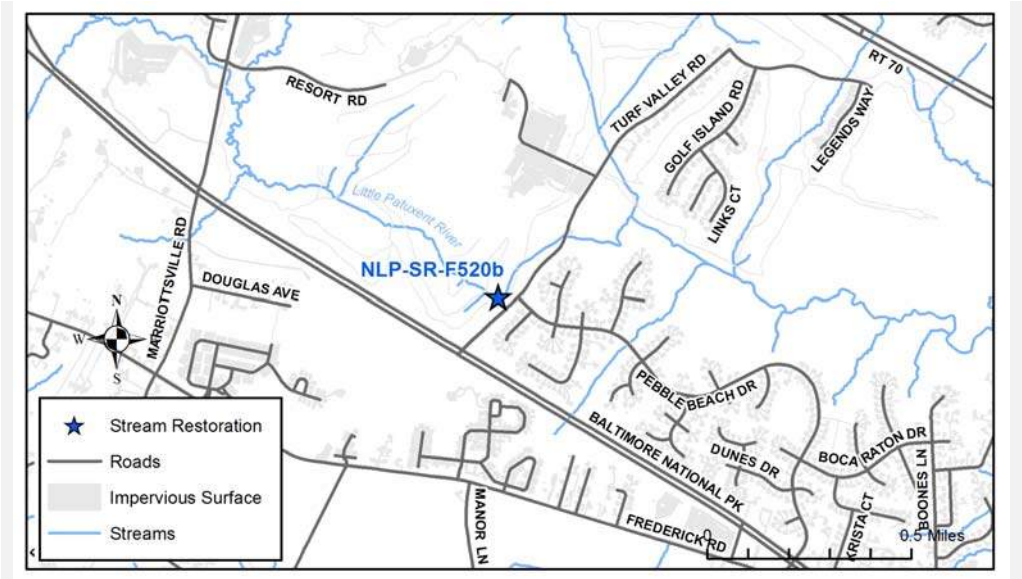
Site ID: NLP-SR-F520b
Site Name: Turf Valley (c)
Contractor: KCI
Watershed: Little Patuxent River

Ownership: Private- Mixed Use
Single Owner

Existing Conditions:

The site includes a reach of the Little Patuxent River located on the Turf Valley Golf Course. The reach has approximately 3 ft. high banks that are 15 to 25 ft. in width at the top of bank. Banks are a silty material that is easily erodible due to the low root depths and little surface protection due to a lack of vegetation along the banks. Near bank stresses are found to be low due to benches and low banks present throughout the site that appear to be bankfull indicators of 2.5 ft. in height above the bed. While benches are observed in some areas, localized areas of undercut banks are observed.

The channel appears to be widening with the presence of eroding and undercut banks. The channel is also moderately to highly embedded with fines and the bed material is composed of mostly silt, sand and gravel with some amounts of cobble. Very little amounts of sand deposition are observed in the channel. There is a marginal presence of available and good quality epifaunal substrate habitat and coverage. Two velocity/depth regimes are apparent and baseflow is occupying the channel width to both banks. Riffle spacing is characterized as being approximately 7 to 15 channel widths. The reach is located within an active play area of the Turf Valley Golf course and therefore contains a lack of riparian buffer and includes mowed turf reaching the top of bank. Minor channel alterations were observed for golf cart path crossings. A sanitary sewer line runs parallel to the restoration reach and crosses the channel in two locations.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F520b
Site Name: Turf Valley (c)
Contractor: KCI
Watershed: Little Patuxent River

Erosion on left bank with poor root depth.

Facing upstream, poor root density and no cover.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F520b
Site Name: Turf Valley (c)
Contractor: KCI
Watershed: Little Patuxent River

Constraints/Utilities:

The restoration reach is located exclusively on private property where access would need to be given by owner. The entire reach runs through the Turf Valley Golf Course playing surface, requiring special consideration to the design and construction access. A sewer line crosses the reach twice, switching from right bank to left bank and back to the right. There are also four golf cart crossings over the reach which could present issues during construction and will need to be given consideration in the restoration design. Given the close proximity of the reach to the golf course field of play, access and timing of construction will be difficult to acquire as to not interfere with normal play.

Concept Description:

The proposed stream restoration includes a design where a limited bench will be established at the current bankfull elevation and where the channel will mainly be stabilized in place. Bank protection is expected to be composed primarily of stone protection and other harder bank treatments as it is expected that plantings will be limited due to the location of the channel within the active play area of the golf course; however, bioengineering techniques such as coir logs and vegetative stabilization can be used in isolated areas which are not in the golf course field of play. Existing bed materials are likely salvageable, but larger cobble material will be necessary to provide better riffle habitat and bed stabilization. Grade control structures may be necessary at the sanitary sewer crossings depending on the elevation of the pipes in relation to the stream channel invert.

A limited planting plan will be developed and will be dependent on plants that are approved for use within the golf course that will not interfere with the active play areas.

Nearby Opportunities:

None recommended

Proposed Project Credit		Costs	
Length Restored (ft):	2,299	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	23	Estimated Construction Cost:	$1,035,000.00
Cost per Impervious Credit Acre:	$71,574.60	30% Contingency:	$310,500.00
		Estimated Total Cost:	$1,645,500.00

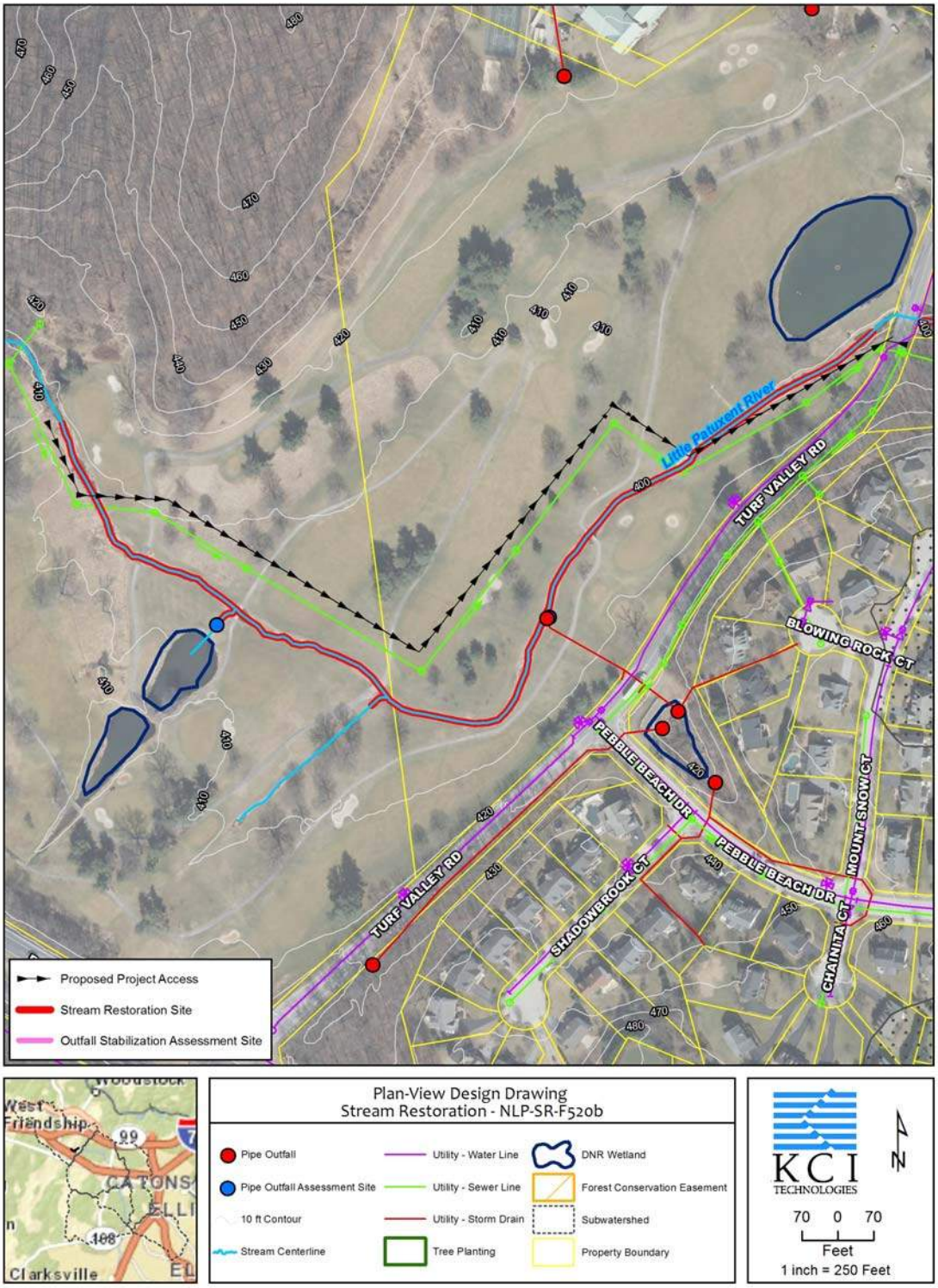
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F520b

Site Name: Turf Valley (c)

Contractor: KCI

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F551a
Site Name: Enchanted Forest 3
Contractor: KCI
Watershed: Little Patuxent River

Ownership: Private- Residential
Multiple Owners

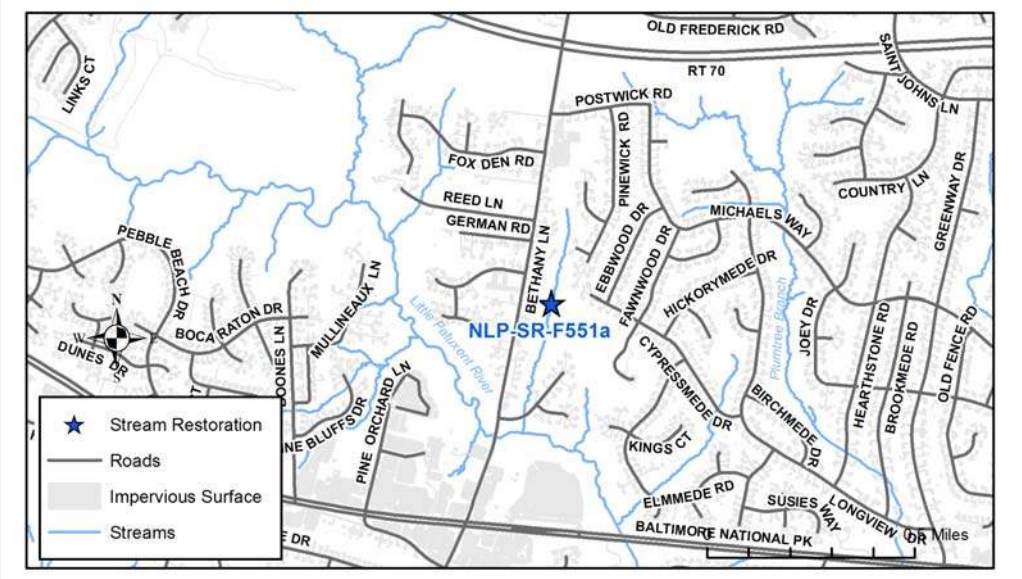
Existing Conditions:

The site is an unnamed tributary that flows to the Little Patuxent River. The banks are approximately 2 to 5 ft. high with a silty material that is easily erodible due to the vertical banks, low to very low root depths and surface protection. Some localized more stable segments are present exhibiting a lower bank slope and stabilizing vegetation. Near bank stresses were found to be moderate to very high with bankfull indicators at 2 to 2.5 ft. above the bed. Banks are undercut in many areas with fallen and falling trees. A stormwater management pond is located at the upstream extent of the site.

The bed material is composed of mostly silt, sand and gravel with some cobbles. Moderate bar formation was observed and the channel is moderately embedded with fines. The presence of available and good quality epifaunal substrate habitat and coverage is marginal to suboptimal. Two to three velocity/depth regimes are apparent and baseflow occupies 75% to 100% of the channel width at the bottom of both banks. Riffle spacing is variable and in moderate condition, with the spacing characterized as being approximately 7 to 15 channel widths.

A sanitary sewer line runs parallel to the channel along the right bank (facing downstream) with three crossings existing throughout the restoration reach. In multiple areas, the channel has eroded towards and is now located within close proximity to the sanitary sewer line and manholes. Few channel alterations were observed and are associated with the sanitary sewer crossings.

The riparian buffer width varies between less than 20 ft. and greater than 60 ft. on both banks, but the quality of the riparian vegetation is moderate to good, at approximately 60 to 80% cover. The bank erosion is more severe in the areas that are lacking a riparian buffer.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F551a
Site Name: Enchanted Forest 3
Contractor: KCI
Watershed: Little Patuxent River

Facing upstream, moderate silt and sand deposition.

Right bank erosion with vertical bank angle, no surface protection and silty bank material.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F551a
Site Name: Enchanted Forest 3
Contractor: KCI
Watershed: Little Patuxent River

Constraints/Utilities:

The majority of the reach is on private property, with the downstream-most 550 lf. being located on Howard County Parks and Recreations property. As a result, property coordination will be necessary to complete the project. A sanitary sewer easement runs parallel to the stream channel along the right bank. While this easement can be used for access, it will not negate the need for property owner coordination. Wetlands were noted on site, requiring special consideration to the design, permitting and construction access. While the easement running parallel to the channel could provide access; the location of the wetlands may determine construction access. Although the design would attempt to limit tree impacts, a moderate impact to trees would likely result during construction of the reach; however, sections of the channel contain little to no riparian buffer and could benefit from the additional plantings that would result from the project.

Concept Description:

The proposed stream restoration includes a design throughout the site where a narrow floodplain could be developed at the current bankfull elevation, and where the stream could be stabilized in place. This design approach will be necessary due to the close proximity of the channel to the sanitary sewer line and since the channel is located within private property. Proposed bank protection will include bioengineering techniques such as coir logs and vegetative stabilization; however, stabilizing the channel in place may result in the need for stone protection and other harder bank treatments in a few isolated locations. Existing bed materials are likely salvageable, but larger cobble material will be necessary to provide better riffle habitat.

A comprehensive planting plan will be developed for the various landscape zones throughout the site that will allow for the establishment of native plant species.

Nearby Opportunities:

None recommended

Proposed Project Credit		Costs	
Length Restored (ft):	2,647	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	26.5	Estimated Construction Cost:	$1,191,150.00
Cost per Impervious Credit Acre:	$69,833.59	30% Contingency:	$357,345.00
		Estimated Total Cost:	$1,848,495.00

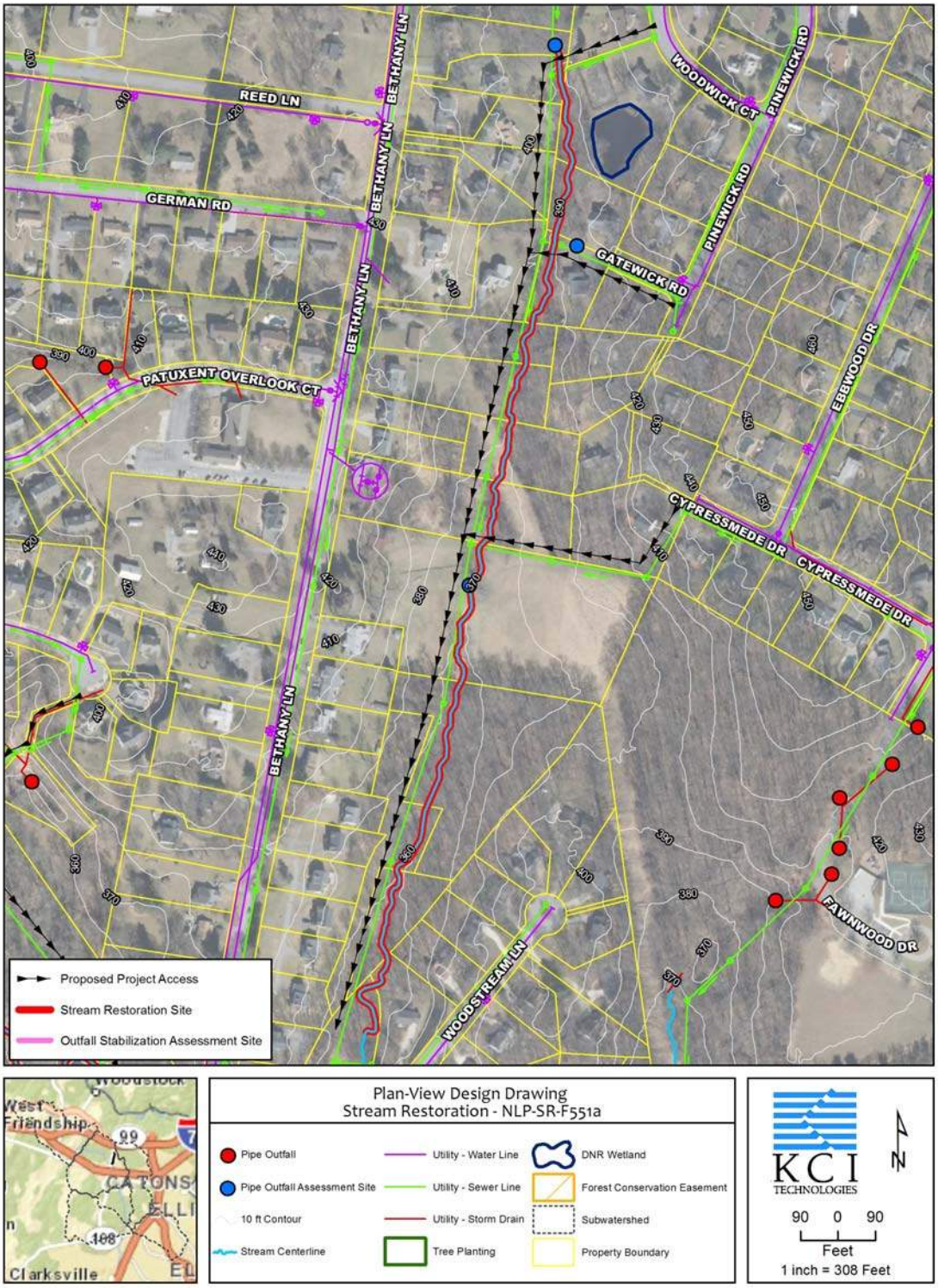
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F551a

Site Name: Enchanted Forest 3

Contractor: KCI

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F552a
Site Name: Boones Lane (a)
Contractor: KCI
Watershed: Little Patuxent River

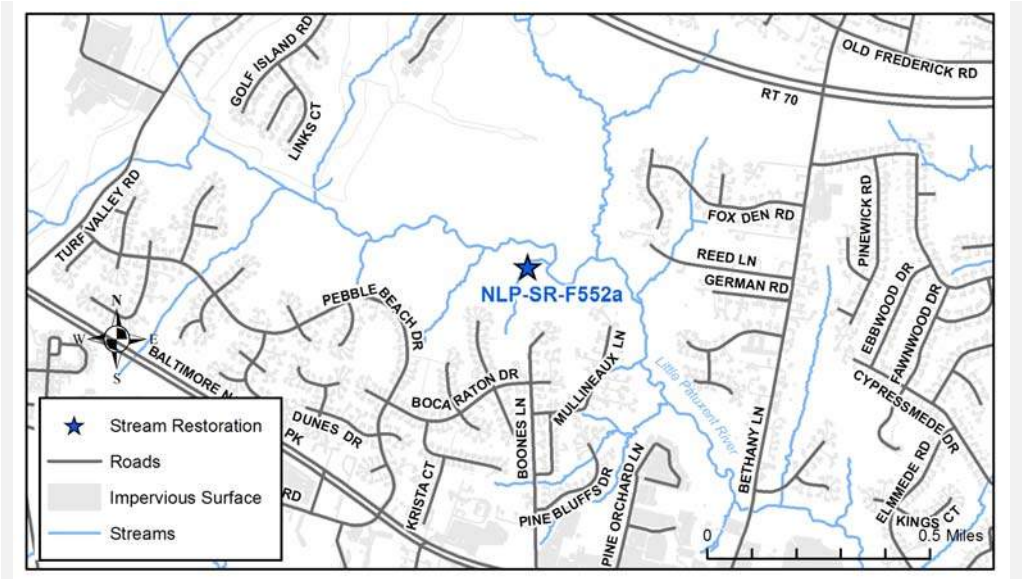
Ownership: County Owned
Single Owner

Existing Conditions:

The site is an unnamed tributary to the Northern Little Patuxent that begins from a storm drain outfall at Boca Raton Drive, between Boones Lane and Congressional Court. The reach has 4.5 to 6.5 ft. high banks with a high silt composition, vertical bank angles, very shallow root depths, and minimal surface protection, making them highly susceptible to erosion. Banks are undercut with recently fallen trees. As a result of continued erosion, this channel has incised at 4.5 to 6.5 times its bankfull depth, and near bank stresses are high to extreme with a bankfull height of 1 ft.

The channel is widening and headcutting, with benches present throughout the site at 1 ft. in height above the bed. The bed material is composed of mostly sand, gravel and cobble, and some deposition was observed in the channel. Deposition was noted mostly in the form of benches as well as accumulation of fines at the downstream extent of this channel. The presence of available and good quality epifaunal substrate habitat and coverage is suboptimal in quality, and only two velocity/depth regimes were apparent through the reach. Riffle spacing is in good condition, with the spacing characterized as being approximately nine channel widths

The riparian buffer width is approximately 100 ft. on both banks and the quality of the riparian vegetation is good with 70% cover.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F552a
Site Name: Boones Lane (a)
Contractor: KCI
Watershed: Little Patuxent River

Erosion on right bank with vertical bank angle and poor root depth.

Vertical banks.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F552a
Site Name: Boones Lane (a)
Contractor: KCI
Watershed: Little Patuxent River

Constraints/Utilities:

The reach is within several Howard County Parks and Recreations property boundaries, providing good property access. Construction access may be possible from Congressional Ct. Parks property joins Congressional Ct at the upstream end of the site. A sewer line crosses the channel at the upstream extent of the site, then runs parallel to the channel on the left bank, which poses some minor constraint to the design. Although the design would attempt to limit tree impacts, a significant impact to trees would likely result during construction due to the existing wide riparian buffer. However, access along the maintained sewer easement, when available, will limit tree impacts. A full tree evaluation has not been conducted, but no specimen trees were noted during initial investigations.

Concept Description:

The proposed stream restoration includes a natural channel design throughout the site, where the bed elevation may be raised to utilize the existing floodplain in some areas of Parks property, but a new floodplain may be graded at a new, lower elevation where private property encroaches onto the floodplain. Proposed bank protection will include bioengineering techniques such as coir logs and vegetative stabilization, but stone protection and other harder bank treatments may be necessary in a few isolated locations. Existing bed materials are likely salvageable, but larger cobble material will be necessary to provide better riffle habitat.

A comprehensive planting plan will be developed for the various landscape zones throughout the site that will allow for the establishment of native plant species.

Nearby Opportunities:

None recommended

Proposed Project Credit		Costs	
Length Restored (ft):	1,276	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	12.8	Estimated Construction Cost:	$574,650.00
Cost per Impervious Credit Acre:	$82,056.82	30% Contingency:	$172,395.00
		Estimated Total Cost:	$1,047,045.00

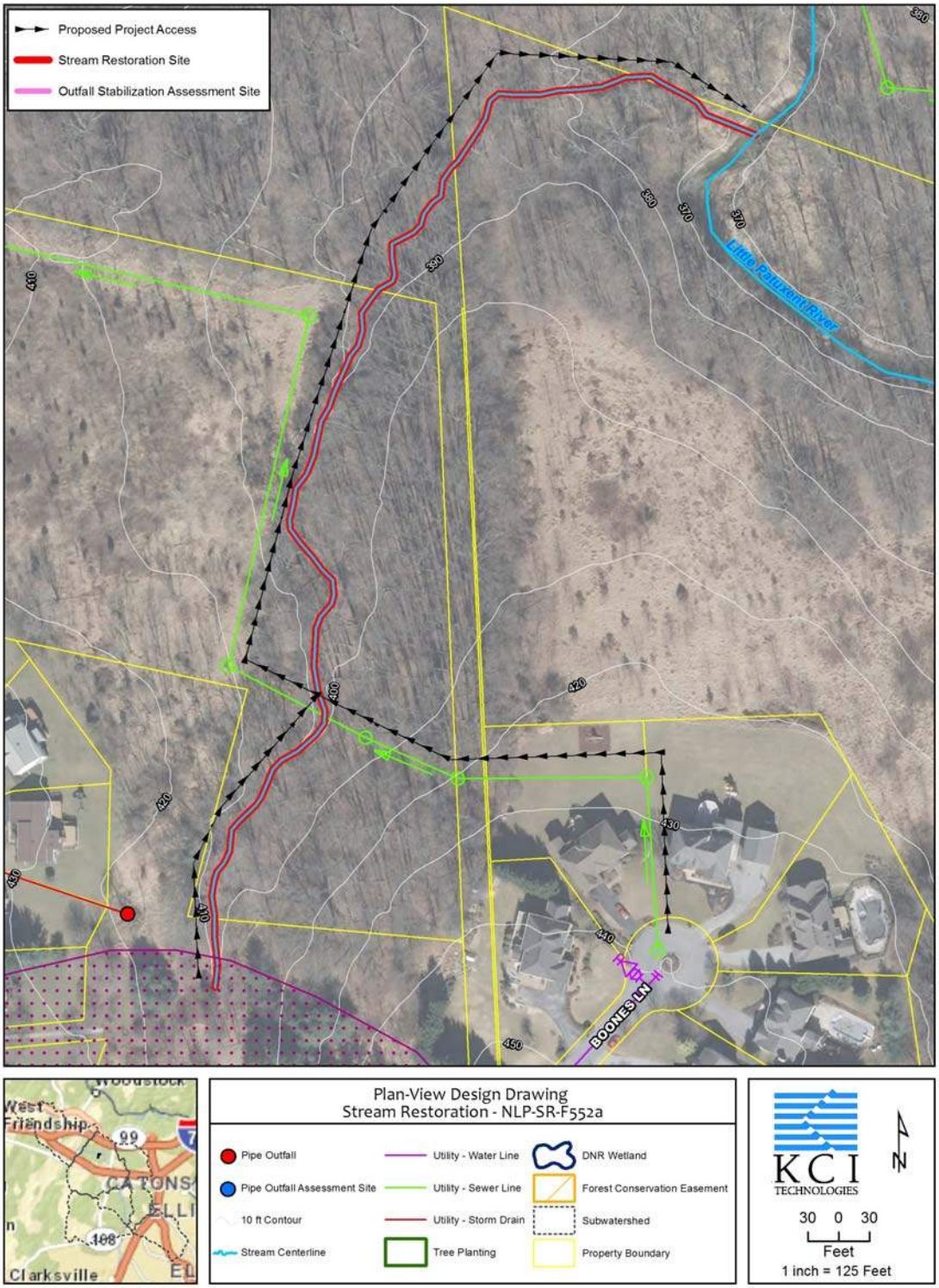
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F552a

Site Name: Boones Lane (a)

Contractor: KCI

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F555a
Site Name: Enchanted Forest (a)
Contractor: KCI
Watershed: Little Patuxent River

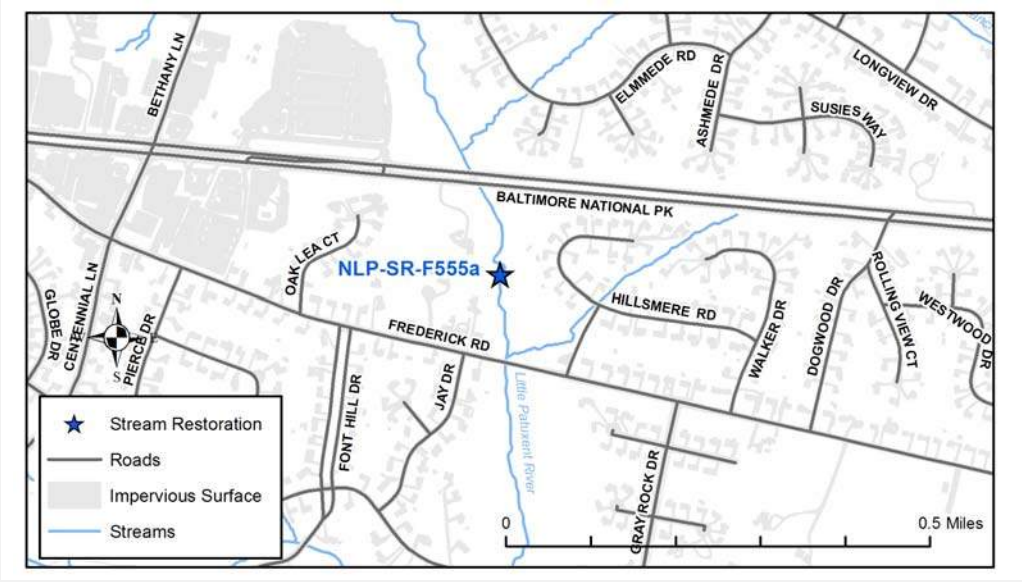
Ownership: County Park
Multiple Owners

Existing Conditions:

The site is on a reach of the Little Patuxent River that has approximately 6 ft. high banks that are 25 to 35 ft. wide at the top of bank. Banks are silty and easily erodible due to the low to moderate root depths and low to moderate surface protection. The banks are vertical with undercut trees. Bar deposition was noted to a height of 1 to 1.5 ft. Multiple fallen trees were noted, particularly near the compressed meanders at the center of the reach.

The channel is highly embedded with fines. Bed material is composed of mostly sand and gravel with some silt, and moderate bar formation was observed in the channel. The presence of available and good quality epifaunal substrate habitat and coverage is very good, and all four velocity/depth regimes are present with baseflow reaching both banks. Riffle spacing was characterized as being approximately 5-7 channel widths. No channel alterations were observed.

The riparian buffer width is greater than 60 ft. on the right bank and approximately 60 ft. on the left, but the quality of the riparian vegetation is moderate, at approximately 70% cover. An abundance of wavy leaf basketgrass and Japanese stiltgrass, both invasive species, was observed throughout the site.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F555a
Site Name: Enchanted Forest (a)
Contractor: KCI
Watershed: Little Patuxent River

Eroding and undercut banks; fallen trees; poor quality riparian zone along right bank.

Abundant sand deposition as bars.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F555a
Site Name: Enchanted Forest (a)
Contractor: KCI
Watershed: Little Patuxent River

Constraints/Utilities:

This reach runs along the western edge a Howard County Parks property with short segments of the channel crossing onto two private residential properties. These same two properties run the length of the reach and are in close proximity to the right bank, throughout. A significant area of wetlands runs parallel to the left bank of the channel for most of the reach, requiring special consideration to the design and construction access and for project permitting. There is a sewer easement running parallel to the right bank that could provide access; however, the proximity of private property to the channel limits the design for floodplain access, as it could cause an increase to the floodplain elevation on private property. Given the abundance of County park property to the east, the left bank presents potential for realigning the channel away from the private properties and allowing for greater floodplain access. Further evaluation of the wetland extents and permitting constraints would be necessary for the next phase of the design strategy for this reach.

Concept Description:

The proposed stream restoration includes a natural channel design throughout this site, where a new floodplain can be graded at a secondary, lower elevation. Proposed bank protection will include bioengineering techniques such as coir logs and vegetative stabilization, but stone protection and other harder bank treatments may be necessary in a few isolated locations. Existing bed materials are likely salvageable, but larger cobble material will be necessary to provide better riffle habitat.

A comprehensive planting plan will be developed for the various landscape zones throughout the site that will allow for the establishment of native plant species.

Nearby Opportunities:

None recommended

Proposed Project Credit		Costs	
Length Restored (ft):	1,194	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	11.9	Estimated Construction Cost:	$537,300.00
Cost per Impervious Credit Acre:	$83,625.63	30% Contingency:	$161,190.00
		Estimated Total Cost:	$998,490.00

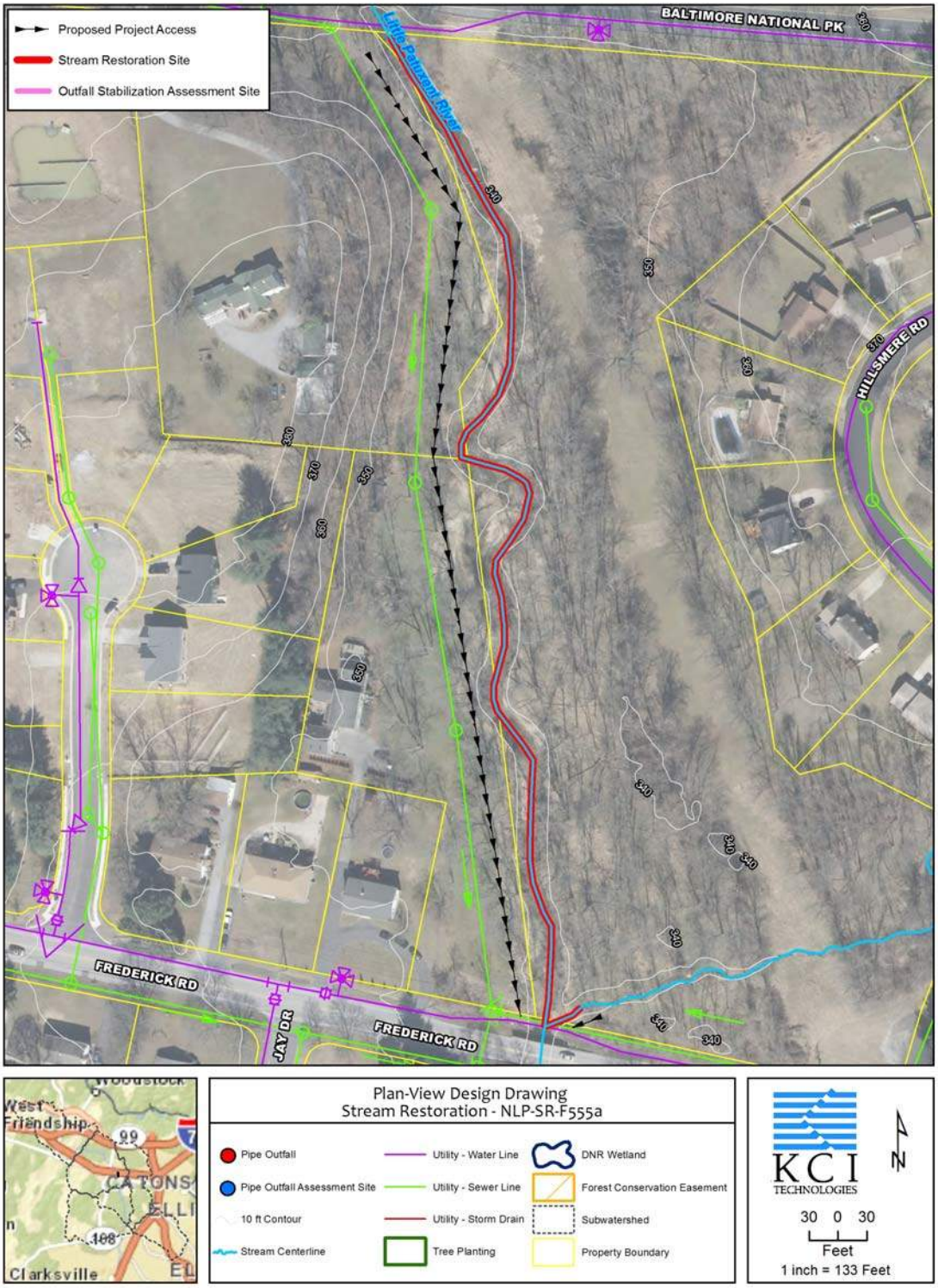
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F555a

Site Name: Enchanted Forest (a)

Contractor: KCI

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Stream Restoration

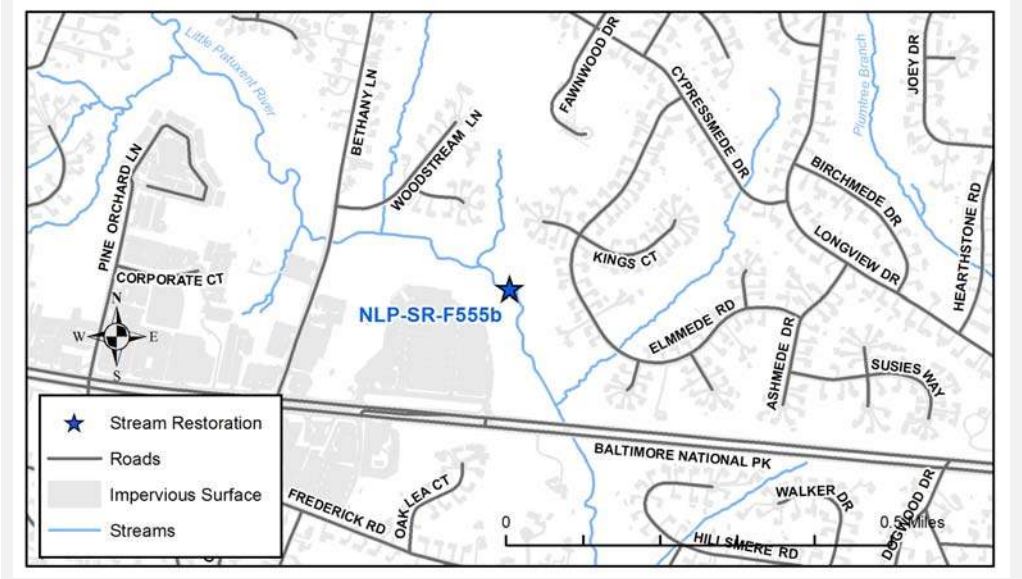
Site ID: NLP-SR-F555b
Site Name: Enchanted Forest (b)
Contractor: KCI
Watershed: Little Patuxent River

Ownership: County Park
Multiple Owners

Existing Conditions:

The site is a reach of the Little Patuxent River located just upstream of Route 40, between the Enchanted Forest Shopping Center to the west and Elmmede Road to the east. The channel contains approximately 5.5 ft. high banks with silty material that is easily erodible due to the vertical banks, moderate root depths and moderate surface protection. Near bank stresses were found to be high due to the bankfull indicator at 2.5 ft. above the bed. An eroded tributary enters the channel at the downstream end of the site. This tributary has approximately 120 lf. of erosion. A stormwater management pond is located at the upstream extent of this site, which appears to be the start of the erosion. The pond may require further evaluation.

A sanitary sewer line runs parallel to the channel along the left bank (facing downstream) in the upper portions and then along the right bank in the lower portion after crossing the channel. In a few areas, the banks have eroded to a degree that they within close proximity to the sanitary sewer line. The channel is highly embedded with fines. The bed material is composed of mostly sand and silt with some cobbles, and moderate bar formation is observed in the channel. The presence of available and good quality epifaunal substrate habitat and coverage is very good. Three velocity/depth regimes are apparent and baseflow occupies the channel width to both banks. Riffle spacing is variable and in moderate condition, with the spacing characterized as being approximately seven to 25 channel widths. No channel alterations were observed. The riparian buffer width is greater than 60 ft. on both banks, but the quality of the riparian vegetation moderate to poor, at approximately 50 to 60% cover.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F555b
Site Name: Enchanted Forest (b)
Contractor: KCI
Watershed: Little Patuxent River

Vertical, eroding banks with undercut trees and debris jams; sand deposition as bars; wide buffer along the left bank.

Vertical, eroding banks with some bench establishment; undercut trees.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F555b
Site Name: Enchanted Forest (b)
Contractor: KCI
Watershed: Little Patuxent River

Constraints/Utilities:

The majority of this reach is within Howard County Parks and Recreations property, with upstream-most third of the site divided between Parks and Recreations property and the Enchanted Forest property. A sewer line runs parallel to the channel just to the west with two crossings identified through available mapping. A maintained easement also runs parallel to the channel, approximately 100 ft. from the left bank, seen in aerial imagery. Wetlands were noted on site, requiring special consideration to the design, permitting and construction access. The parallel easements could provide access; however, the location of the wetlands may determine construction access. Although the design would attempt to limit tree impacts, a moderate impact to trees would likely result during construction due to the existing wide riparian buffer. A full tree evaluation has not been conducted, but no specimen trees were noted during initial investigations, and riparian cover is described as moderate.

Concept Description:

The proposed stream restoration includes a natural channel design throughout the site, where a new floodplain can be graded at a secondary, lower elevation, or where a bench can be established at the current bankfull elevation. Some minor channel realignment may be proposed to shift the channel away from the parallel sanitary sewer line in areas that are currently within close proximity. A portion of the tributary is also proposed for design to stabilize the eroding banks, prevent further downcutting along the tributary, and provide a stable tie-in with the mainstem at the confluence.

Proposed bank protection will include bioengineering techniques such as alternating roughness protection, branch layering, coir logs and vegetative stabilization, but stone protection and other harder bank treatments may be necessary in a few isolated locations, especially in areas that are in close proximity to the parallel sanitary sewer line. Existing bed materials are likely salvageable, but larger cobble material will be necessary to provide better riffle habitat. Grade control structures will be used as necessary to stabilize the sanitary sewer crossing, depending on the elevation of the pipe in relation to the stream invert. A comprehensive planting plan will be developed for the various landscape zones throughout the site that will allow for the establishment of native plant species.

Nearby Opportunities:

None recommended

Proposed Project Credit		Costs	
Length Restored (ft):	1,786	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	17.9	Estimated Construction Cost:	$803,700.00
Cost per Impervious Credit Acre:	$75,297.31	30% Contingency:	$241,110.00
		Estimated Total Cost:	$1,344,810.00

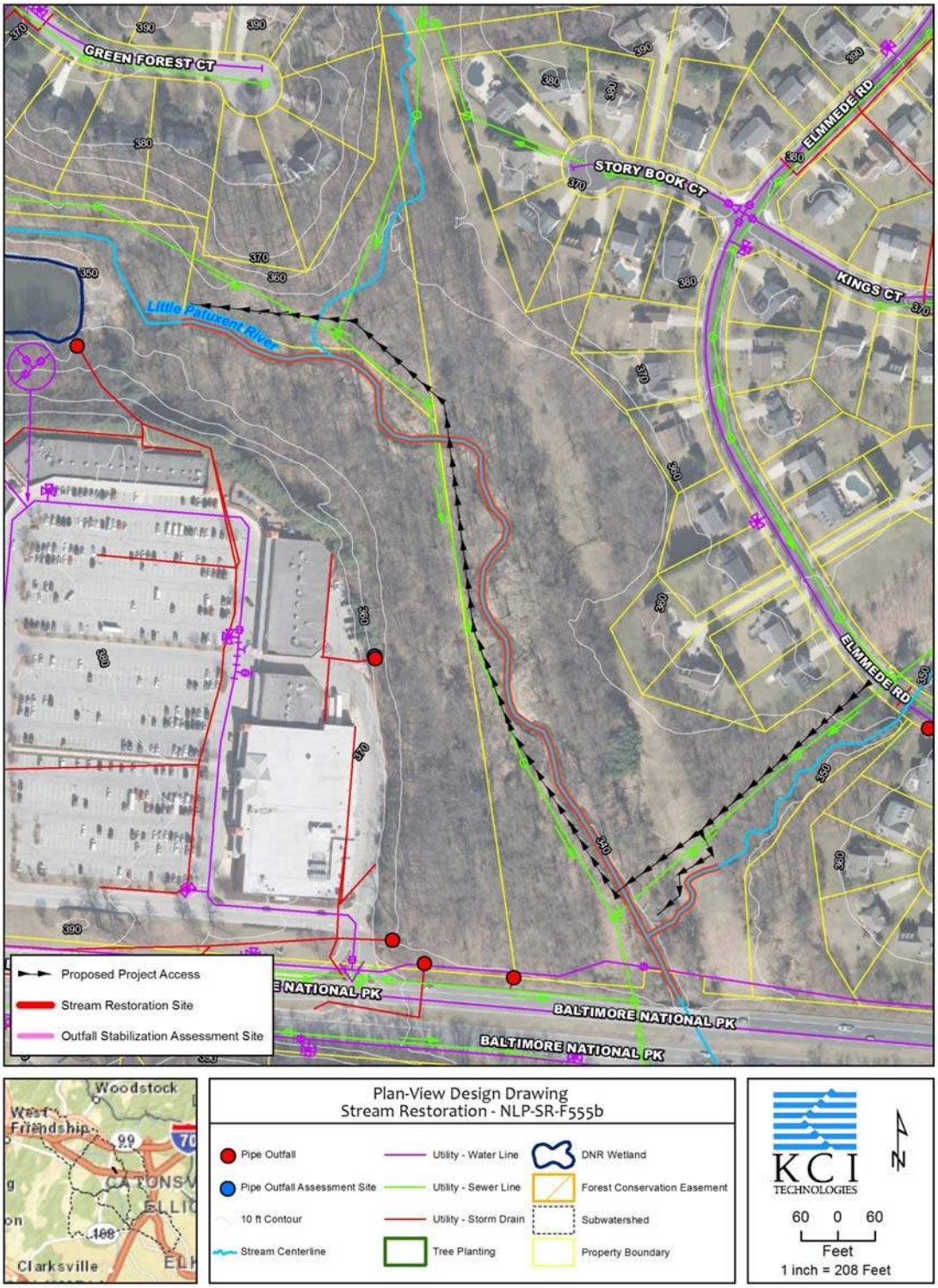
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F555b

Site Name: Enchanted Forest (b)

Contractor: KCI

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F557a
Site Name: Boones Lane (b)
Contractor: KCI
Watershed: Little Patuxent River

Ownership: County Owned
Single Owner

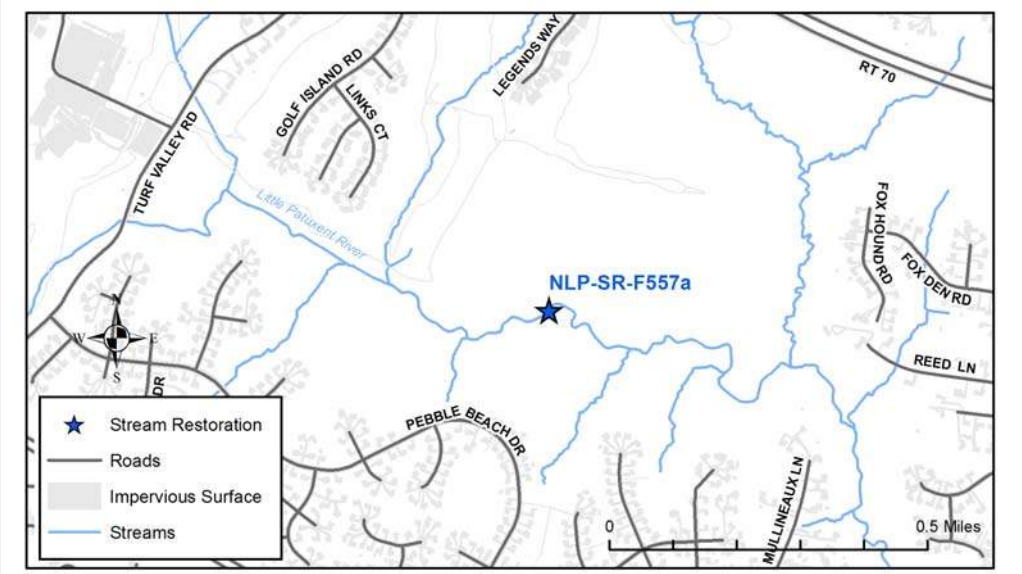
Existing Conditions:

The site is a reach located along the Little Patuxent River, just downstream of David W Force Park. The reach has 5.5 ft. high banks that are comprised mainly of silt and are easily erodible due to the vertical banks, moderate root depths, and moderate surface protection. Near bank stresses were found to be moderate to high with benches present throughout the site that appear to be bankfull indicators at 3 ft. in height above the bed. Banks are undercut with near fallen and falling trees. In addition, a large amount of debris was noted along the overbanks and within the channel bed throughout the reach as a result of fallen trees that are being transported by storm flows.

The channel appears to be in the process of widening and aggrading. The channel is low to moderately embedded with fines. Bed material is composed of mostly sand, gravel and cobble, and moderate amounts of deposition were observed in the channel. The presence of available and good quality epifaunal substrate habitat and coverage is suboptimal. Four velocity/depth regimes are apparent and baseflow occupies the entire channel width from bank to bank. Riffle spacing is in good condition, with the spacing characterized as being approximately five to seven channel widths.

A sanitary sewer line runs parallel to the channel along the left bank (facing downstream) and crosses the channel in one location along the restoration reach. In a few locations the channel has migrated towards the sanitary sewer line and appears to be in close proximity to the line and manholes. In addition, a water line crossing exists in the upper portion of the restoration reach. Minor channel alterations were observed in this channel and are associated with utility crossings.

The riparian buffer width is approximately 330 ft. on both the right and left banks, but the quality of riparian vegetation is moderate with 60% cover.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F557a
Site Name: Boones Lane (b)
Contractor: KCI
Watershed: Little Patuxent River

Erosion on right bank, vertical banks with poor root depth.

Undercut banks with falling trees and poor root depth.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F557a
Site Name: Boones Lane (b)
Contractor: KCI
Watershed: Little Patuxent River

Constraints/Utilities:

This reach is located within various Howard County Parks and Recreation properties, allowing for minimal coordination necessary to gain access; however, the site is located within a wide forested buffer that will require a long access path to the channel, which will impact the adjacent forest. Construction access may be possible from Pebble Beach Dr. or Pinehurst Ct. Although there are no property owner constraints, the access route from Pebble Beach Dr. to the restoration reach is 650 ft. and will require significant impacts to trees. The access route from Pinehurst Ct is along a sewer easement, but is 1,300 ft. from the reach and will require a stream crossing at an unnamed tributary to the Little Patuxent River that is not included in the current extents of restoration. The sewer line that runs parallel to the channel on the left bank with a stream crossing at the downstream end of the site, poses some minor constraint to the design. Although the design would attempt to limit tree impacts, a significant impact to trees would likely result during construction due to the existing wide riparian buffer in most areas; however, the forest was noted as being somewhat sparse in areas and the trees are not overly healthy.

Concept Description:

The proposed stream restoration includes a natural channel design throughout the site, where a secondary floodplain can be graded at a new, lower elevation. Proposed bank protection will include bioengineering such as alternating roughness protection, live branch layering, and vegetative stabilization; however, stone protection and other harder bank treatments may be necessary in a few isolated locations, particularly to stabilize the parallel sanitary sewer and water line. Existing bed materials are likely salvageable, but larger cobble material will be necessary to provide better riffle habitat.

A comprehensive planting plan will be developed for the various landscape zones throughout the site that will allow for the establishment of native plant species.

Nearby Opportunities:

None recommended

Proposed Project Credit		Costs	
Length Restored (ft):	1,795	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	18	Estimated Construction Cost:	$807,750.00
Cost per Impervious Credit Acre:	$75,171.21	30% Contingency:	$242,325.00
		Estimated Total Cost:	$1,350,075.00

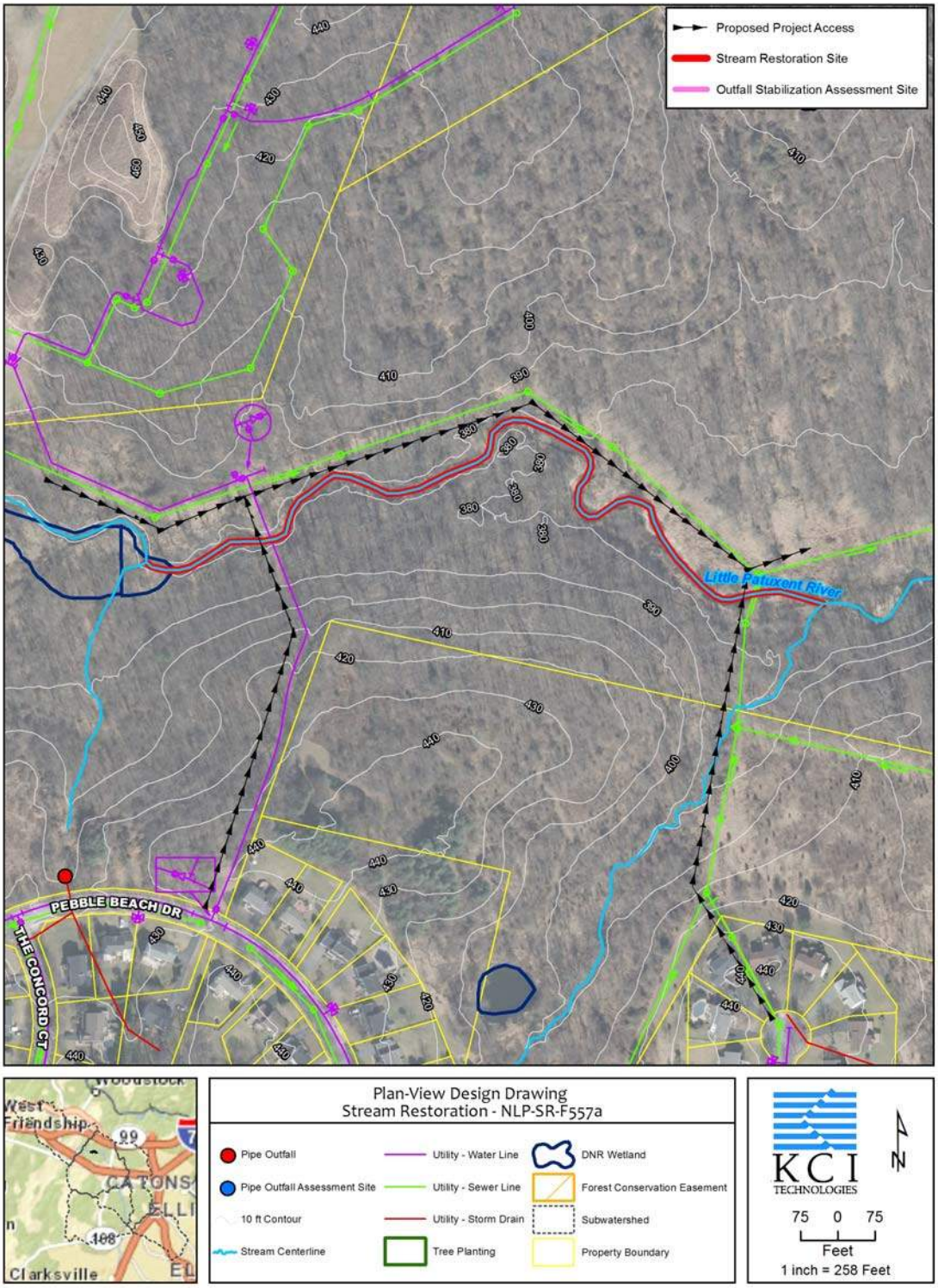
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F557a

Site Name: Boones Lane (b)

Contractor: KCI

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F571a
Site Name: Red Hill Branch at Santa Fe Court
Contractor: KCI
Watershed: Little Patuxent River

Ownership: County Owned
Multiple Owners

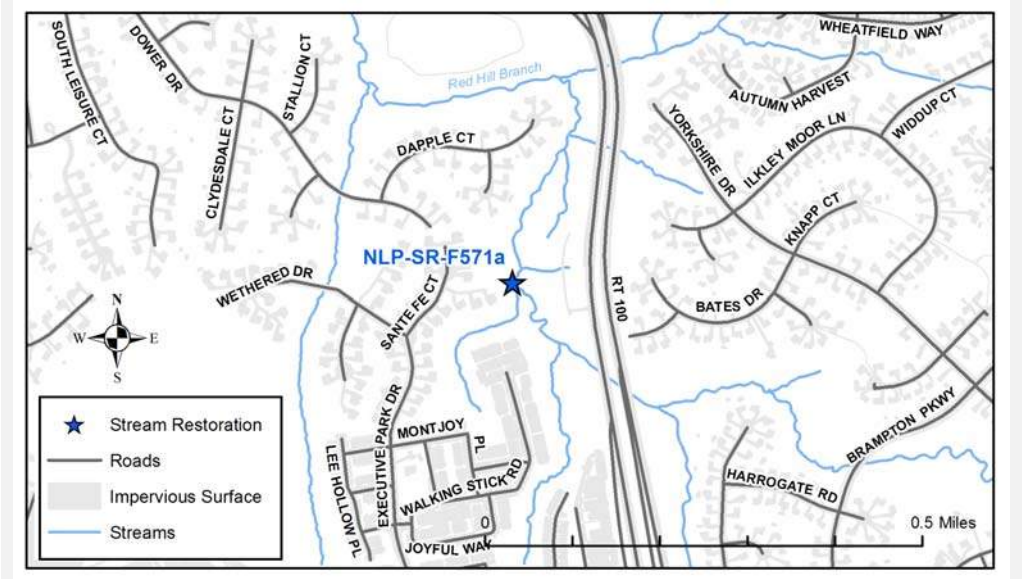
Existing Conditions:

The site is located on Red Hill Branch between MD 100 to the east and Sante Fe Court to the west. The reach has 4 to 8 ft. high banks with silty to clay material that is easily erodible due to the vertical banks, shallow root depths and very little surface protection. Near bank stresses were found to be moderate to very high due to the change in bank heights. Possible bankfull indicators ranged from the presence of inner berms at 1.5 and 2 ft. above the bed at the upstream extent of the site, the low bank at 3.5 ft. above the bed at the middle section of the reach, and the presence of benches at 3 ft. above the bed in the downstream extent of the site.

A stormwater management pond drains to the middle of the site. The pond outfall channel is severely backwatered, and is functioning more like a continuation of the pond; therefore, its banks are in good condition. The pond is adjacent to MD 100, and includes access from MD 100 that may be useful for this site.

The channel is moderately embedded with fines. The bed material is composed of mostly gravel, sand, and silt with some cobbles, and moderate bar formation is observed in the channel. The presence of available and good quality epifaunal substrate habitat and coverage is moderate. Three velocity/depth regimes are apparent and baseflow occupies approximately 75% of the channel width at the bottom of the banks. Riffle spacing is variable and in moderate condition, with the spacing characterized as being approximately 15 channel widths. No channel alterations were observed.

The potential riparian buffer width is great than 60 ft. on both banks; however, the sewer easement along the left bank interrupts the potential for a completely uninterrupted forested buffer. Despite the open space and available land, the quality of forest cover is poor, and poor survival was noted for a recent tree planting project adjacent to the channel.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F571a

Site Name: Red Hill Branch at Santa Fe Court

Contractor: KCI

Watershed: Little Patuxent River

Vertical banks and undercut trees; abundant woody debris; bar deposition.

Raw and undercut banks with poor riparian vegetation.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F571a
Site Name: Red Hill Branch at Santa Fe Court
Contractor: KCI
Watershed: Little Patuxent River

Constraints/Utilities:

This reach is within various Howard County properties, making property access feasible. Construction access may be possible using the sewer easement from Santa Fe Court or from MD 100, though this will require coordination with MD SHA . A sewer line runs parallel to the channel with a stream crossing at the upstream end of the site, which poses some constraint to the design. Although the design would attempt to limit tree impacts, a moderate impact to trees would likely result during construction due to the existing wide riparian buffer. A full tree evaluation has not been conducted, but no specimen trees were noted during initial investigations. The largest constraint to the success of this project is the beaver activity.

Concept Description:

The proposed stream restoration includes a natural channel design throughout the site, where a secondary floodplain can be graded at a new, lower elevation. Proposed bank protection will include bioengineering techniques such as coir logs and vegetative stabilization, but stone protection and other harder bank treatments may be necessary in a few isolated locations. Existing bed materials are likely salvageable, but larger cobble material will be necessary to provide better riffle habitat. A few areas were noted during the assessment that did not appear eroded, including approximately 500 lf. downstream of the confluence with the pond. Such areas may require bank grading and plantings only. Further, the more severely eroded conditions of this channel occur at the downstream extents of the site and beyond. Further evaluation is recommended downstream of this site in order to better assess the project limits.

A comprehensive planting plan will be developed for the various landscape zones throughout the site that will allow for the establishment of native plant species. Additional plantings may also be feasible surrounding this site as a tree planting site; however, beaver activity was noted, and a failed tree planting site adjacent to the channel was observed. Beaver activity could also be detrimental to success of this stream restoration project as well, as vegetative stabilization measures are key to the success of a stream restoration project.

Nearby Opportunities:

None recommended

Proposed Project Credit		Costs	
Length Restored (ft):	1,067	Estimated Design Cost:	$200,000.00
Impervious Area Treated Credit (ac.):	10.7	Estimated Construction Cost:	$480,150.00
Cost per Impervious Credit Acre:	$77,244.14	30% Contingency:	$144,045.00
		Estimated Total Cost:	$824,195.00

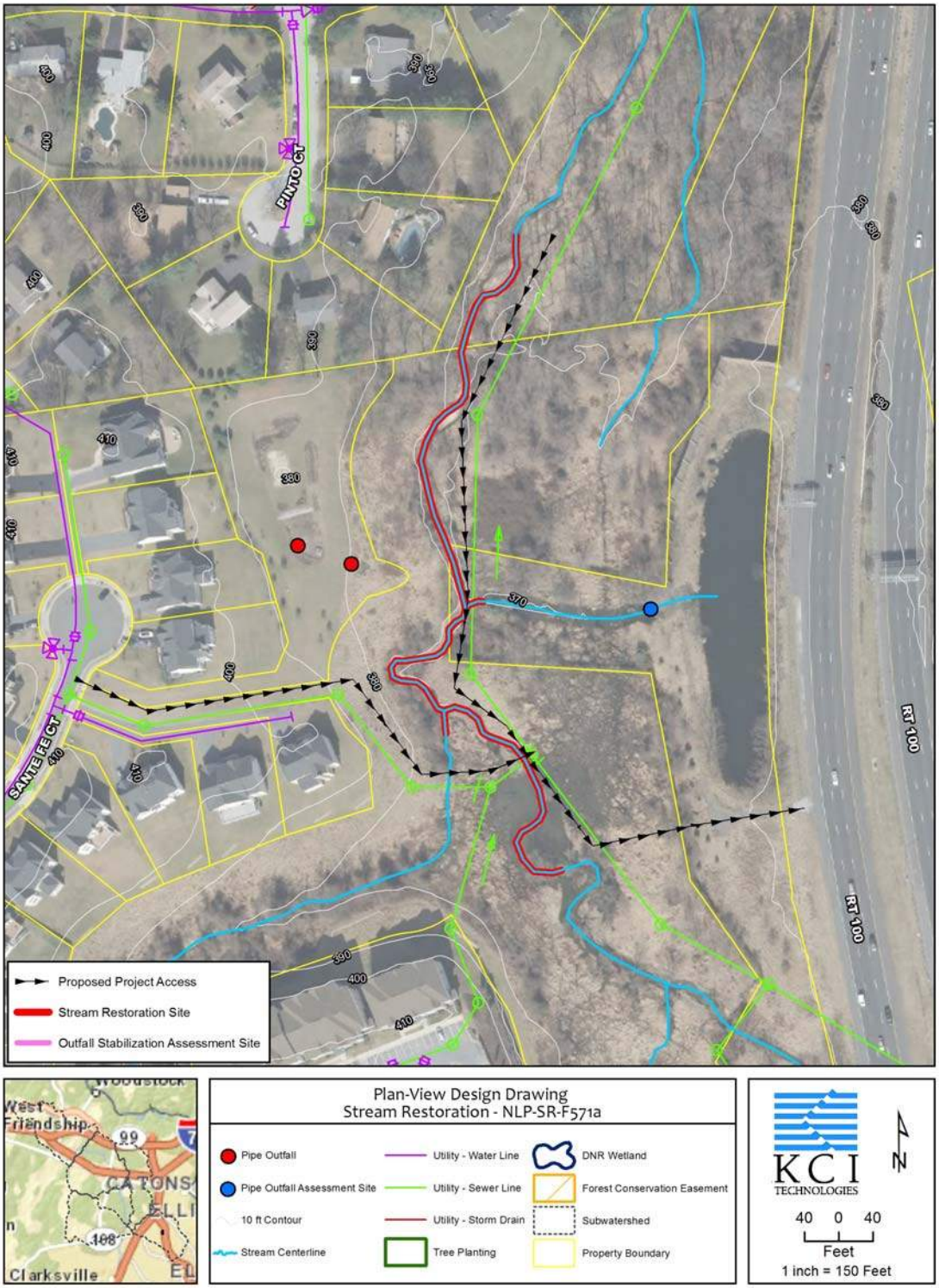
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F571a

Site Name: Red Hill Branch at Santa Fe Court

Contractor: KCI

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Stream Restoration

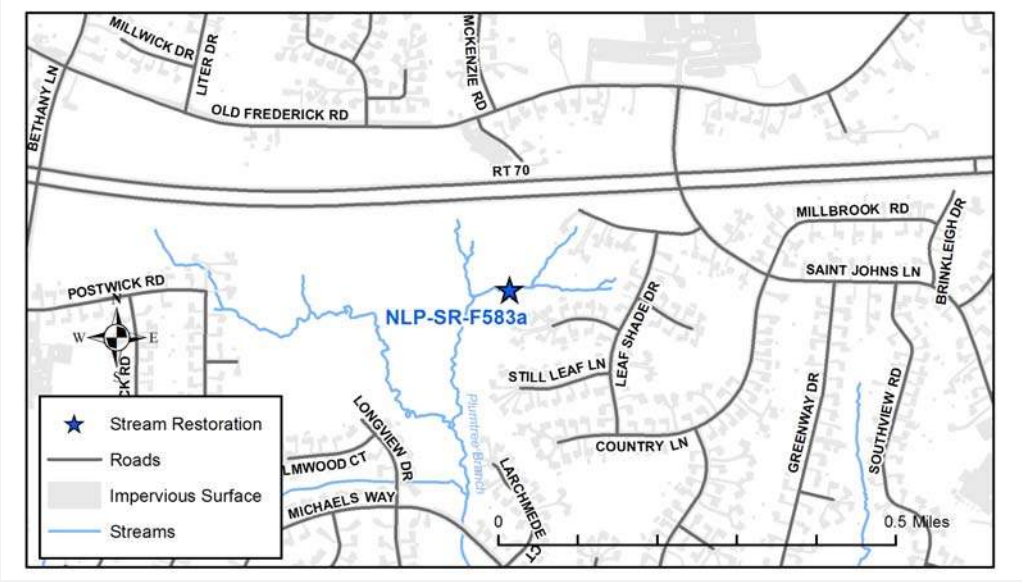
Site ID: NLP-SR-F583a
Site Name: Tributaries to Plumtree Branch, North
Contractor: KCI
Watershed: Little Patuxent River

Ownership: Private- Residential
Multiple Owners

Existing Conditions:

The site is located on several unnamed tributaries to Plumtree Branch. The reach includes branching of several tributaries that contribute flow to a mainstem segment. The bank heights range from 4 to 10 ft., with silt and clay material that is easily erodible due to their vertical bank angles, shallow root depths and poor surface protection. These tributaries are incised, when comparing their bank heights to the bankfull indicator (2 ft.). Thus, near bank stresses are very high. Erosion is recent and active, with sections of slumping banks and destabilized bank material, causing large amounts of deposition within the channel.

The bed material is composed of mostly sand and silt, but some gravel and cobbles were found in the riffles. As a result of the fine bed and bank material, the channel is highly embedded. The presence of available and good quality epifaunal substrate habitat and coverage is suboptimal due to the abundance of woody debris and leaf packs; however, the stability of habitat is uncertain due to the active erosion. Flow regimes are limited to two velocity/depth regimes, and riffle spacing is variable, ranging from seven to 20 channel widths. The riparian buffer width is greater than 60 ft. on both banks, with approximately 70% vegetative cover. No channel alterations were observed.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F583a
Site Name: Tributaries to Plumtree Branch, North
Contractor: KCI
Watershed: Little Patuxent River

Vertical and eroding banks, severe erosion.

Undercut banks, some deposition.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F583a
Site Name: Tributaries to Plumtree Branch, North
Contractor: KCI
Watershed: Little Patuxent River

Constraints/Utilities:

The majority of the reach is within private property. The area, however, is landlocked, and is not likely to be developed. Access from Leaf Shade Dr. can be achieved through a Howard County Parks and Recreations property near the upstream end of the site, or from a number of sewer easements along private property to the left bank of the channel. The sewer line runs parallel to the channel with three crossings through the stream that will require special considerations during design and construction.

Although the design would attempt to limit tree impacts, a moderate impact to trees would likely result during construction due to the existing wide riparian buffer. A full tree evaluation has not been conducted, but no specimen trees were noted during initial investigations and riparian cover was described as moderate and sparse due to the sewer easement along the channel.

Concept Description:

The proposed stream restoration includes a natural channel design throughout the site, where a secondary floodplain can be graded at a new, lower elevation. Proposed bank protection will include bioengineering techniques such as coir logs and vegetative stabilization, but stone protection and other harder bank treatments may be necessary in a few isolated locations. Existing bed materials are likely salvageable for the pools, but larger cobble material will be necessary to provide better riffle habitat.

A comprehensive planting plan will be developed for the various landscape zones throughout the site that will allow for the establishment of native plant species.

Nearby Opportunities:

None recommended

Proposed Project Credit		Costs	
Length Restored (ft):	1,987	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	19.9	Estimated Construction Cost:	$894,600.00
Cost per Impervious Credit Acre:	$73,627.58	30% Contingency:	$268,380.00
		Estimated Total Cost:	$1,462,980.00

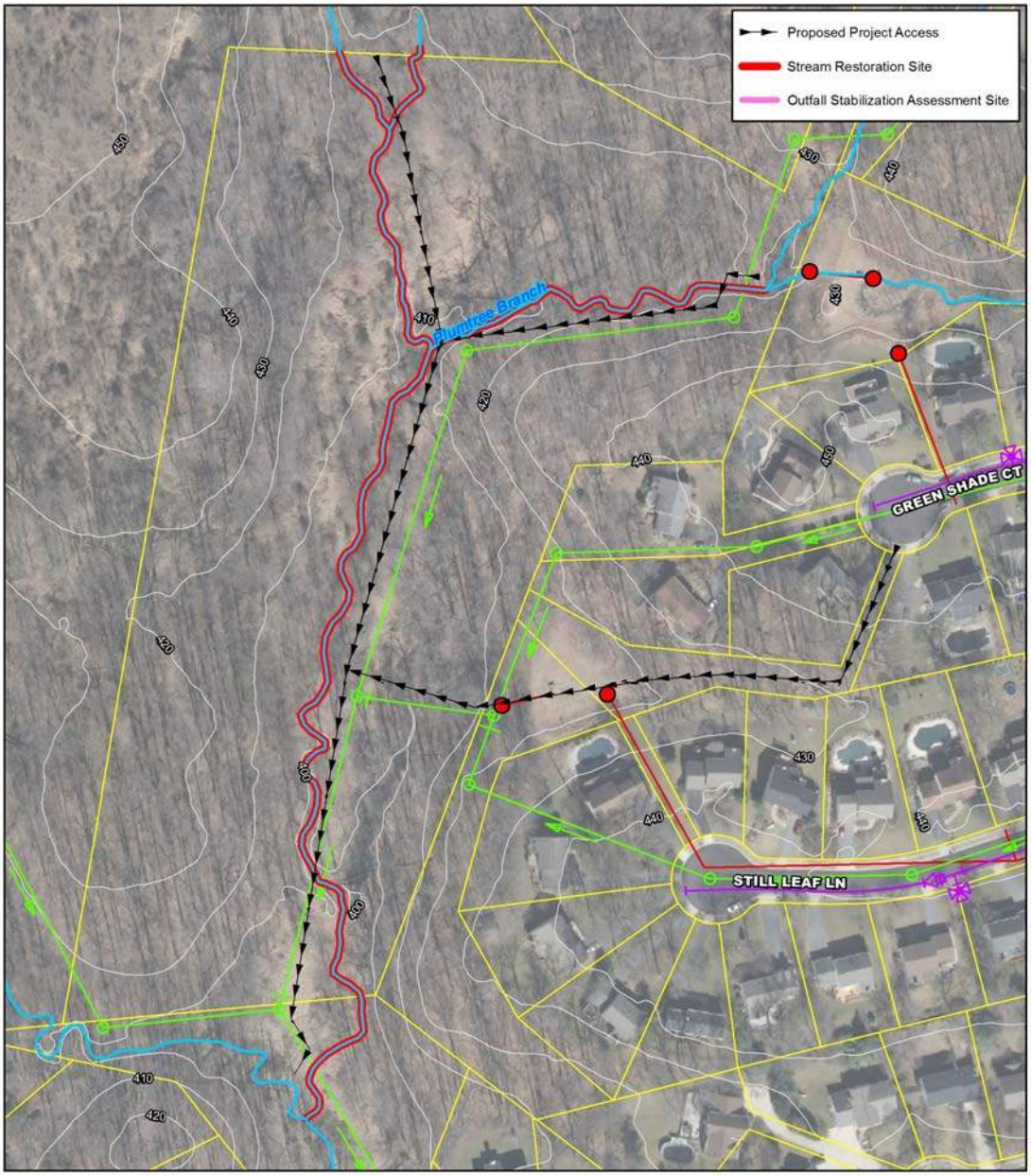
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F583a

Site Name: Tributaries to Plumtree Branch, North

Contractor: KCI

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Stream Restoration

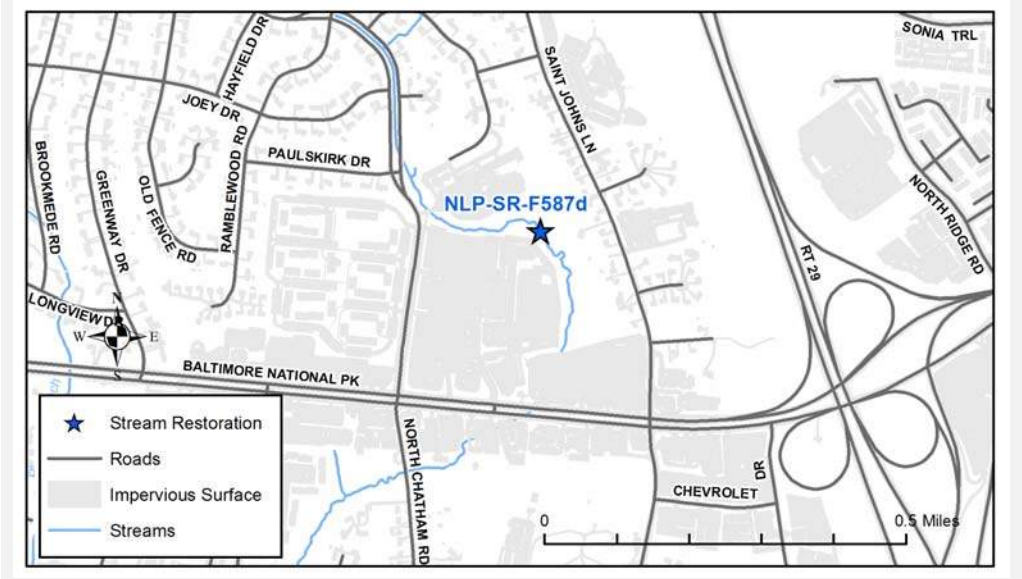
Site ID: NLP-SR-F587d
Site Name: Lutheran Village North
Contractor: KCI
Watershed: Little Patuxent River

Ownership: Private- Commercial/Industrial
Multiple Owners

Existing Conditions:

This site runs behind the parking lot for the Chatham Station Shopping Center, with its embankment greater than 25 ft. above the channel. The right bank of the channel is pinned close to this embankment, with boulders encroaching upon the channel banks. The left bank contains a wide, flat floodplain with a riparian buffer width greater than 60 ft. Banks are 3 to 6 ft. in height, and approximately 15 to 20 ft. wide. Erosion is present throughout the reach due to the silt-clay bank composition, steep bank angles, and shallow root depth, and minimal surface protection. Some bar deposition was noted as sandy lateral and point bars up to 1 ft. in height. An inner berm at 2 ft. in height above the bed was observed as the bankfull height. Thus, near bank stresses are moderate, based on the mean bankfull depth to near-bank maximum depth ratio.

The channel is highly embedded with fines and contains very poor quality epifaunal substrate and cover. Geomorphic variability is also limited, based on the number of velocity/depth regimes (2) and riffle spacing (15-25 channel widths). Nonetheless, an abundance of fish was noted throughout the site, compared to other sites.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F587d
Site Name: Lutheran Village North
Contractor: KCI
Watershed: Little Patuxent River

Undercut and eroding banks with no surface protection and shallow root depth; deposition as bar deposits.

Incised and eroding outfall channel.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F587d
Site Name: Lutheran Village North
Contractor: KCI
Watershed: Little Patuxent River

Constraints/Utilities:

The channel runs through multiple private commercial and residential properties, including the Chatham Mall Company, and a large parcel owned by the Church of the Resurrection and two large parcels owned by the Roman Catholic Archbishop of Baltimore through which access will need to be coordinated. Construction access may be feasible from the northwest corner of the Chatham Shopping Center parking lot, where shopping center activity is minimal or behind St. John's Plaza. Access from the Church of the Resurrection may also be possible, if coordination agreements can be made, particularly with regard to time of the school day.

The embankment to the Chatham Station Shopping Center is very steep and is composed of very large boulders down to the channel. This embankment and its boulders present significant constraints to the design, as moving the boulders would be intensive and costly. It is recommended that the horizontal alignment of this channel be pulled away from the embankment to limit grading along the right bank to fill areas, which will also provide some flood relief along this bank.

The existence of wetlands will require special considerations to the design. Tree removals will also be required; however tree cover is sparse.

Concept Description:

The proposed stream restoration includes a natural channel design throughout this site, where a secondary floodplain can be graded at a new, lower elevation. Bank protection is expected to be composed primarily of bioengineering techniques such as coir logs and vegetative stabilization, but stone protection and other harder bank treatments may be necessary in a few isolated locations. Existing bed materials are likely salvageable, but larger cobble material will be necessary to provide better riffle habitat.

A comprehensive planting plan will be developed for the various landscape zones throughout the site that will allow for the establishment of native plant species. Several areas were noted as having potential for further planting beyond the LOD, including an area in the rear of the adjacent Church of the Resurrection parking lot, and another area of open space towards the downstream end and on the left bank of the channel.

Nearby Opportunities:

None recommended

Proposed Project Credit		Costs	
Length Restored (ft):	1,980	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	19.8	Estimated Construction Cost:	$891,450.00
Cost per Impervious Credit Acre:	$73,681.06	30% Contingency:	$267,435.00
		Estimated Total Cost:	$1,458,885.00

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F587d

Site Name: Lutheran Village North

Contractor: KCI

Watershed: Little Patuxent River

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F590a
Site Name: Turf Valley (d)
Contractor: KCI
Watershed: Little Patuxent River

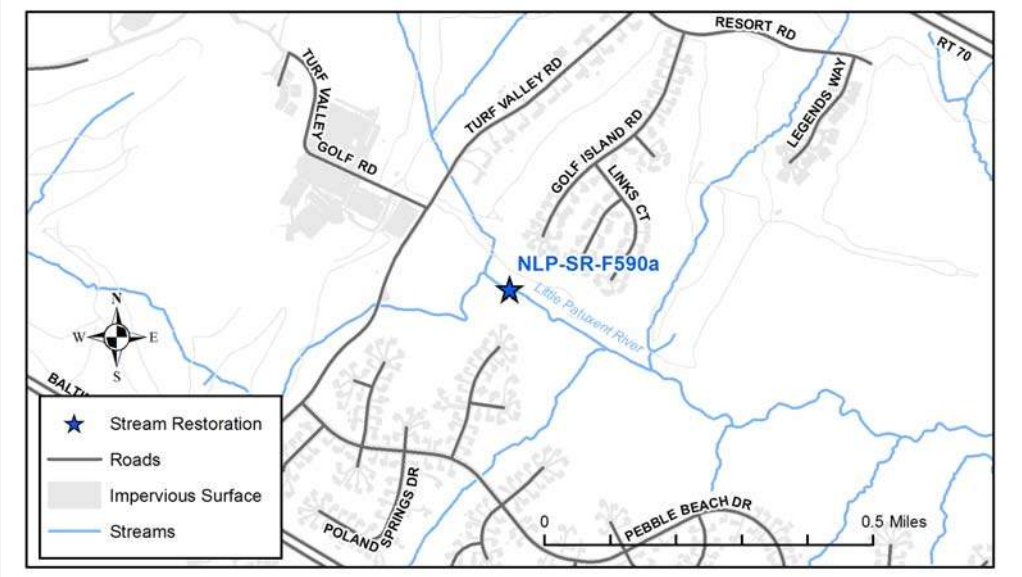
Ownership: Private- Mixed Use
Multiple Owners

Existing Conditions:

The restoration reach is located on the Little Patuxent River. It has approximately 3 to 6 ft. high vertical banks comprised of easily erodible silty material; however, the banks contain areas of moderate to high root depths and high surface protection. Bank heights are lower, around 3 ft., in the upper portions of the restoration reach to the confluence with an unnamed tributary. Downstream of the confluence the bank height increases, reaching up to 6 ft. in height. Overall, the restoration reach has approximately 1,800 linear ft. of moderately eroded banks.

The reach has a low level of embeddedness and the bed material is composed of mostly sand, gravel, cobble and boulders with some silt. The presence of available and good quality epifaunal substrate habitat and coverage is suboptimal to optimal. Three velocity/depth regimes are apparent and baseflow occupies more than 75% of the width between both banks. Riffle spacing is characterized as being approximately 5 to 15 channel widths. Minimal channel alterations were observed and are associated with a sanitary sewer crossing. The sanitary sewer line also runs parallel to the restoration reach.

The riparian buffer width is greater than 60 ft. on both banks until after the confluence at the middle of the reach where the left bank changes to less than 20 ft. because the reach runs along the Turf Valley Golf Course. The quality of the riparian vegetation is good, at approximately 90% cover.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F590a
Site Name: Turf Valley (d)
Contractor: KCI
Watershed: Little Patuxent River

Facing downstream, vertical left banks with moderate root depth.

Facing upstream, erosion on left bank with poor root depth. Good epifaunal habitat availability.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F590a
Site Name: Turf Valley (d)
Contractor: KCI
Watershed: Little Patuxent River

Constraints/Utilities:

Half of the restoration area is within Howard County Parks and Recreations property while the other half is on Mangione Enterprises Turf Valley property, so property owner coordination will be necessary to complete the project. A sewer line runs parallel to the channel with a crossing at the midpoint of the reach. A maintained easement also runs parallel to the channel in the lower half of the site.

The easements running parallel to the channel could provide access; however, the location of the wetlands may determine construction access. Although the design would attempt to limit tree impacts, a significant impact to trees would likely result during construction due to the existing wide riparian buffer. A full tree evaluation has not been conducted, but no specimen trees were noted during initial investigations.

Concept Description:

The proposed stream restoration includes a natural channel design throughout the site, where a secondary floodplain can be graded at a new, lower elevation, and where a limited bench can be established at the current bankfull elevation. As the reach runs along the border of Howard County Parks property and Mangione Enterprises Turf Valley property, there is potential to realign portions of the reach so it is solely on Howard County Parks property and better floodplain access would be available. Proposed bank protection will include bioengineering techniques such as coir logs and vegetative stabilization, but stone protection and other harder bank treatments may be necessary in a few isolated locations. Existing bed materials are likely salvageable, but larger cobble material will be necessary to provide better riffle habitat.

A comprehensive planting plan will be developed for the various landscape zones throughout the site that will allow for the establishment of native plant species.

Nearby Opportunities:

None recommended

Proposed Project Credit		Costs	
Length Restored (ft):	1,762	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	17.6	Estimated Construction Cost:	$793,350.00
Cost per Impervious Credit Acre:	$75,559.31	30% Contingency:	$238,005.00
		Estimated Total Cost:	$1,331,355.00

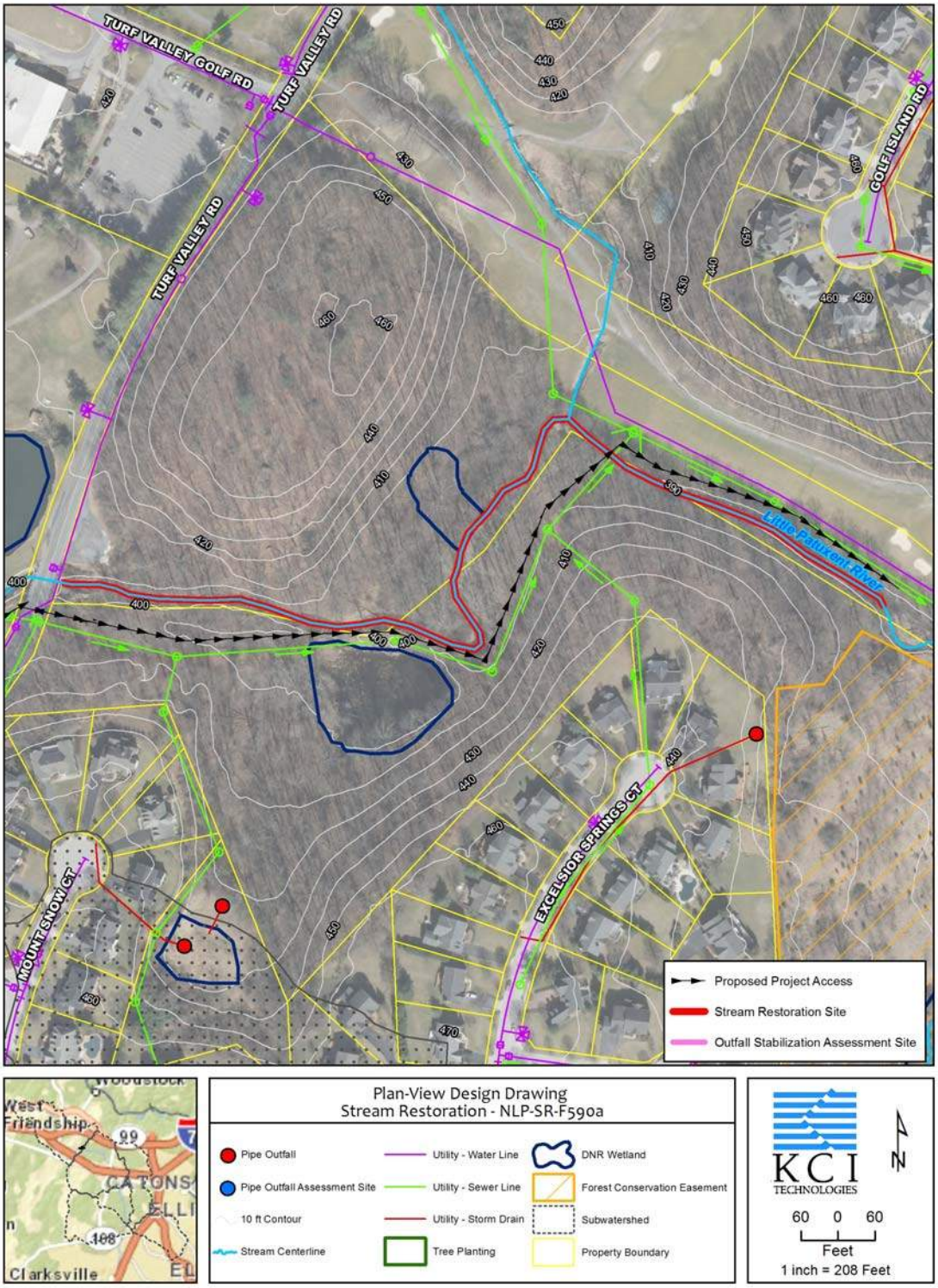
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F590a

Site Name: Turf Valley (d)

Contractor: KCI

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Stream Restoration

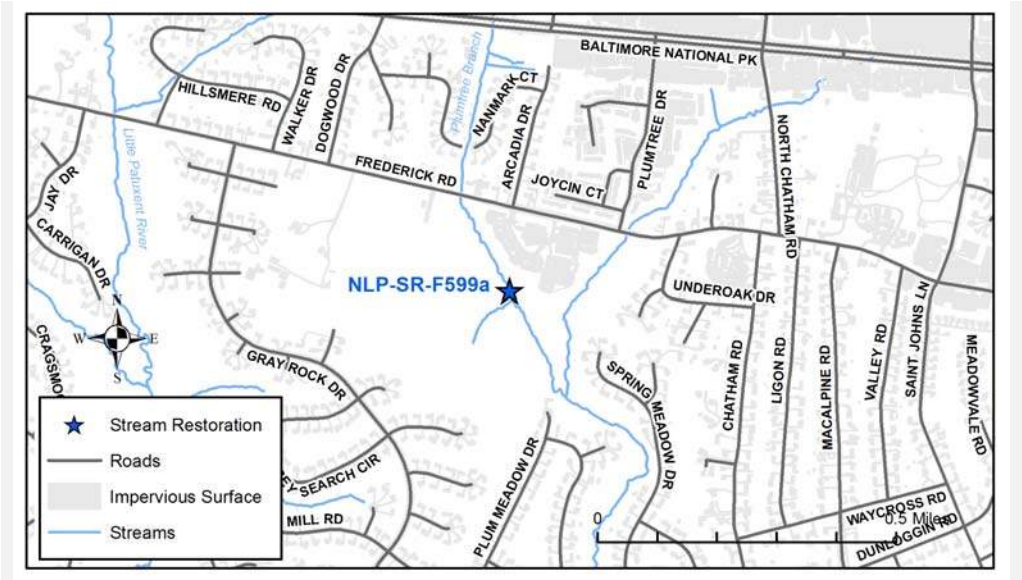
Site ID: NLP-SR-F599a
Site Name: Plumtree Branch
Contractor: KCI
Watershed: Little Patuxent River

Ownership: Private- Mixed Use
Multiple Owners

Existing Conditions:

The project site is a segment of Plumtree Branch bounded to the north by Frederick Road and ending at the confluence with the unnamed tributary from proposed project SR-50. A sewer line runs parallel to the channel along the right bank, with two contributing lines that cross the channel from the left bank; the easement contains abundant grasses and few trees. Reach 1 is approximately 560 lf. and starts at the upstream end of the project site. Banks are generally 5 ft. in height along the right bank and 3 ft. on the left bank. The top of bank width is approximately 15 ft., and bed material is sand and silt with some cobbles present in the riffles. A few benches along the right bank have formed out of slumped bank material, with a stabilized height above the bed at 2 ft. The reach is characterized by vertical and eroding banks and localized erosion on outer meander bends of the left bank. A very large debris jam was noted. Reach 2 is approximately 1,070 lf., and has shorter stretches of less severe erosion than Reach 1. The riparian floodplain has a few more trees and shrubs that provide better rooting depth for bank protection. The reach ends at a new bridge under construction. Reach 3 is approximately 575 lf. in length, with 4 to 5 ft. high banks. Banks are 15 to 20 ft. wide, vertical, and raw with very low root depth.

A very large construction operation is under way on the right bank, and construction has recently been completed at the library and senior center along the left bank of this project site. The right bank was formerly abandoned agricultural land with abundant unmowed grasses and some trees and shrubs. Because of the recent construction surrounding this site, it is doubtful that the effects of the change in land use have impacted the channel at this time. However, with the existing channel erosion and recent environmental disturbances, this site is a prime candidate for stream restoration. A channel design that addresses the new stormwater inputs prior to significant degradation would be in good timing to mitigate future erosion. With the recent community and environmental disturbance surrounding construction, an immediate restoration strategy might lessen the total time to recovery, as opposed to disrupting newly established vegetation and other riparian and aquatic life. The project may also provide a good educational opportunity due to its proximity to several community facilities and could be visible from Frederick Road.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F599a
Site Name: Plumtree Branch
Contractor: KCI
Watershed: Little Patuxent River

Vertical banks and sand deposition, very fine bed material.

Bench establishment at approximately 2 ft. in height.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F599a
Site Name: Plumtree Branch
Contractor: KCI
Watershed: Little Patuxent River

Constraints/Utilities:

Ownership through the study area includes four large parcels: the right bank is owned predominantly by Lutheran Village, and the left bank is split between Howard County and the Miller Land Company. The final parcel of land is owned by Howard County, and includes approximately 340 lf. along both banks.

A sewer line runs parallel to the channel along the right bank, with two contributing lines that cross the channel from the left bank. The maintained sewer easement contains abundant grasses and few trees. Although this may be a constraint in some areas, it also provides good access for construction.

A few specimen trees were noted along the channel that appears to be in good condition, and some wetlands may be present along the left bank at the lower extent of the project reach.

Concept Description:

The proposed stream restoration includes a natural channel design throughout this site, where a new secondary floodplain can be graded at a lower elevation. The width of the proposed secondary floodplain will be determined by distance to private property, wetlands, and specimen trees. Bank protection is expected to be composed primarily of bioengineering techniques such as coir logs and vegetative stabilization, but stone protection and other harder bank treatments may be necessary in a few isolated locations, particularly in close proximity to the sewer line. Some existing bed materials are likely salvageable, but larger cobble material will be necessary to provide better riffle habitat.

Riffle Grade Controls are also proposed at the sewer crossings to provide vertical control of the channel bed to protect the sanitary sewer. A comprehensive planting plan will be developed for the various landscape zones throughout the site that will allow for the establishment of native plant species.

Nearby Opportunities:

NLP-SR-50, NLP-SR-F586a (not selected for concept phase)

Proposed Project Credit		Costs	
Length Restored (ft):	2,204	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	22.0	Estimated Construction Cost:	$992,250.00
Cost per Impervious Credit Acre:	$72,138.16	30% Contingency:	$297,675.00
		Estimated Total Cost:	$1,589,925.00

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: NLP-SR-F599a

Site Name: Plumtree Branch

Contractor: KCI

Watershed: Little Patuxent River

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SLP-SR-F735

Site Name: Wilde Lake Headwaters Stream Restoration

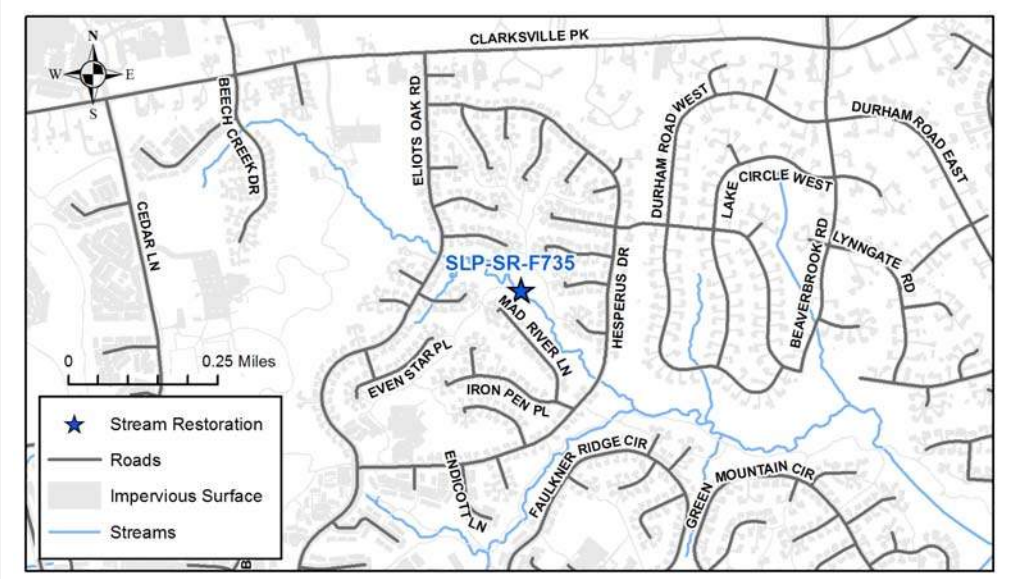
Contractor: Versar

Watershed: Little Patuxent River

Ownership: Columbia Association
Single Owner

Existing Conditions:

The stream corridor recommended for restoration is fully contained within Columbia Association property, though several private residential houses and yards are within 100 ft. of the stream channel. Three outfalls discharge directly into the stream reach. Erosion is present along 70-80% of the stream reach, but only 10-20% of the existing erosion is severe. Several large point bars are present within the reach. The assessments of habitat conditions conducted within the reach yielded a Partially Supporting rating.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SLP-SR-F735

Site Name: Wilde Lake Headwaters Stream Restoration

Contractor: Versar

Watershed: Little Patuxent River

Cut bank erosion occurring along the left bank. Photo taken approximately 250 ft. upstream of Hesperus Drive. Bank height is approximately 4 ft.

Cut bank erosion occurring along the right bank. Photo taken approximately 650 ft. upstream of Hesperus Drive from the top of a large point bar. Bank height is approximately 5 ft.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SLP-SR-F735
Site Name: Wilde Lake Headwaters Stream Restoration
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:

Two sewer line crossings exist within the proposed restoration reach. One crossing is located approximately 800 ft. upstream of Hesperus Drive, and one crossing is located 450 ft. downstream of Eliot Oaks Road. Mature trees exist along both sides of the stream for the entire length of the proposed project, with several that have recently fallen into the stream channel. Two wetland areas were noted within the reach, one near the very downstream extent, and another near the upstream extent.

Concept Description:

The proposed restoration will stabilize eroding banks and reconnect the stream channel with the floodplain. Any floodplain reconnection work will have to be mindful of the Columbia Association trails that are often adjacent to the channel, and wetland areas that are present along the floodplain. The large point bars that dominate the inside of meander bends should be addressed as well. It is also recommended that a drop structure replaces the outfall (SLP-OF-F854) located on the right side of the channel, close to the middle of the reach. Approximately 30 ft. of riprap should also be installed along the associated outfall channel. The cost of the outfall stabilization is not included in the total cost for this site. The site can be accessed from Columbia Association trails located on either side of the proposed restoration reach.

Nearby Opportunities:

SLP-OF-F854

Proposed Project Credit		Costs	
Length Restored (ft):	2,008	Estimated Design Cost:	$320,000.00
Impervious Area Treated Credit (ac.):	20.1	Estimated Construction Cost:	$903,676.50
Cost per Impervious Credit Acre:	$74,441.21	30% Contingency:	$271,102.95
		Estimated Total Cost:	$1,494,779.45

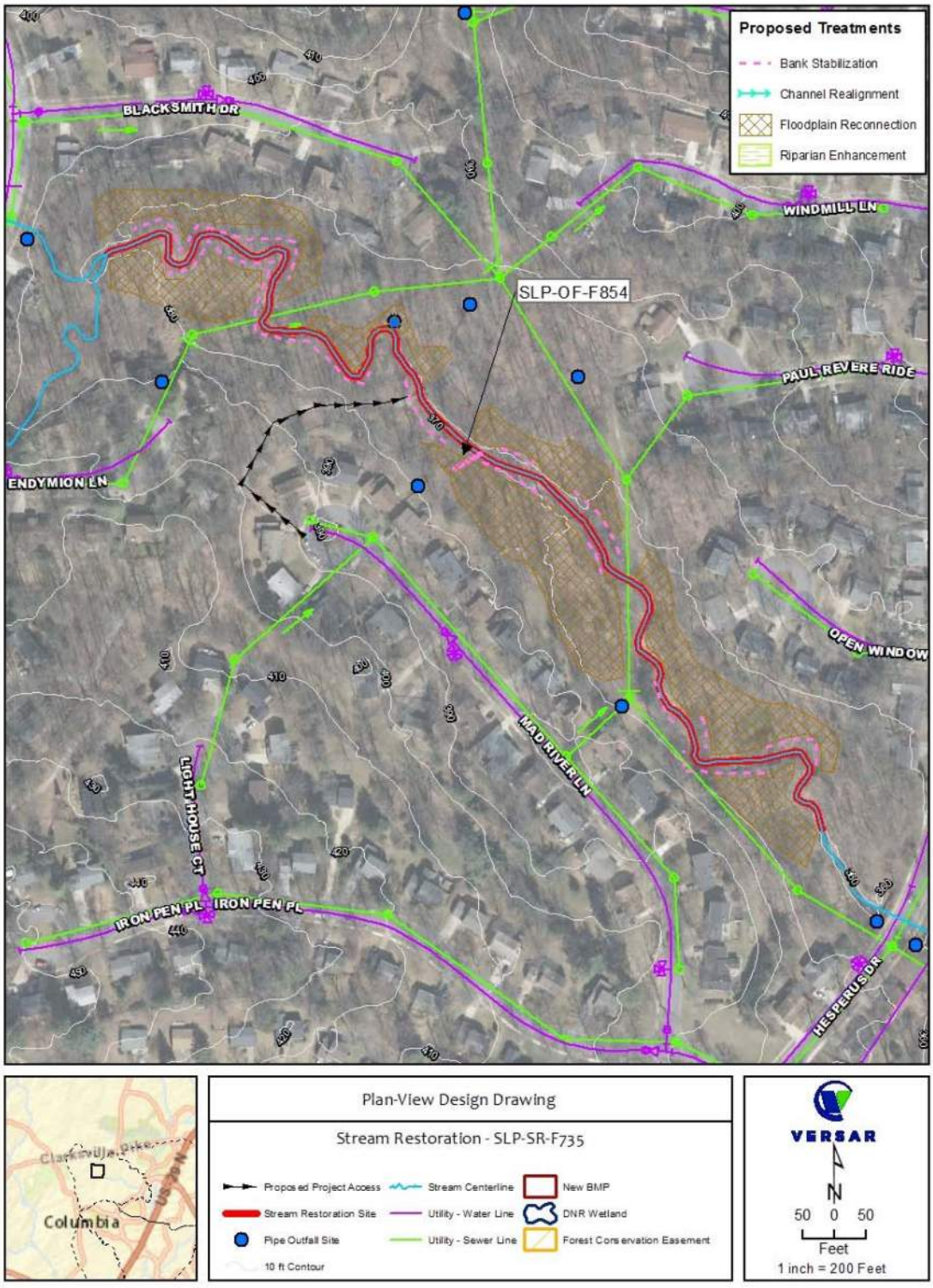
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SLP-SR-F735

Site Name: Wilde Lake Headwaters Stream Restoration

Contractor: Versar

Watershed: Little Patuxent River



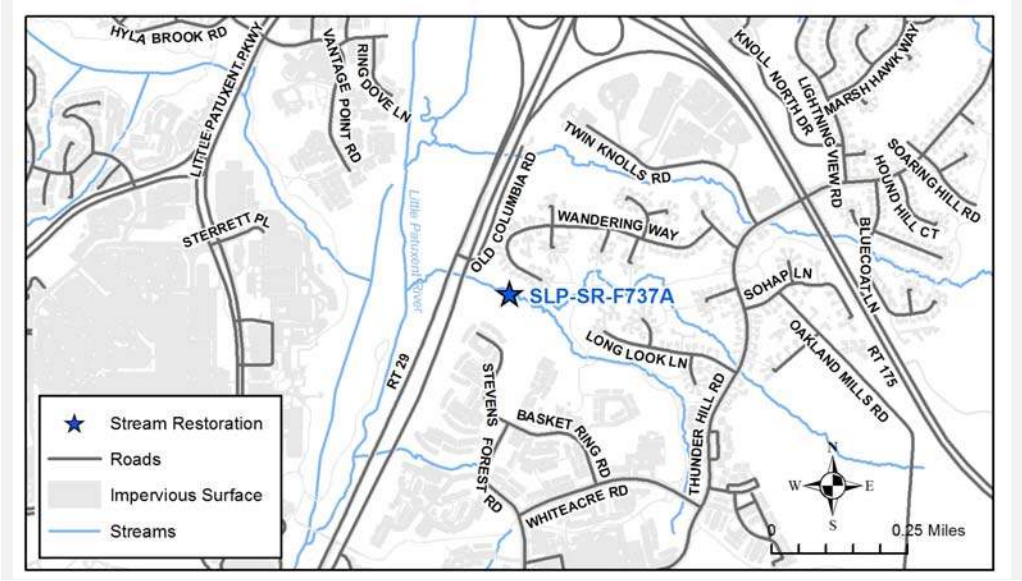
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SLP-SR-F737A
Site Name: Oakland Mills
Contractor: Versar
Watershed: Little Patuxent River

Ownership: Columbia Association
Multiple Owners

Existing Conditions:

Nearly the entire stream corridor recommended for restoration is contained within Columbia Association property, with approximately 50 lf. being located within State Highway Administration Right of Way for Route 29. One stabilized outfall discharges directly into the stream reach and appears to have been installed within the past few years. A few patches of minor to moderate erosion exist in the downstream portion of the reach, and severe erosion exists in the upstream portion of the reach. Large and raw stream banks in the upstream portion of the reach appear to be the result of an old dam that once blocked the stream channel; remnants of this dam still remain in the channel. An exposed utility pipe was observed in the upper most portion of the reach. The assessment of habitat conditions conducted within the reach yielded a Non-supporting rating.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SLP-SR-F737A
Site Name: Oakland Mills
Contractor: Versar
Watershed: Little Patuxent River

An approximately 7 ft. high sediment deposit located along the left bank. Sediment appears to have accumulated behind an old dam. Dam remnants can be found approximately 500 ft. upstream of Route 29.

Erosion occurring along the left bank of the stream. Photo taken approximately 800 ft. upstream of Route 24. Bank height is approximately 5 ft.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SLP-SR-F737A
Site Name: Oakland Mills
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:

One mapped sewer line crosses the restoration reach approximately 75 ft. upstream of Route 29. Another utility line was noted in the upper most section of the restoration reach, but this crossing does not appear in the County's GIS mapping. Forested land exists on the left side of the stream channel and extends approximately 300-350 ft. to the south. Any construction activities occurring on the left side of the channel will result in a disturbance to trees.

Concept Description:

The focus of the proposed restoration will be reconnecting the stream channel with the floodplain. The lack of residential encroachment and the sparsity of trees along the right side of the channel should be conducive for a floodplain reconnection project. The proposed project should also address the exposed utility pipe that was observed in the upstream portion of the restoration reach, and should include an option to plant trees in the floodplain. Best access to the proposed restoration site is to follow the Columbia Association trail from end of Wandering Way into woods located along northern side of stream.

Nearby Opportunities:

None recommended

Proposed Project Credit		Costs	
Length Restored (ft):	973	Estimated Design Cost:	$220,000.00
Impervious Area Treated Credit (ac.):	9.73	Estimated Construction Cost:	$437,778.00
Cost per Impervious Credit Acre:	$81,100.86	30% Contingency:	$131,333.40
		Estimated Total Cost:	$789,111.40

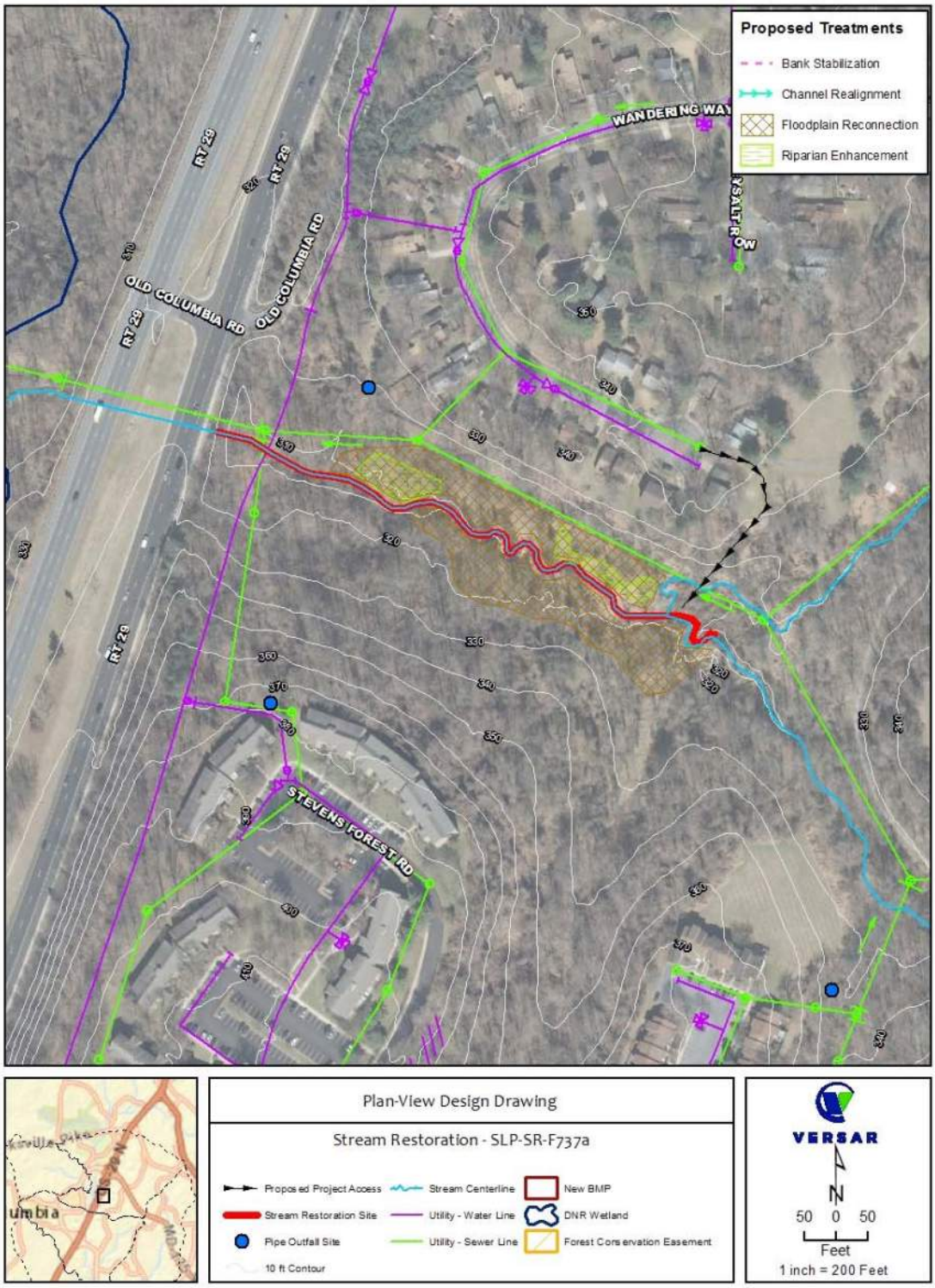
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SLP-SR-F737A

Site Name: Oakland Mills

Contractor: Versar

Watershed: Little Patuxent River



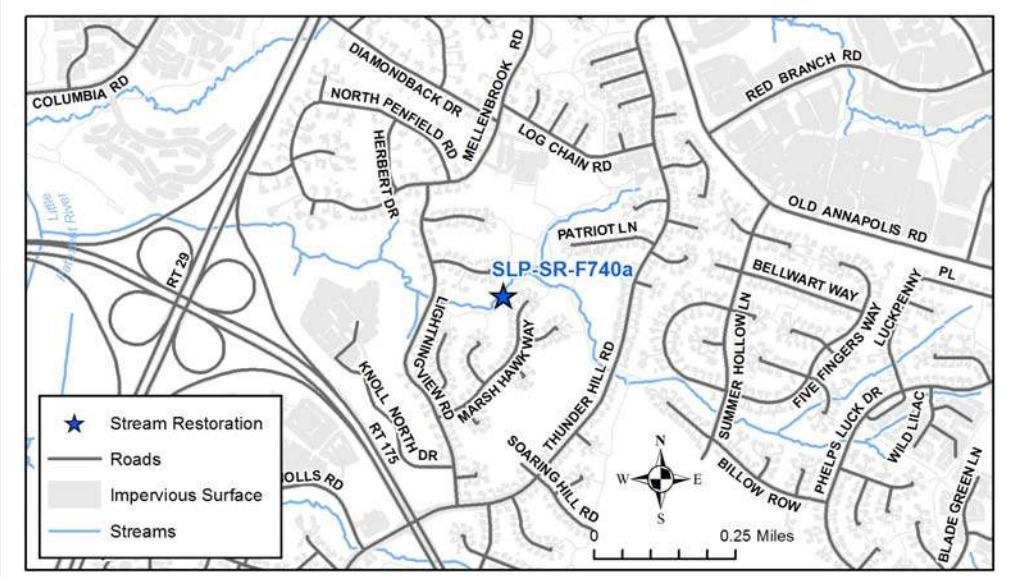
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SLP-SR-F740a
Site Name: Lightning View Road
Contractor: Versar
Watershed: Little Patuxent River

Ownership: Columbia Association
Multiple Owners

Existing Conditions:

The stream corridor recommended for restoration is fully contained within Columbia Association property on the left side of the stream, but several private residential properties abut the channel on the right side. Four outfalls discharge into the stream reach, two of which have been recommended for stabilization and are having separate concept plans developed. Moving upstream from Lightning View Road, the first 600 ft. of the proposed restoration reach exhibits nearly continuous erosion, with smaller patches of erosion existing in the upper portions of the reach. The upstream extent of the reach is marked by a step pool outfall channel that drains a large wet pond. The assessment of habitat conditions conducted within the reach yielded a Non-supporting rating.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SLP-SR-F740a
Site Name: Lightning View Road
Contractor: Versar
Watershed: Little Patuxent River

Erosion occurring along the left bank. Private residential yards with no trees are nearly abutting the stream in this section of the reach. Bank height is approximately 4.5 ft.

Erosion occurring along the right bank. Mowing is occurring along the bank in a private residential yard abutting the stream. Bank height is approximately 4.5 ft.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SLP-SR-F740a
Site Name: Lightning View Road
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:

Two mapped sewer lines cross the proposed restoration reach, one of which is approximately 150 ft. upstream of Lightning View Road, and the other is approximately 750 ft. upstream of the same road. Although a well established forest is not present, several small to medium sized trees will need to be removed during construction.

Concept Description:

The proposed restoration will stabilize eroding banks and prevent the further loss of private property. While floodplain reconnection would help alleviate erosive flows and reduce sediment and nutrient loads, it may not be feasible due to the proximity of the residential yards on the right side of the channel, and the Columbia Association trail on the left side of the channel. Details for the two outfall stabilization projects that are contained within the restoration reach can be found on the factsheets for SLP-OF-F851 and SLP-OF-F852. The total cost estimate for the stream restoration work does not include the two stabilization projects. The site can be accessed from either the Columbia Association trail that crosses Lightning View Road or the Columbia Association trail that originates at the end of Marsh Hawk Way.

Nearby Opportunities:

SLP-OF-F851, SLP-OF-F852

Proposed Project Credit		Costs	
Length Restored (ft):	1,048	Estimated Design Cost:	$220,000.00
Impervious Area Treated Credit (ac.):	10.5	Estimated Construction Cost:	$471,447.00
Cost per Impervious Credit Acre:	$79,473.39	30% Contingency:	$141,434.10
		Estimated Total Cost:	$832,881.10

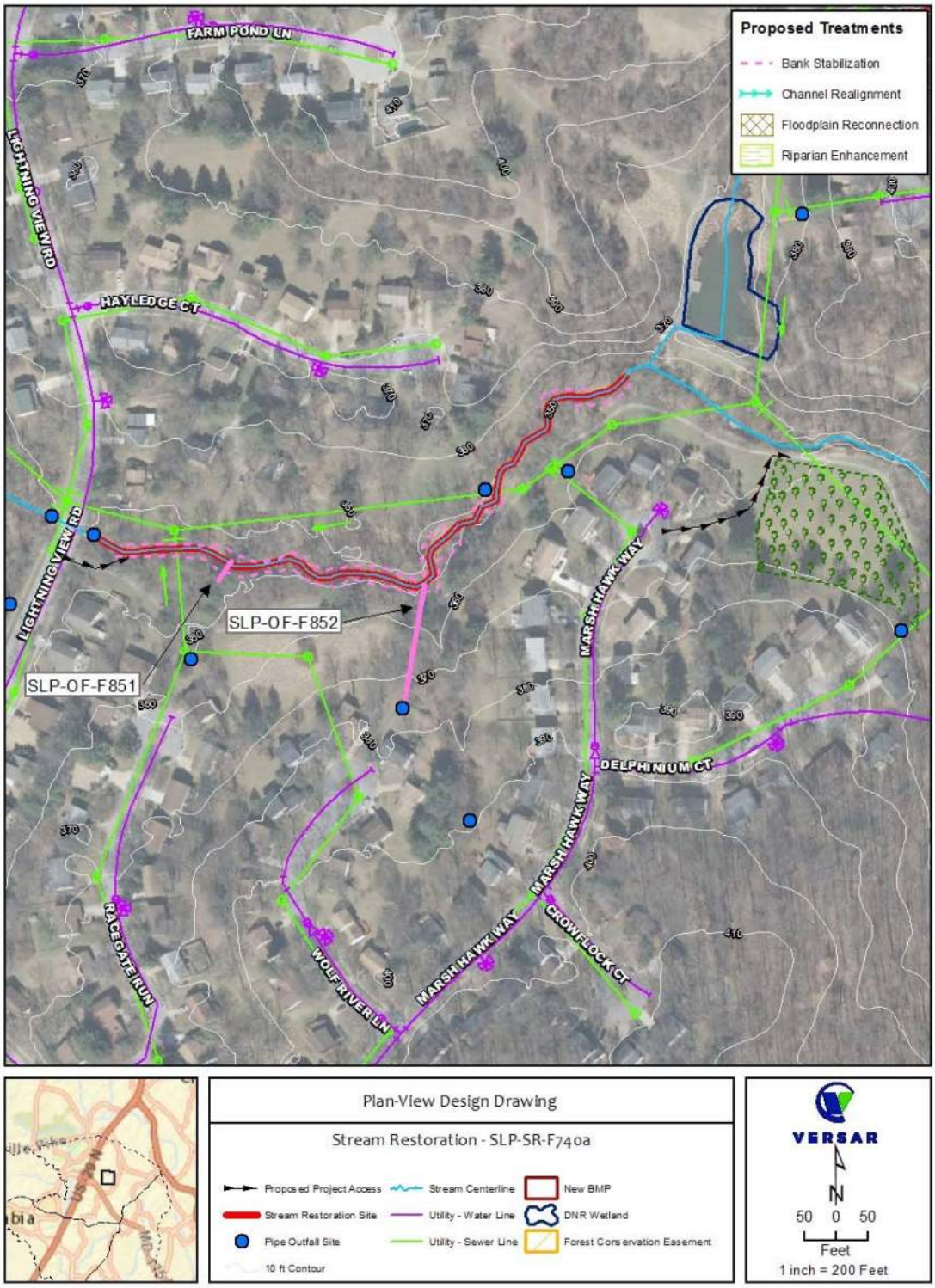
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SLP-SR-F740a

Site Name: Lightning View Road

Contractor: Versar

Watershed: Little Patuxent River



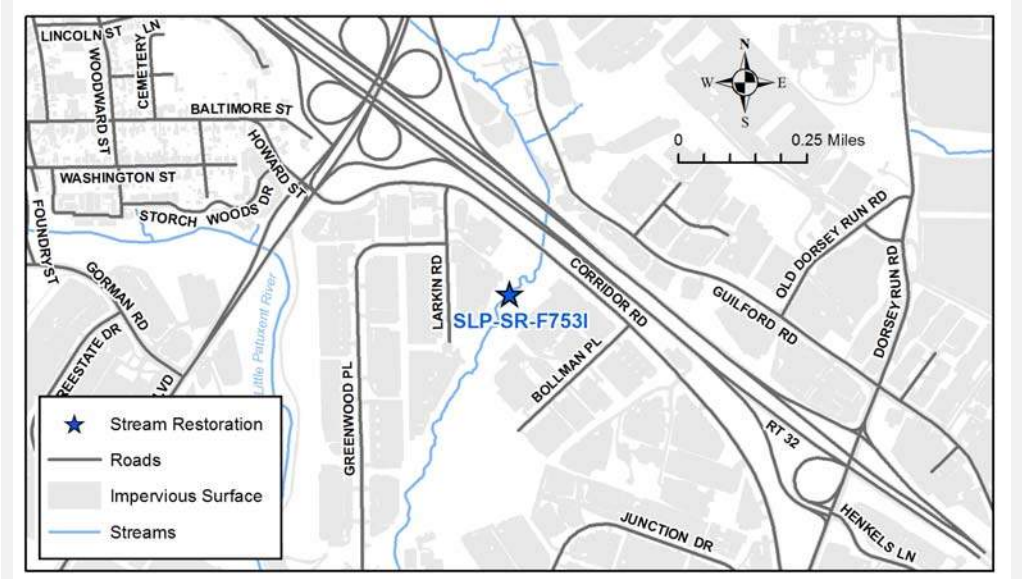
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SLP-SR-F753I
Site Name: North Laurel Industrial Park
Contractor: Versar
Watershed: Little Patuxent River

Ownership: County Owned
Single Owner

Existing Conditions:

The stream corridor recommended for restoration is fully contained within Howard County property, with the exception of the portion that abuts Route 32, which is considered State Highway Administration Right of Way. A proposed outfall stabilization site is located just downstream of the proposed stream restoration reach, and is partially contained on private commercial property. Three outfalls discharge directly into the stream reach. Moderate to severe erosion exists throughout approximately 50% of the reach. Large point bars can be found throughout most of the reach. The assessment of habitat conditions conducted within the reach yielded a Non-supporting rating.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SLP-SR-F753I
Site Name: North Laurel Industrial Park
Contractor: Versar
Watershed: Little Patuxent River

Erosion occurring along the right stream bank. A large gravel bar is present on the left side of the stream.

Erosion occurring along the right stream bank. Bank height is approximately 6.5 ft. A large cobble bar is present on the left side of the stream.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SLP-SR-F753I
Site Name: North Laurel Industrial Park
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:

A sewer main crosses the channel at one location, and runs along side the channel throughout most of the proposed restoration reach. Mature trees are present through the entire reach, and will almost certainly be impacted by construction activities.

Concept Description:

The focus of the proposed restoration will be stabilizing eroding banks and restoring a natural flow regime to prevent the future formation of large point bars throughout the reach. Little to no residential or commercial encroachment is present on either side of the channel, which is conducive for floodplain reconnection; however, several mature trees exist on both sides of the channel, which may lead to a difficult permitting process. The outfall recommended for stabilization (SLP-OF-F736) has a 6 ft. drop between the mouth of the outfall and the receiving outfall channel bed. A step pool conveyance should be constructed if enough space is available, otherwise a drop structure should be used to reconnect the outfall pipe with the channel bed. The total cost estimate does not include the outfall stabilization option. The easiest access to the proposed restoration project is from Corridor Road.

Nearby Opportunities:

SLP-OF-F736

Proposed Project Credit		Costs	
Length Restored (ft):	1,534	Estimated Design Cost:	$320,000.00
Impervious Area Treated Credit (ac.):	15.3	Estimated Construction Cost:	$690,160.50
Cost per Impervious Credit Acre:	$79,348.67	30% Contingency:	$207,048.15
		Estimated Total Cost:	$1,217,208.65

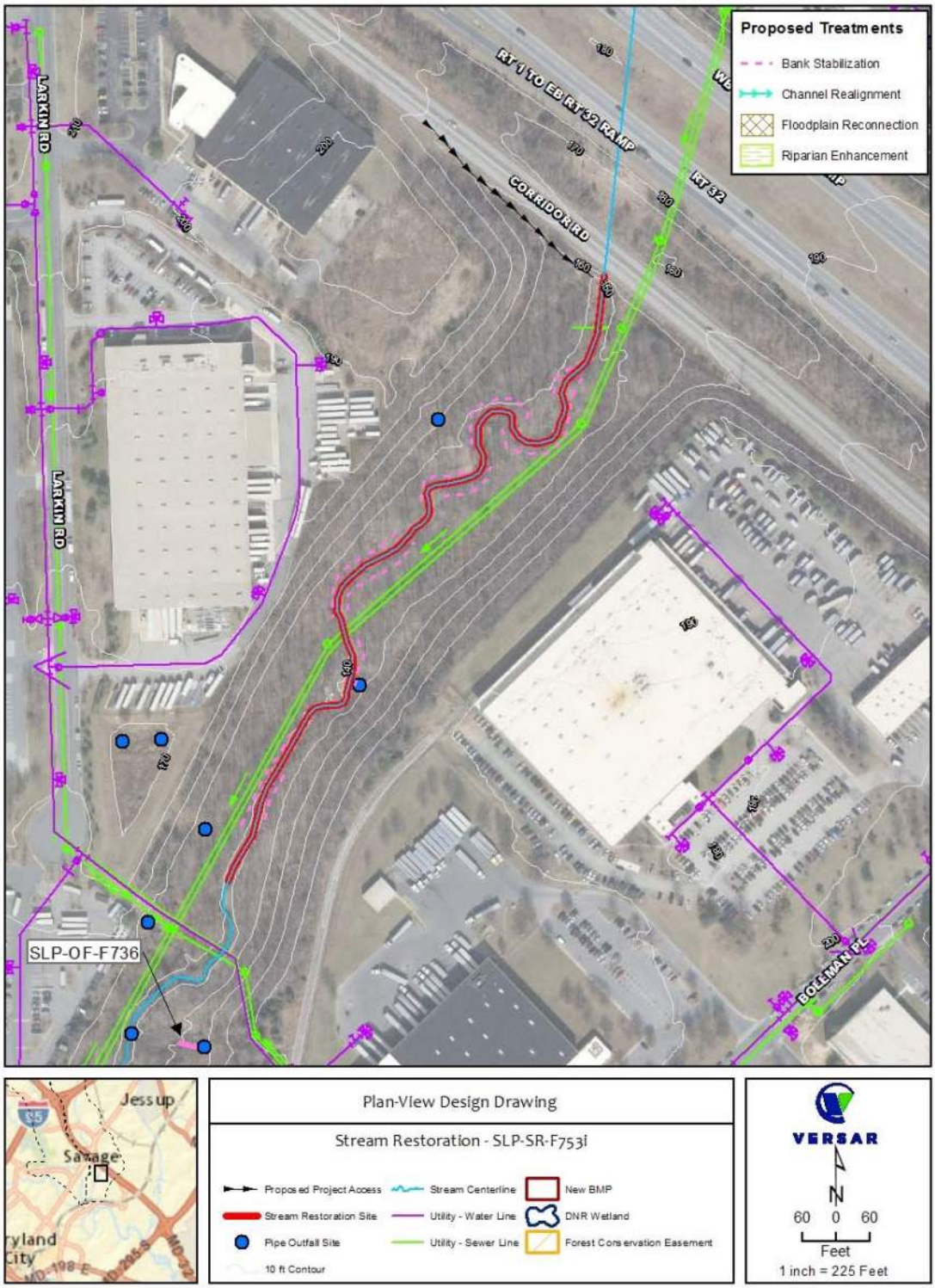
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SLP-SR-F753I

Site Name: North Laurel Industrial Park

Contractor: Versar

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SLP-SR-F754

Site Name: Lake Elkhorn Receiving Channel

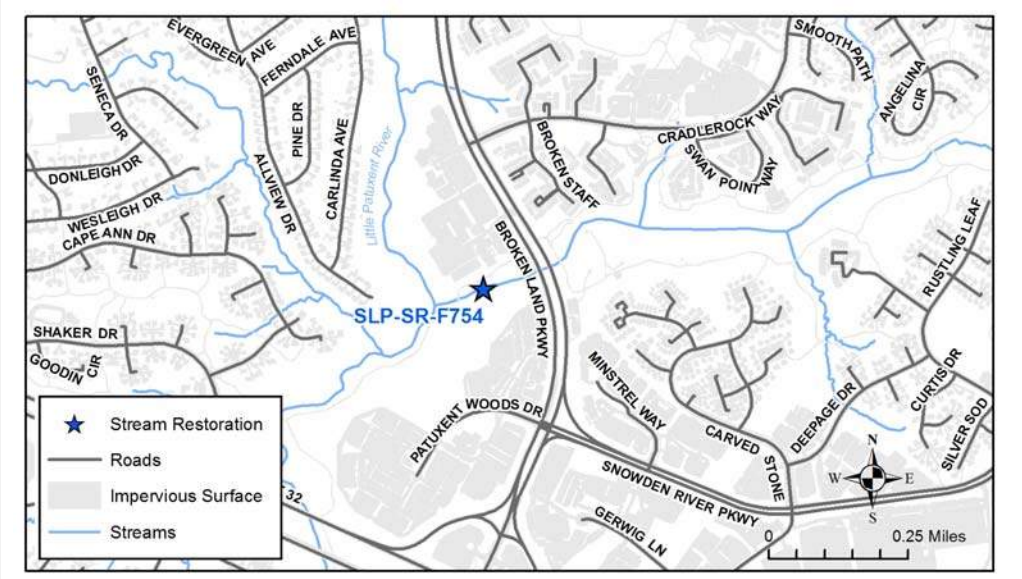
Contractor: Versar

Watershed: Little Patuxent River

Ownership: Columbia Association
Single Owner

Existing Conditions:

The stream corridor recommended for restoration is fully contained within Columbia Association property and is located just downstream of Lake Elkhorn; between Broken Land Parkway and the mainstem of the Little Patuxent River. No observed outfalls discharge directly into the reach. Stream bank erosion is present throughout approximately 60% of the reach, with the majority of that erosion being categorized as severe. The majority of the stream banks are 4-6 ft. high and exhibit a high amount of stratigraphy. The assessments of habitat conditions conducted within the reach yielded a Partially Supporting rating.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SLP-SR-F754
Site Name: Lake Elkhorn Receiving Channel
Contractor: Versar
Watershed: Little Patuxent River

Erosion occurring along the left stream bank. Bank height is approximately 5.5 ft. Photo taken near the stream's confluence with the main stem of the Little Patuxent River.

Erosion occurring along the right stream bank. Bank height is approximately 5 ft. Photo taken approximately 250 ft. upstream of the stream's confluence with the main stem of the Little Patuxent River.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SLP-SR-F754
Site Name: Lake Elkhorn Receiving Channel
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:

A sewer line crosses the channel in one location , and runs along side the channel for approximately 80% of the reach. Moderate sized trees run along the entire length of the proposed restoration reach, and will likely be disturbed by any stream bank or floodplain construction activities.

Concept Description:

The focus of the proposed restoration will be reconnecting the incised stream channel with the floodplain. Localized stabilization of the banks is possible, but not preferred due to the consistent nature of severe erosion and channel incision. The lack of residential and commercial encroachment on either side of the channel should be conducive for a floodplain reconnection project; however, many small to moderate sized trees would need to be removed during construction. The site can be accessed from a Columbia Association trail that originates at a parking lot that is adjacent to Broken Land Parkway.

Nearby Opportunities:

None recommended

Proposed Project Credit		Costs	
Length Restored (ft):	997	Estimated Design Cost:	$220,000.00
Impervious Area Treated Credit (ac.):	9.97	Estimated Construction Cost:	$448,524.00
Cost per Impervious Credit Acre:	$80,549.77	30% Contingency:	$134,557.20
		Estimated Total Cost:	$803,081.20

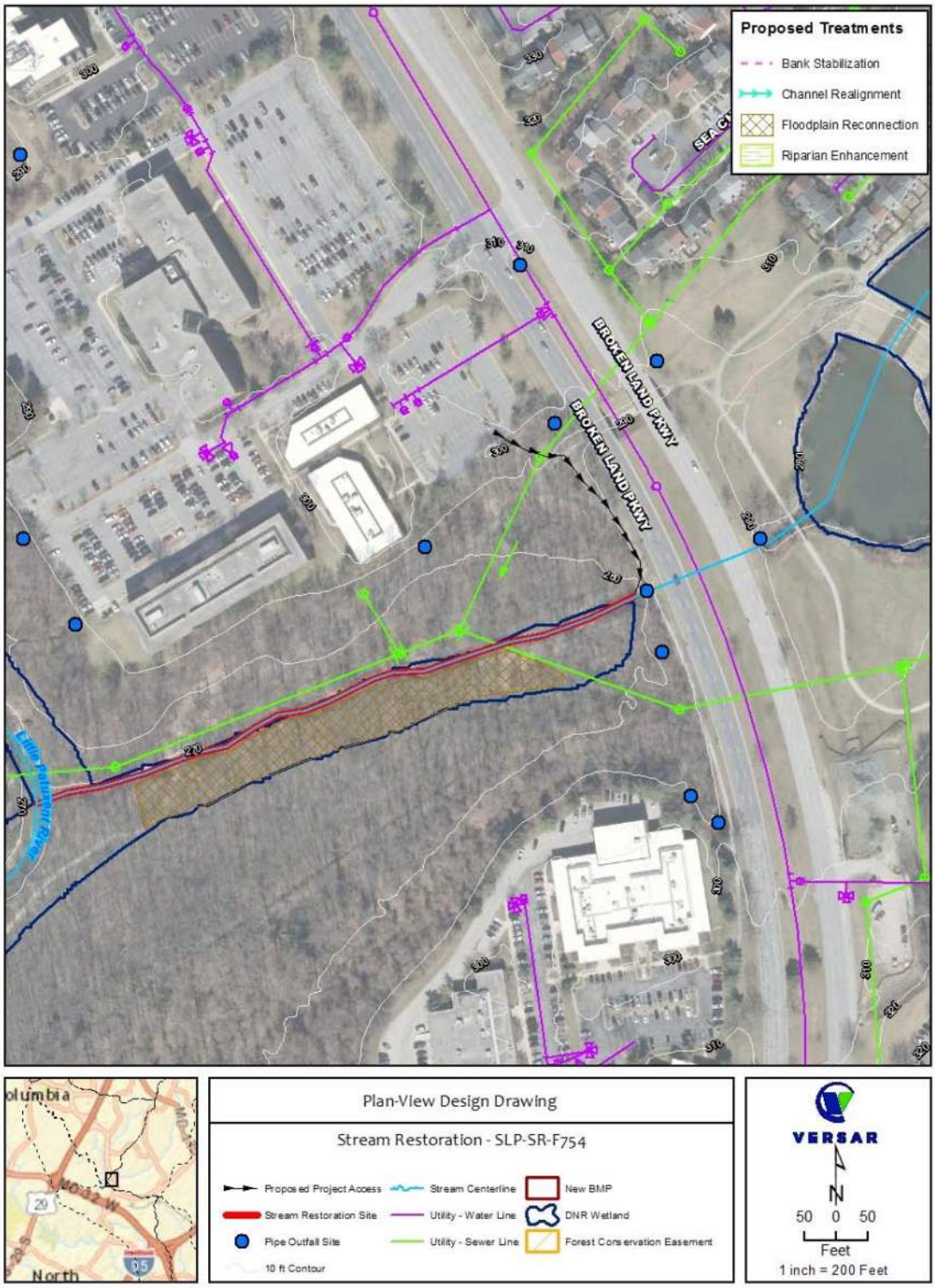
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SLP-SR-F754

Site Name: Lake Elkhorn Receiving Channel

Contractor: Versar

Watershed: Little Patuxent River



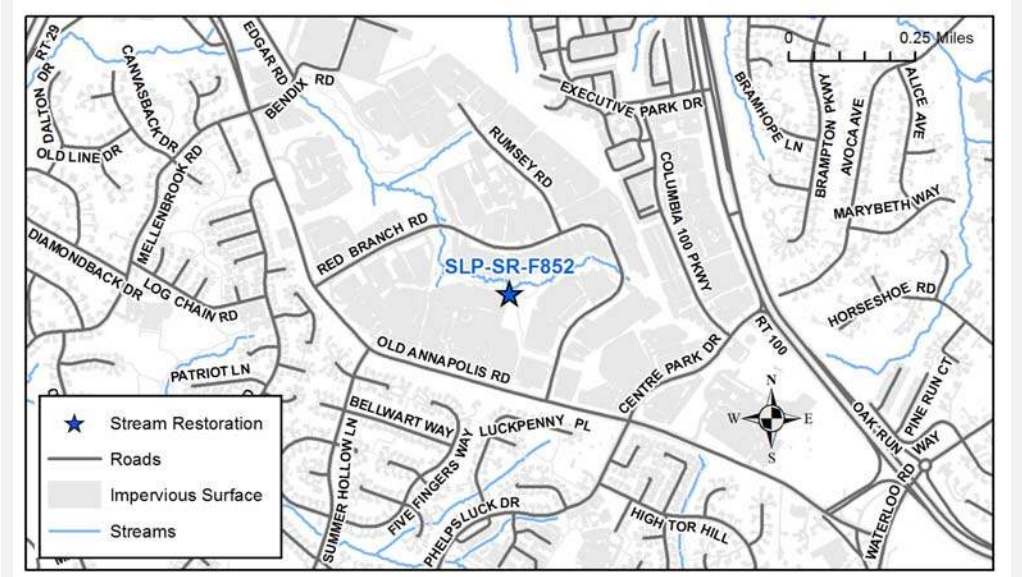
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SLP-SR-F852
Site Name: Oakland Ridge Industrial Park
Contractor: Versar
Watershed: Little Patuxent River

Ownership: Private- Commercial/Industrial
Single Owner

Existing Conditions:

The stream reach recommended for restoration is fully contained within Howard Research and Development property, and is located in a small wooded corridor between Oakland Ridge business parks. Two distinct sections of stream are present within the targeted reach, one of which is an incised intermittent channel that drains to a perennial channel, which is the second section. One outfall discharges directly within the intermittent portion of the stream reach. Nearly the entire length of the restoration reach contains eroded banks, and the mainstem has appeared to widen to the point of no longer being able to transport a large portion of the sediment load, as evidenced by the large amount of in-channel deposition.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SLP-SR-F852
Site Name: Oakland Ridge Industrial Park
Contractor: Versar
Watershed: Little Patuxent River

Erosion occurring along both banks of the mainstem. Photo was taken looking upstream.

Erosion occurring along both banks of the incised tributary channel. Photo was taken looking upstream.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SLP-SR-F852
Site Name: Oakland Ridge Industrial Park
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:

One sewer line crossing exists along the tributary channel approximately 100 ft. upstream of the confluence with the mainstem. There are several other locations along the channels where a sewer line comes within 20 ft. of the channel, but does not cross. Several small to moderate size trees will need to be removed for construction. The valley slope along the tributary channel will make heavy machinery access difficult.

Concept Description:

The proposed restoration will stabilize the eroding stream banks and restore the channel's natural flow regime in order to prevent future instream sedimentation along the mainstem. Work along the tributary channel will focus on restoring the bed to its original elevation and preventing future incision by installing step pools or similar structures that provide grade control. There is an option to conduct a small outfall stabilization project (SLP-OF-F775) for a dry pond outfall located just downstream of the mainstem restoration work. The outfall stabilization work for SLP-OF-F775 is not included in the total cost estimate. The restoration site can be accessed from Columbia Association trails that originate in parking lots located on either side of the site, and a Columbia Association trail that can be accessed directly from Red Branch Road.

Nearby Opportunities:

SLP-OF-F775

Proposed Project Credit		Costs	
Length Restored (ft):	1,342	Estimated Design Cost:	$320,000.00
Impervious Area Treated Credit (ac.):	13.4	Estimated Construction Cost:	$603,769.50
Cost per Impervious Credit Acre:	$82,332.37	30% Contingency:	$181,130.85
		Estimated Total Cost:	$1,104,900.35

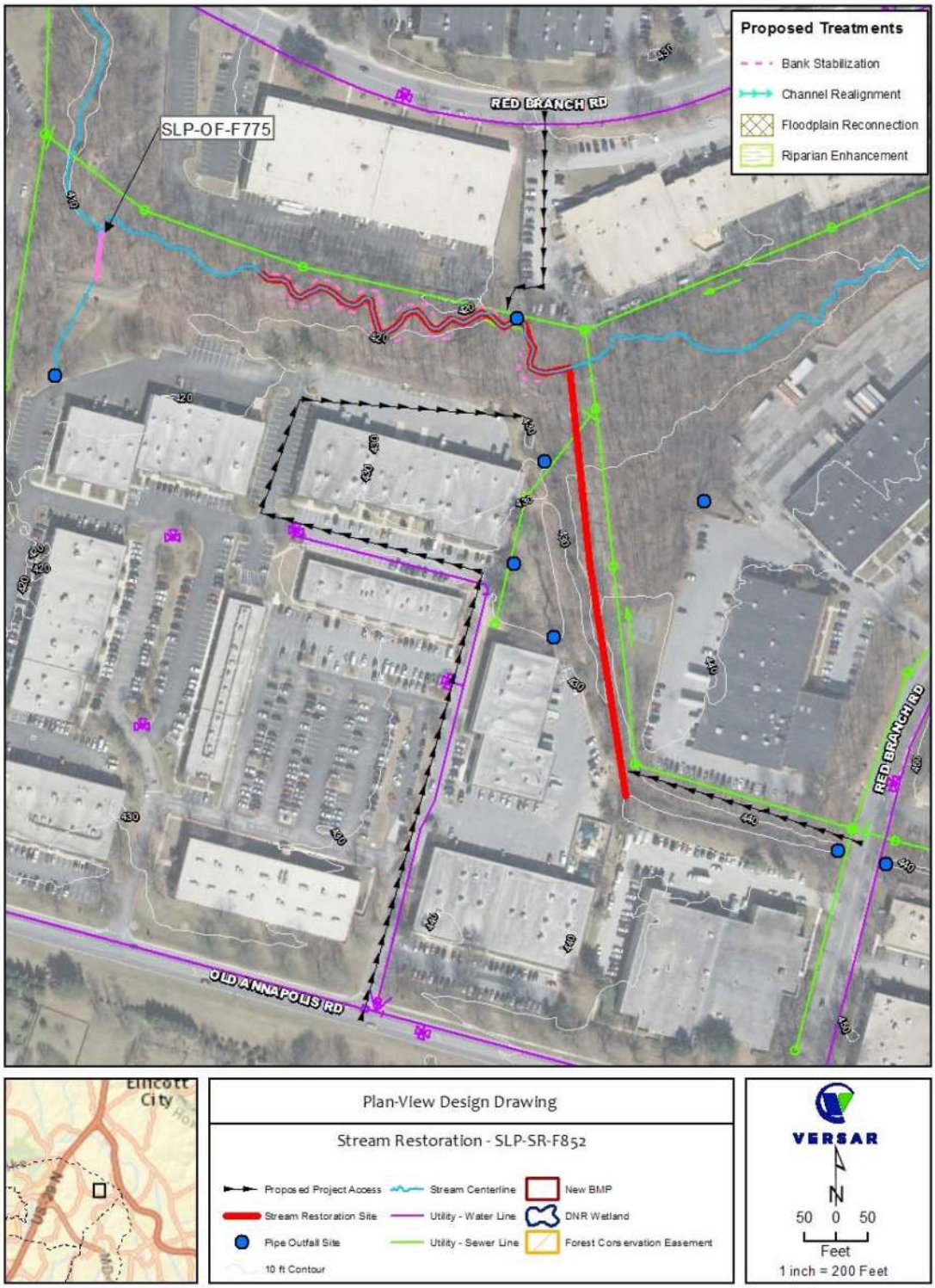
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SLP-SR-F852

Site Name: Oakland Ridge Industrial Park

Contractor: Versar

Watershed: Little Patuxent River



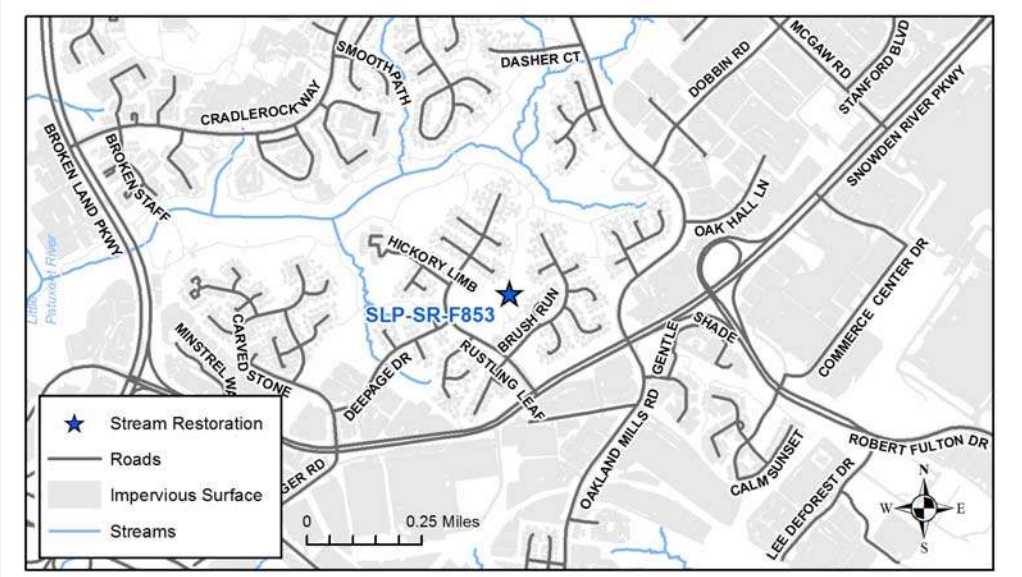
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SLP-SR-F853
Site Name: Hopewell Park
Contractor: Versar
Watershed: Little Patuxent River

Ownership: Columbia Association
Single Owner

Existing Conditions:

The stream corridor recommended for restoration is fully contained within Columbia Association property, though several private residential houses and yards are within 50 ft. of the stream channel in the upstream portion of the stream reach. The reach begins at an outfall located downstream of Brush Run. This outfall's concrete apron is cracked and falling apart. The stream contains a moderate amount of erosion as it flows from the outfall, through a wooded area, and through a small park with a playground. There are a series of headcuts just downstream of the playground, and the stream bank erosion becomes severe in several locations downstream of these headcuts. Three outfalls discharge directly into the channel within the proposed restoration reach.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SLP-SR-F853
Site Name: Hopewell Park
Contractor: Versar
Watershed: Little Patuxent River

Erosion occurring along both stream banks. Photo was taken looking downstream and approximately 100 ft. downstream of Brush Run. Bank height is approximately 3.5 ft.

Erosion occurring along the left bank. Photo was taken close to the downstream extent of the proposed restoration reach. Bank height is approximately 4.5 ft.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SLP-SR-F853
Site Name: Hopewell Park
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:

One sewer line crossing is located approximately 600 ft. downstream of Brush Run. Several rows of trees buffer the stream channel for most of the proposed restoration reach, some of which are mature trees, and any construction activities occurring outside of the channel will impact these trees. A Columbia Association trail located along the left side of the stream will limit the amount and type of earth work that can be undertaken.

Concept Description:

The proposed project will focus on stabilizing eroding banks throughout the reach, especially those closest to Brush Run, and those below the series of headcuts found just downstream of the playground. Floodplain reconnection is needed below the headcuts, and may be feasible along the right side of the stream channel, where the loss of trees seems to be the only issue, but not the left side where a Columbia Association trail and a sewer line may be too costly to relocate. The failing outfall apron at the upstream extent of the reach should be removed. Multiple access routes may be used for this project, but the removal of the outfall apron will likely need to be accessed from Brush Run, while other portions of the project can be accessed from Columbia Association trails, as sketched on the map.

Nearby Opportunities:

None recommended

Proposed Project Credit		Costs	
Length Restored (ft):	1,221	Estimated Design Cost:	$320,000.00
Impervious Area Treated Credit (ac.):	12.2	Estimated Construction Cost:	$550,243.00
Cost per Impervious Credit Acre:	$84,792.46	30% Contingency:	$165,072.90
		Estimated Total Cost:	$1,035,315.90

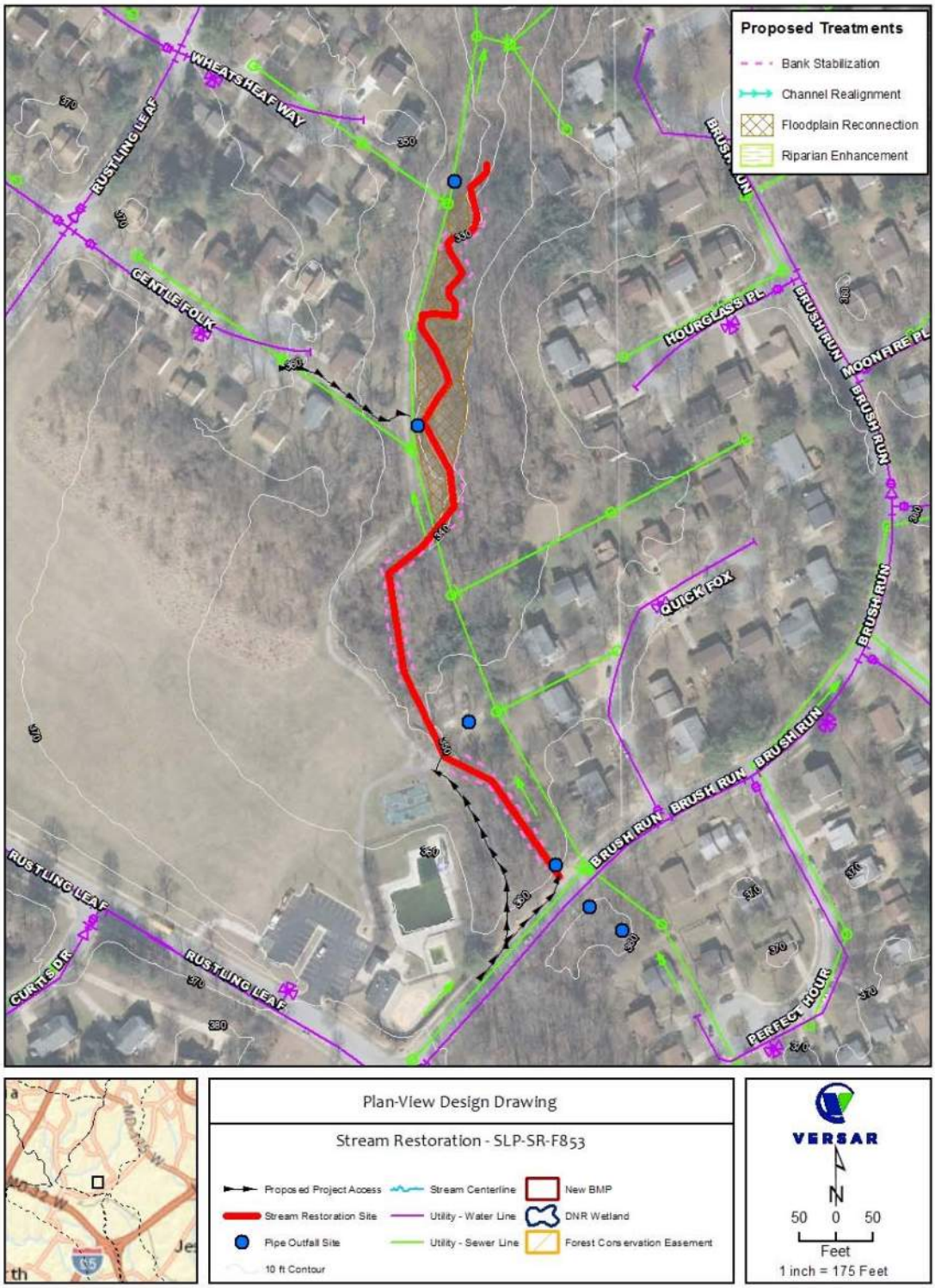
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SLP-SR-F853

Site Name: Hopewell Park

Contractor: Versar

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Stream Restoration

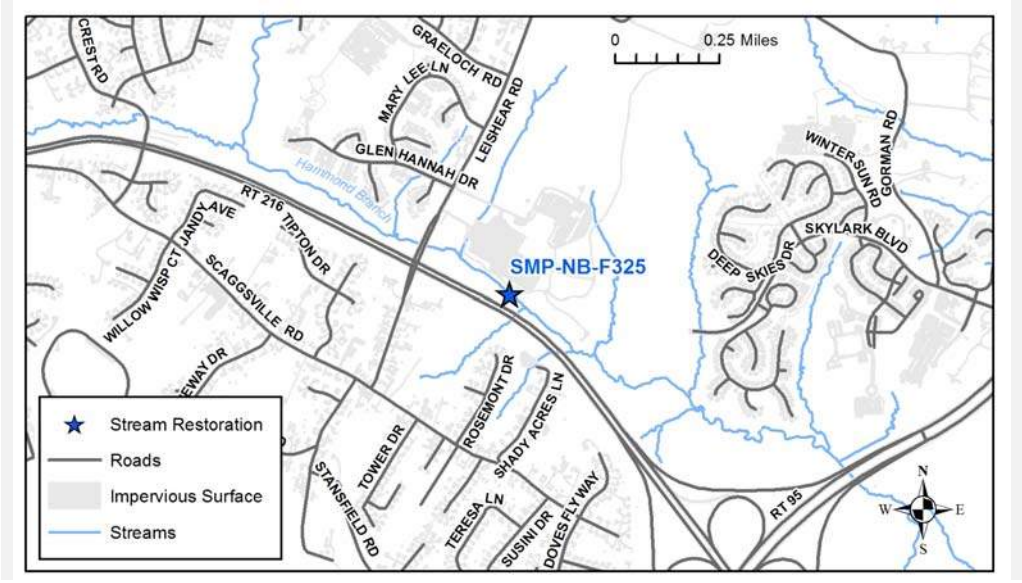
Site ID: SMP-NB-F325
Site Name: BGE Substation
Contractor: Biohabitats
Watershed: Little Patuxent River

Ownership: Private- Commercial/Industrial
Single Owner

Existing Conditions:

The stream is located on BGE property at the corner of Route 216 and Leishear Road in Laurel, MD. The stream flows adjacent to a large BGE substation and has transmission poles that run along the left bank (looking downstream) and another utility line that crosses the stream at the upstream end. The utility line that crosses the stream is a relatively low hanging line that could be a hazard during construction. When assessed, invasive species and other vegetation had overgrown and covered most of the banks making it difficult to identify erosion points. Originally, the proposed stream restoration length was 613 ft.; however, after the field assessment was completed, the proposed stream restoration length was extended an additional 179 ft. downstream. The new proposed stream length to be restored is 792 ft. A road culvert was spotted during the field assessment that was allowing a small stream to pass under Route 216 and discharge into the stream. The small stream could not be assessed due to overgrowth of vegetation surrounding the pipe outfall and discharge channel; however, the small stream appears to be an incised channel and should be restored along with the assessed stream.

The instream habitat within the discharge channel scored in the marginal range. The epifaunal substrates consists of 20-40% stable habitat with some embeddedness (25-50%) making these substrates less available for colonization. The velocity/depth regime of the channel is consistently marginal with only two velocities present. Sediment deposition in the form of bar features is not a concern; however, the overall sediment supply did influence the embeddedness score especially within pools where more sediment was found. The channel flow status is suboptimal with water filling over 75% of the channel and some riffle substrate exposed. The left stream bank is more unstable and raw compared to the right bank; however, it was difficult to determine how unstable these banks were because of extreme vegetation overgrowth. Vegetative protection along the stream bank is high with 70-90% of the surface covered by vegetation and invasive species. Shading along the discharge channel is extremely poor (0%) due to the stream being located at a BGE substation.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SMP-NB-F325
Site Name: BGE Substation
Contractor: Biohabitats
Watershed: Little Patuxent River

Facing downstream, an old concrete channel along the right bank that is causing bank erosion.

Facing upstream, recent bank failure and surrounding overgrown vegetation.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SMP-NB-F325
Site Name: BGE Substation
Contractor: Biohabitats
Watershed: Little Patuxent River

Constraints/Utilities:

The site is located on BGE property and is next to a large BGE substation, which could create a hazardous work environment. An unknown utility line crosses the stream and transmission poles are located adjacent to the stream. A sewer line also runs adjacent to the stream. The BGE access road could be used as an access road for the stream. The use of woody vegetation would be limited due to the BGE lines above.

Concept Description:

Before pursuing this project, the County will coordinate with the State Highway Administration (SHA) to determine if there is additional work to be performed in relation to the SHA stream mitigation project in this area. The objective for this project is to reduce bank erosion and improve instream habitat for aquatic organisms. This may be accomplished by grading banks back to a stable angle and stabilizing them with boulder and integrated native vegetation to hold soil in place. Adding woody debris, cobble riffles, pools, and other nature-like habitat structures will reinforce the stream bed and banks, improve the flow diversity and structural complexity of the stream bed, and uplift the instream habitat. The proposed channel restoration work would occur predominately on the existing channel alignment; however some minor realignment may be necessary where the stream approaches transmission poles. A floodplain bench could be integrated into the proposed channel restoration work to optimize as much floodplain reconnection as possible. Because the stream is located on BGE property and under electrical lines, no trees can be planted along the stream banks; however, establishing riparian buffer will increase shading, reduce stream temperature and provide needed litter inputs and woody debris. This channel restoration has the potential to reduce sediment supply, improve habitat and provide opportunities for nutrient uptake. The site can be accessed from the BGE access road that is adjacent to the stream. There are no nearby project recommendations for concurrent implementation.

Nearby Opportunities:

None recommended

Proposed Project Credit		Costs	
Length Restored (ft):	792	Estimated Design Cost:	$200,000.00
Impervious Area Treated Credit (ac.):	7.92	Estimated Construction Cost:	$356,400.00
Cost per Impervious Credit Acre:	$83,752.53	30% Contingency:	$106,920.00
		Estimated Total Cost:	$663,320.00

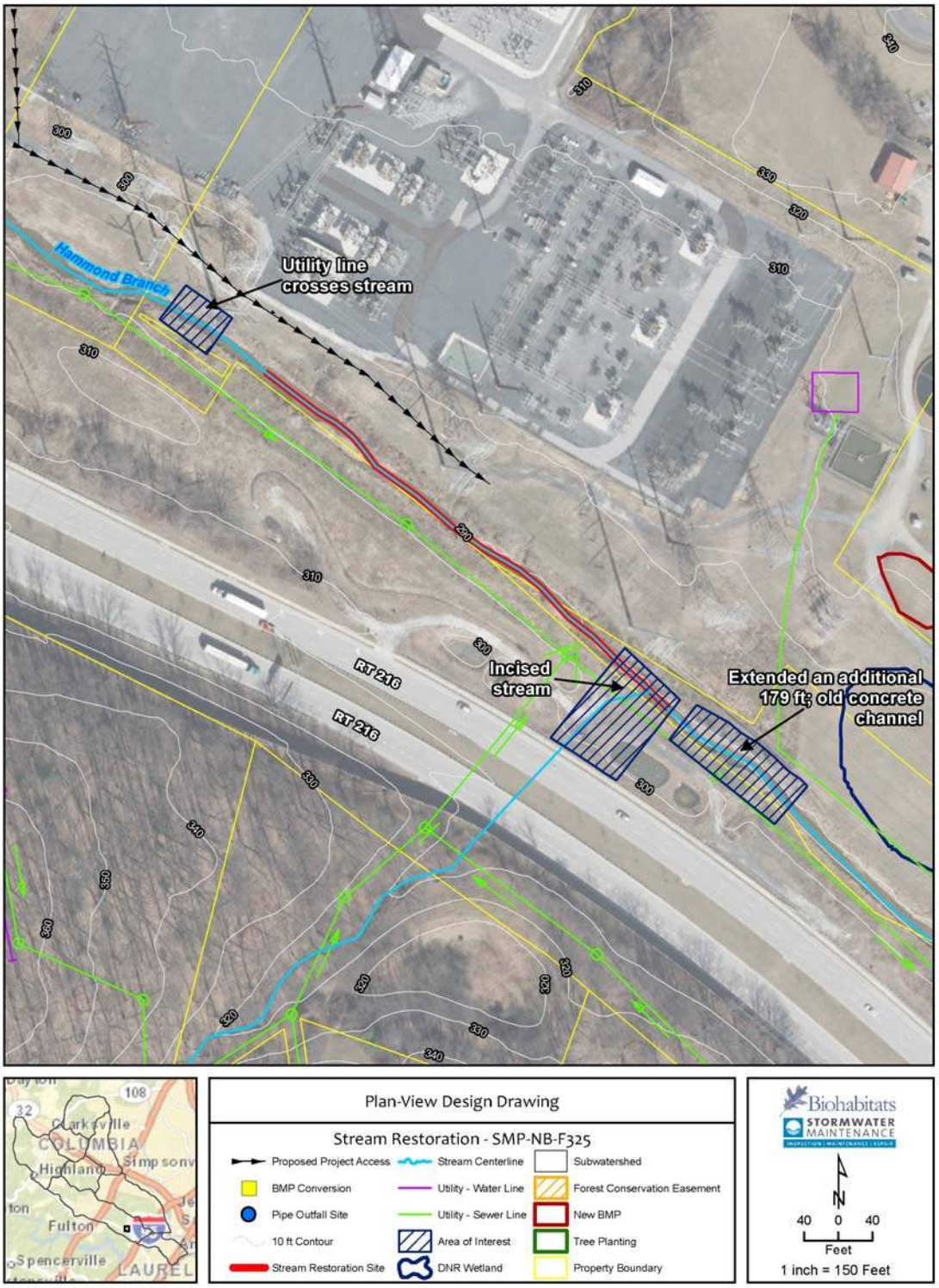
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SMP-NB-F325

Site Name: BGE Substation

Contractor: Biohabitats

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Stream Restoration

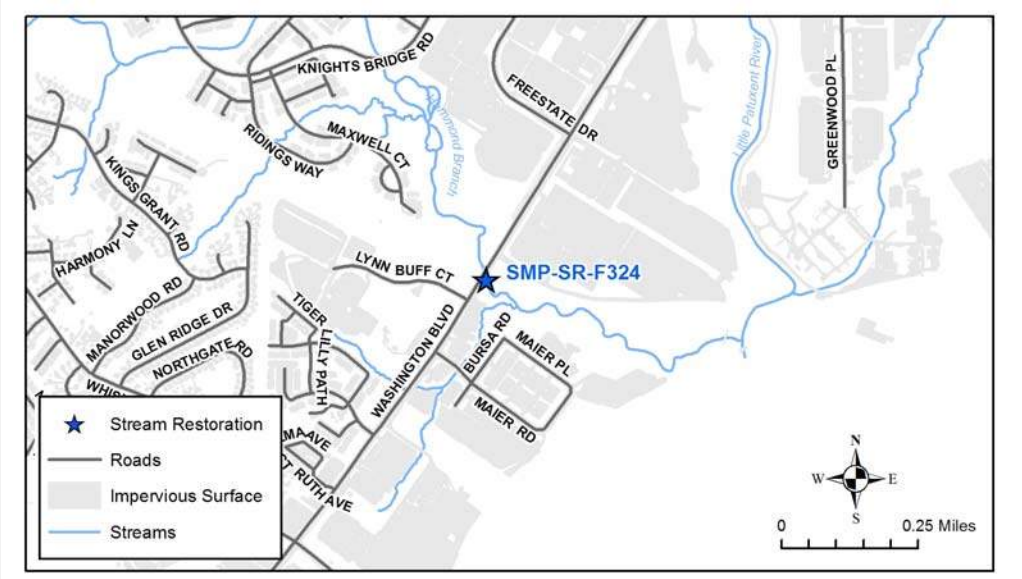
Site ID: SMP-SR-F324
Site Name: BGE ROW Washington Boulevard
Contractor: Biohabitats
Watershed: Little Patuxent River

Ownership: Private- Commercial/Industrial
Single Owner

Existing Conditions:

The existing channel is located within a forested area until it reaches a BGE Right-of-Way (ROW) that runs perpendicular to Washington Boulevard and east of Lynn Buff Court in Laurel, MD. The channel within the forest is stable, with one problem area in which the stream creates a tight bend into a valley wall that shows signs of recent slumping and fallen trees. More severe erosion is occurring within the BGE ROW and downstream of the assessed reach. The BGE ROW has an inadequate buffer along the channel on both banks, which is affecting stream bank erosion. The channel is meandering throughout the BGE ROW and is impeding on transmission poles. Recent bank failure was observed during the stream assessment and an abandoned utility pipe was exposed on the right bank (looking downstream). The existing channel currently exhibits moderate erosion with 3-5 ft. eroding banks with recent bank erosion and deposition evident; however, severe erosion of 5 ft. or greater eroding banks was also found throughout the stream due to very tight bends.

The instream habitat within the existing channel scored in the suboptimal range overall with the existing channel being worse within the BGE ROW. The epifaunal substrates consists of 40-70% stable habitat well suited for full colonization and adequate habitat with relatively low embeddedness (25-50%) making these substrates fairly desirable for colonization. The velocity/depth regime of the channel is suboptimal with all velocities present minus fast-deep. Some new sediment deposition throughout the channel is evident based on recent bank failure which is creating some new bar formations, but is not affecting the bottom of the channel; therefore, the overall sediment supply did influence the embeddedness score. The channel flow status is suboptimal with water filling more than 75% of the channel and less than 25% of the riffle substrate exposed. Both stream banks are moderately stable and have 70% vegetative protection along both banks. Shading along the existing channel is poor (10%) within the BGE ROW, but is better (70%) within the forest area.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SMP-SR-F324
Site Name: BGE ROW Washington Boulevard
Contractor: Biohabitats
Watershed: Little Patuxent River

Facing downstream from the assessed channel. Downstream channel was not assessed, but should be considered as part of the stream restoration.

Facing downstream, existing channel where a deep pool has formed and recent bank failure has exposed pipes and geotextile fabric.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SMP-SR-F324
Site Name: BGE ROW Washington Boulevard
Contractor: Biohabitats
Watershed: Little Patuxent River

Constraints/Utilities:

Stream is located on BGE Company's property and coordination with them will need to occur in order to access the stream. Utility poles and electric lines are a constraint for this site. Proposed access is via an access road already in place. Both water and sewer lines cross the stream more than once. A major road (Washington Blvd) crosses the stream. Revegetation of the site will need to be coordinated with BGE.

Concept Description:

The objective for this project is to reduce bank erosion and improve instream habitat for aquatic organisms. This will be accomplished by grading banks back to a stable angle and stabilizing them with native vegetation to hold soil in place. Adding woody debris, cobble riffles, pools, and other nature-like habitat structures will reinforce the stream bed and banks, improve the flow diversity and structural complexity of the stream bed, and uplift the instream habitat. The proposed channel restoration work would occur predominately on the existing channel alignment; however, to pull flow off of the valley wall and away from the BGE transmission poles, realignment of tight meanders would be proposed. In addition, establishing the maximum riparian buffer will increase the shading to reduce the stream temperature and provide needed litter inputs and woody debris to the channel over time to maintain the habitat complexity and quality. Because this channel runs through a BGE ROW, no large tree plantings should be associated with this project. This channel restoration has the potential to reduce the sediment supply, improve habitat and provide opportunities for nutrient uptake. The site can be accessed from the BGE ROW access road that runs parallel to the existing stream. There are no nearby project recommendations for concurrent implementation for this site.

Nearby Opportunities:

None recommended

Proposed Project Credit		Costs	
Length Restored (ft):	1,047	Estimated Design Cost:	$200,000.00
Impervious Area Treated Credit (ac.):	10.5	Estimated Construction Cost:	$471,150.00
Cost per Impervious Credit Acre:	$77,602.20	30% Contingency:	$141,345.00
		Estimated Total Cost:	$812,495.00

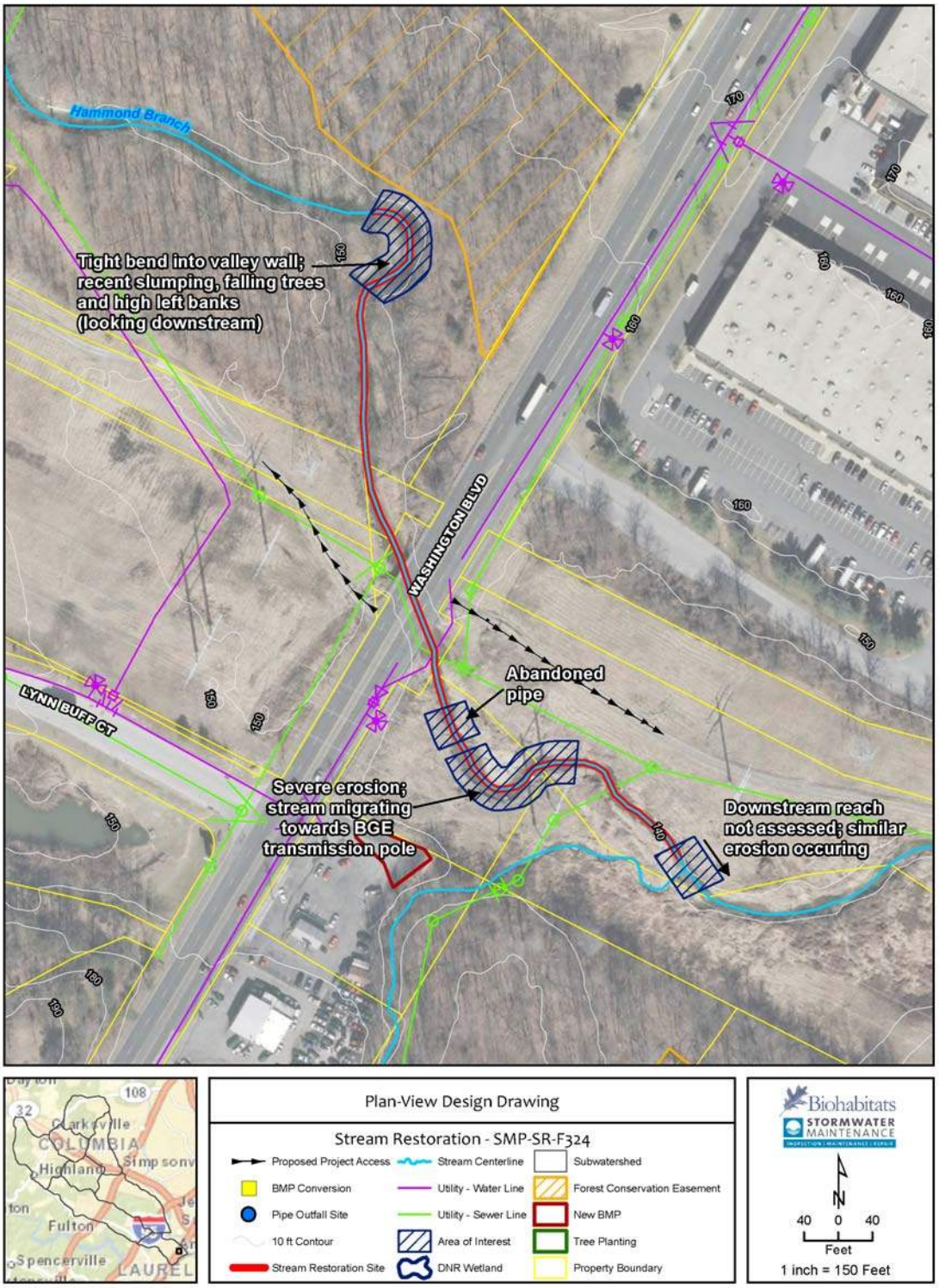
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SMP-SR-F324

Site Name: BGE ROW Washington Boulevard

Contractor: Biohabitats

Watershed: Little Patuxent River



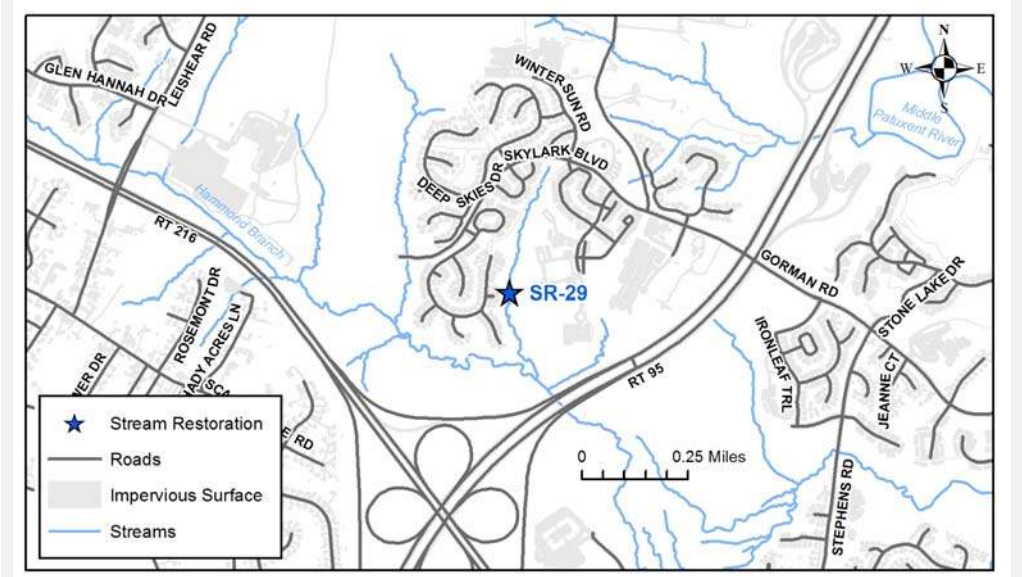
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-29
Site Name: Emerson Community Association
Contractor: Biohabitats
Watershed: Little Patuxent River

Ownership: Private- Residential
Single Owner

Existing Conditions:

This site consists of three stream assessments including: SMP-SR-F330B, SMP-SR-F330C, and SMP-SR-F330E. These stream segments are located along one stream which is created from an upstream extended detention wet pond located within the Emerson Community Association. The stream runs through an approximately 7 ac. forest conservation easement called Emerson (F-05-049). The system has had multiple headcuts move upstream, which has created a stream channel that is no longer connected with the surrounding floodplain. Currently the headcuts are located just downstream of a walking path and together are over 6 ft. in height. The entire system is entrenched with severe eroding banks. More pipe outfalls are encountered as the stream moves downstream. The stream is becoming incised due to these extremely high eroded banks. The instream habitat within the existing channel scored in the marginal range overall. The epifaunal substrates consists of 20-40% stable habitat not well suited for full colonization with substrate frequently disturbed and/or removed, causing the embeddedness throughout the stream to vary. The velocity/depth regime of the channel is marginal with only one to two velocities present throughout the stream. Sediment deposition throughout the channel is evident with moderate deposition occurring creating bar formations and some sediment deposition within the stream bed. The channel flow status is marginal with water filling only 50% of the channel and most of the riffle substrate exposed. Both stream banks are moderately unstable with 60% of the stream banks having little cover and erosional scars. The stream has 70% vegetative protection along both banks. Shading along the existing channel is poor (10%) within the BGE ROW, but is better (70%) within the forest area.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-29
Site Name: Emerson Community Association
Contractor: Biohabitats
Watershed: Little Patuxent River

Facing upstream, extremely high and raw banks with fallen trees creating debris jams.

Facing upstream, variable bank heights with no bank protection and more fallen trees.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-29
Site Name: Emerson Community Association
Contractor: Biohabitats
Watershed: Little Patuxent River

Constraints/Utilities:

Sewer line easement runs adjacent to the stream and could act as an access road to the stream. Because this stream is located within a forest conservation easement, tree impacts need to be reduced as much as possible. Stream surrounded by private properties.

Concept Description:

The objective for this project is to reduce bank erosion and improve instream habitat for aquatic organisms. This will be accomplished by raising the stream invert to connect the channel to the existing floodplain, grading banks back to a stable angle and stabilizing them with native vegetation to hold soil in place. Adding woody debris, cobble riffles, pools, and other nature-like habitat structures will reinforce the stream bed and banks, improve the flow diversity and structural complexity of the stream bed, and uplift the instream habitat. The proposed channel restoration work would occur predominately on the existing channel alignment; however, some minor realignment may be necessary at the tight meander bends. In addition, establishing the maximum riparian buffer will increase the shading to reduce the stream temperature and provide needed litter inputs and woody debris to the channel over time to maintain the habitat complexity and quality. This channel restoration has the potential to reduce the sediment supply, improve habitat and provide opportunities for nutrient uptake. The site can be accessed from Skylark Boulevard near the existing stormwater pond or from Ebb Tide Lane and use the sewer line easement to access the stream. There are no project recommendations that could be implemented concurrently with this site.

Nearby Opportunities:

None recommended

Proposed Project Credit		Costs	
Length Restored (ft):	1,605	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	16.1	Estimated Construction Cost:	$722,700.00
Cost per Impervious Credit Acre:	$77,228.04	30% Contingency:	$216,810.00
		Estimated Total Cost:	$1,239,510.00

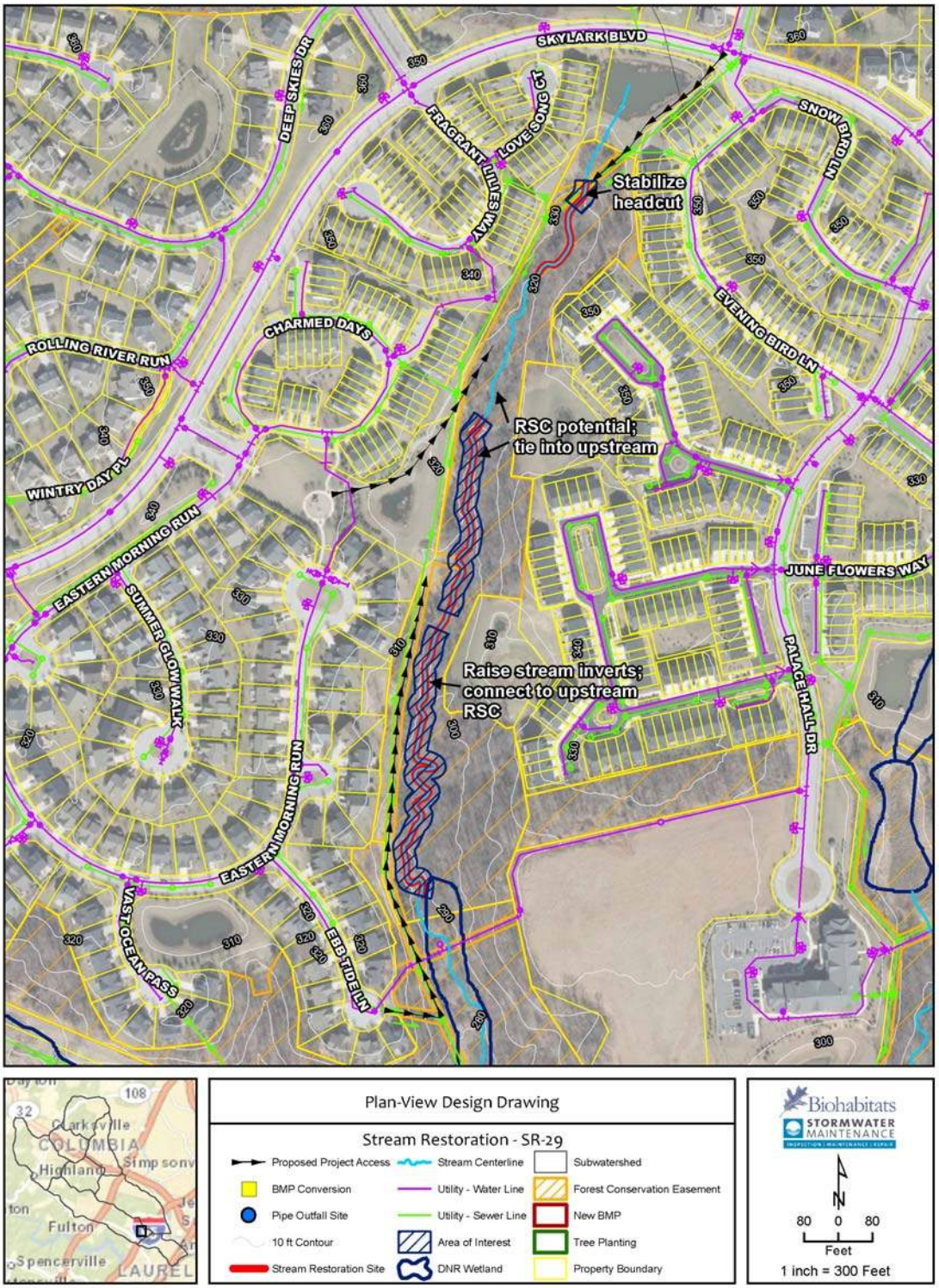
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-29

Site Name: Emerson Community Association

Contractor: Biohabitats

Watershed: Little Patuxent River



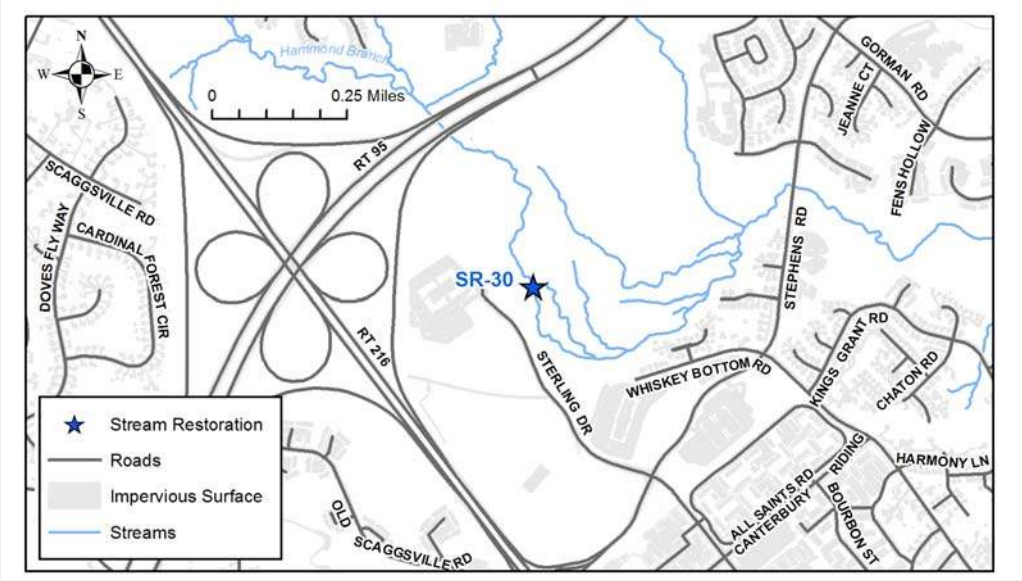
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-30
Site Name: Sterling Drive
Contractor: Biohabitats
Watershed: Little Patuxent River

Ownership: County Owned
Single Owner

Existing Conditions:

This site consists of two stream assessments including: SMP-SR-F329A and SMP-SR-F329B. These two assessed areas are part of Hammond Branch. The site is located along Sterling Drive near Whiskey Bottom Road and Promise Court in Laurel, MD. The site is located on Howard County property. The stream is located within a Department of Natural Resources Wetland Class PF01A and within a Forest Conservation Easement named Emerson (F-08-082). The stream is eroded heavily on both banks with bank height averaging 3-5 ft. Upstream of the assessed stream, the stream runs through a BGE ROW. The stream near the BGE ROW has higher eroding banks of greater than 5 ft. and extremely raw banks with little vegetative bank protection. As the stream moves downstream, both banks are continually raw with no root protection, but eroded bank height decreases. The stream has a high velocity, which is increasing the rate of erosion. The stream is meandering and creating tight bends throughout while widening at the same time; therefore, trees are falling into the stream causing major debris jams and large pools to form. Wetland species growing right up to stream bank edge, but are not providing enough vegetative protection. The instream habitat within the existing channel scored in the marginal range overall. The epifaunal substrates consists of 40-50% stable habitat well suited for full colonization with substrate frequently disturbed and/or removed, causing the embeddedness throughout the stream to be high with 50-75% of stream particles being covered by sediment. The velocity/depth regime of the channel is marginal with only two velocities present throughout the stream. Sediment deposition throughout the channel is evident with moderate deposition occurring creating bar formations and some sediment deposition within the stream bed. The channel flow status is marginal with water filling only 50-75% of the channel and some of the riffle substrate exposed. Both stream banks are moderately unstable with 60% of the stream banks having little cover and erosional scars. Despite being within a Department of Natural Resources wetland and forest conservation easement, vegetative protection along both banks is poor with less than 50% of the stream bank surface being covered by vegetation. Shading along the stream is better within the forested area at about 60% coverage; however, upstream near the BGE ROW less shading occurs.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-30
Site Name: Sterling Drive
Contractor: Biohabitats
Watershed: Little Patuxent River

Facing downstream, high and bare stream banks, large sand bar and downed trees. Photo taken near the end of the assessed stream by the BGE ROW.

Facing downstream, lower bare stream banks with wetland species growing right to the edge. Photo captures a tree fallen into the stream creating a debris jam, which occurs frequently throughout the length of the stream.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-30
Site Name: Sterling Drive
Contractor: Biohabitats
Watershed: Little Patuxent River

Constraints/Utilities:

Healthy wetlands and trees surround the stream; therefore, impact to these systems would be the biggest constraint. Another constraint is access. The property is surrounded by a fence and there are no easements located near the stream; therefore, more trees may be impacted trying to access the site.

Concept Description:

The objective for this project is to reduce bank erosion and improve instream habitat for aquatic organisms. This will be accomplished by raising the stream invert, grading banks back to a stable angle, and stabilizing them with native vegetation to hold soil in place. Private properties might have a higher risk of flooding with raising the stream invert. A floodplain bench could be added within the stream instead of raising the stream invert to reduce potential flooding issues downstream. Adding woody debris, cobble riffles, pools, and other nature-like habitat structures will reinforce the stream bed and banks, improve the flow diversity and structural complexity of the stream bed, and uplift the instream habitat. Trees have recently fallen into the stream and should be reused for structures and/or bank protection. By raising the stream invert, floodplain reconnection will occur and support the surrounding wetlands. The proposed channel restoration work would occur predominately on the existing channel alignment; however, some minor realignment may be necessary at the tight meander bends. In addition, establishing the maximum riparian buffer will increase the shading to reduce the stream temperature and provide needed litter inputs and woody debris to the channel overtime to maintain the habitat complexity and quality. This channel restoration has the potential to reduce the sediment supply, improve habitat and provide opportunities for nutrient uptake. The site can be accessed from Whiskey Bottom Road which currently is a dead end. The site could also be accessed along Sterling Drive, but a fence does surround the property from the woods where the stream is located. SMP-SR-F325 was a stream assessment completed that was not selected for a project recommendation, but should be considered because the site is just downstream of SR-30 and is eroding into private property. SR-31 and SR-32 should also be considered for concurrent implementation with SR-30.

Nearby Opportunities:

SMP-SR-F325A, SR-31, SR-32

Proposed Project Credit		Costs	
Length Restored (ft):	2,221	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	22.2	Estimated Construction Cost:	$999,450.00
Cost per Impervious Credit Acre:	$72,007.43	30% Contingency:	$299,835.00
		Estimated Total Cost:	$1,599,285.00

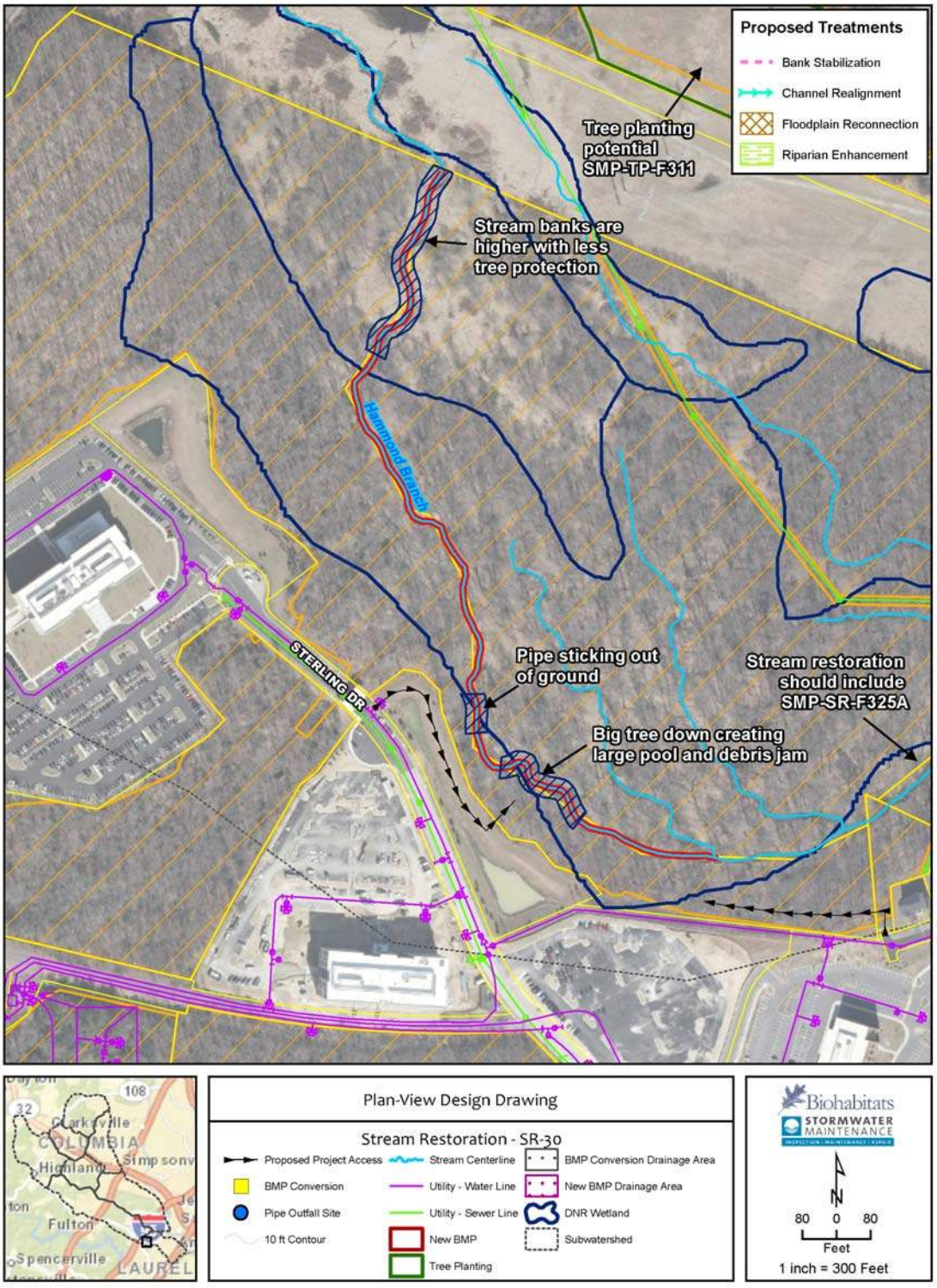
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-30

Site Name: Sterling Drive

Contractor: Biohabitats

Watershed: Little Patuxent River



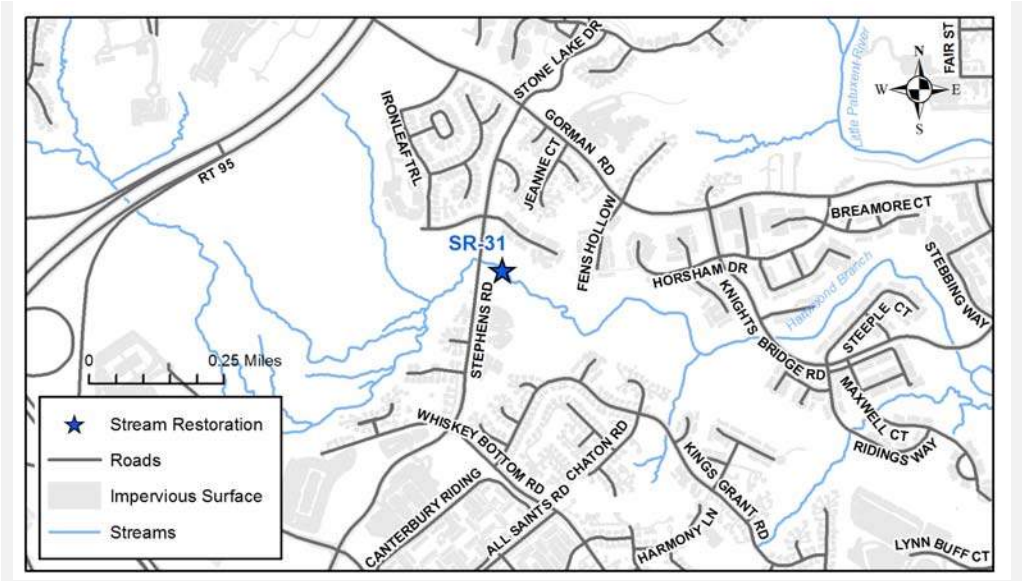
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-31
Site Name: BGE ROW Stephens Road
Contractor: Biohabitats
Watershed: Little Patuxent River

Ownership: Private- Commercial/Industrial
Multiple Owners

Existing Conditions:

This site consists of four separate stream assessments including: SMP-SR-F328A, SMP-SR-F328B, SMP-SR-F328C, and SMP-SR-F328D. These four sites are all part of Hammond Branch, just downstream of I-95. Downstream of the site, Hammond Branch flows through private properties and county owned properties. These properties include private residential, private commercial (Baltimore Gas and Energy Company), and county owned (Howard County Rec and Parks). Stream has multiple tight bends and is currently meandering and approaching some BGE transmission poles. In areas where these tight bends occur, large pools are forming and the stream banks are very raw. Both banks have relatively patchy erosion with some vegetative protection, but recent bank failure is evident along the stream bank. Most of the stream is located within a BGE ROW where there are no trees providing bank stabilization and shade. The instream habitat within the existing channel scored in the marginal range overall. The epifaunal substrates upstream is worse than downstream consisting of only of 20-40% stable habitat well suited for full colonization with substrate frequently disturbed and/or removed, causing the embeddedness throughout the stream to be high with greater than 75% of stream particles being covered by sediment. As the stream moves downstream, epifaunal substrate and embeddedness becomes better. The velocity/depth regime of the channel is marginal with only two velocities present throughout the stream. Sediment deposition throughout the channel is evident with moderate deposition occurring creating bar formations and increased sediment deposition within the stream bed at the upstream end of the channel. The channel flow status is suboptimal with water filling only 75% of the channel and some of the riffle substrate exposed. Both stream banks are moderately unstable with 30-60% of the stream banks having little cover and erosional scars. Vegetative protection along both banks is poor with 50% of the stream bank surface being covered by vegetation. Because the majority of the stream is within a BGE ROW, there is no shade along the stream.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-31

Site Name: BGE ROW Stephens Road

Contractor: Biohabitats

Watershed: Little Patuxent River

Looking downstream at recent bank failure along the left bank.

Looking upstream at a tight bend in the stream creating a deep pool with high banks with little to no cover.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-31
Site Name: BGE ROW Stephens Road
Contractor: Biohabitats
Watershed: Little Patuxent River

Constraints/Utilities:

Coordination with multiple owners, including private residential, private commercial, and county owned properties will be a constraint. Access is easy with most of the stream being located within a BGE ROW; therefore, an access road is already there that could be used to access the stream. No trees or wetlands will be impacted due to the lack of these surrounding the stream.

Concept Description:

The objective for this project is to reduce bank erosion and improve instream habitat for aquatic organisms. This will be accomplished by grading banks back to a stable angle and stabilizing them with native vegetation to hold soil in place. Adding woody debris, cobble riffles, pools, and other nature-like habitat structures will reinforce the stream bed and banks, improve the flow diversity and structural complexity of the stream bed, and uplift the instream habitat. The pipe outfall should be cut back and the bank should be graded around the pipe to provide a stable outfall into the stream. The proposed channel restoration work would occur predominately on the existing channel alignment; however, to pull flow away from the BGE transmission poles, realignment of tight meanders or hydraulic controls such as rock vanes would be proposed. In addition, establishing the maximum riparian buffer will increase the shading to reduce the stream temperature and provide needed litter inputs and woody debris to the channel over time to maintain the habitat complexity and quality. Because this channel runs through a BGE ROW, no large tree plantings should be associated with this project. This channel restoration has the potential to reduce the sediment supply, improve habitat and provide opportunities for nutrient uptake. The site can be accessed from the BGE ROW access road that runs parallel to the existing stream. SR-30 is a nearby project recommendation that could be implemented concurrently with SR-31.

Nearby Opportunities:

SR-30, SR-32

Proposed Project Credit		Costs	
Length Restored (ft):	2,904	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	29.0	Estimated Construction Cost:	$1,307,250.00
Cost per Impervious Credit Acre:	$68,850.72	30% Contingency:	$392,175.00
		Estimated Total Cost:	$1,999,425.00

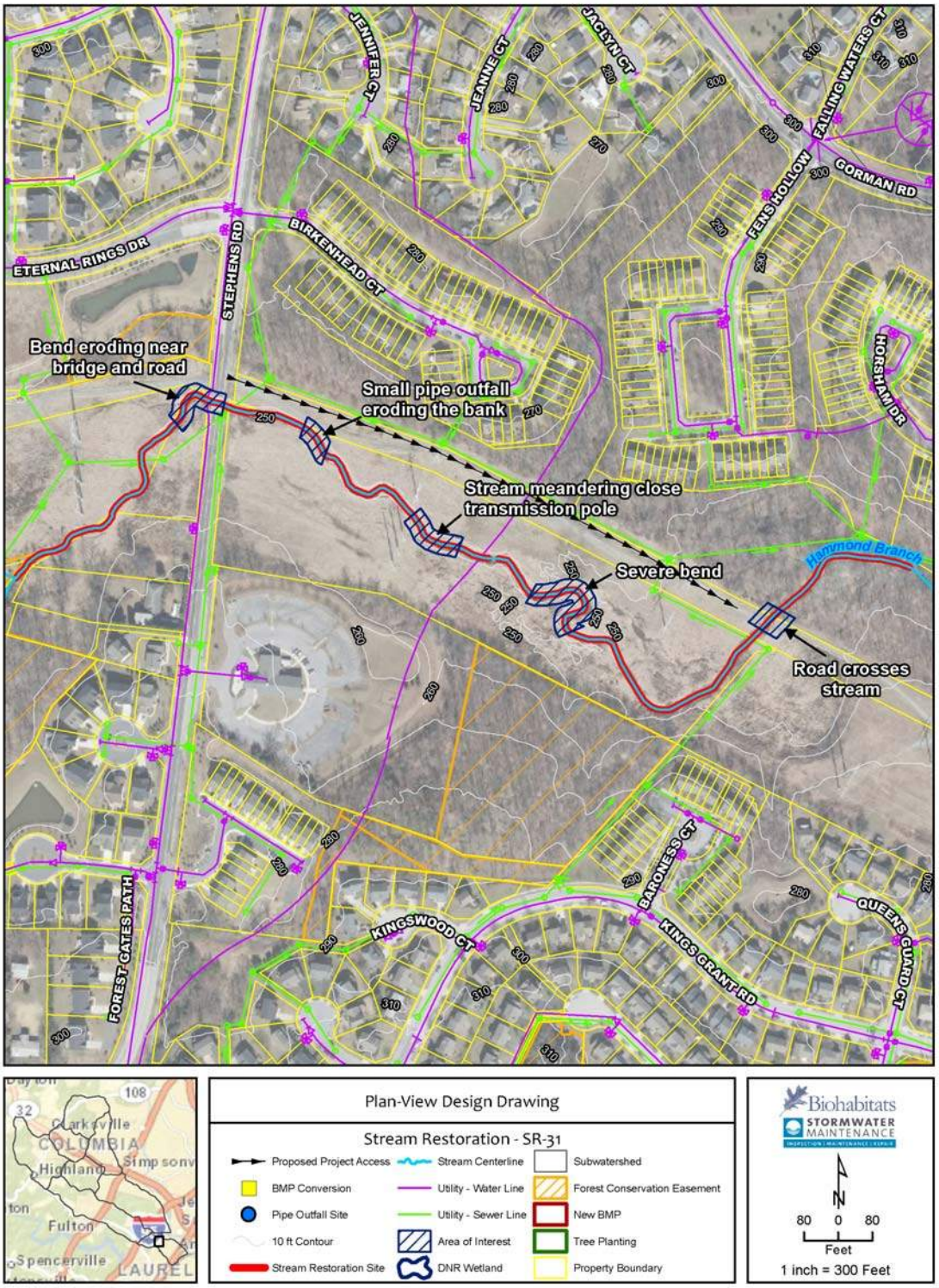
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-31

Site Name: BGE ROW Stephens Road

Contractor: Biohabitats

Watershed: Little Patuxent River



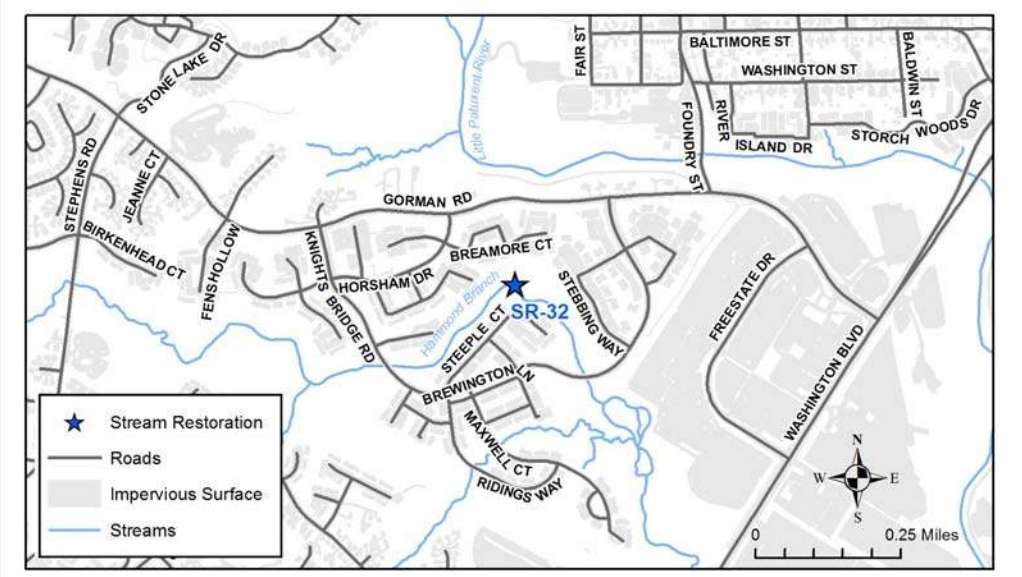
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-32
Site Name: Bowling Brook Farms
Contractor: Biohabitats
Watershed: Little Patuxent River

Ownership: County Owned
Single Owner

Existing Conditions:

This site involves two stream assessments including: SMP-SR-F327B and SMP-SR-F327C. These two site assessments are part of Hammond Branch and are downstream of project SR-31. The stream within this project area is near a condominium complex called Bowling Brook Farms; however, the stream is located within Howard County property. The stream is meandering closer to the condos and beginning to cut into private property. There are several pipe outfalls along the stream that discharge into the stream. One pipe outfall did not have a stabilized outfall with exposed geotextile and moved riprap was found downstream of the outfall. The pipe outfall could be restored with the stream with a RSC safely discharging the water into the stream. The average stream bank height is around 3 ft.; however, in problem areas, most of the stream banks are greater than 5 ft. with an eroded bank of 5 ft. or greater. Areas where the stream banks are greater than 5 ft., the length of erosion is typically between 100-200 ft. long and mostly on the right bank which is closest to the condos. One problem area that poses a concern is located on site SMP-SR-F327C, where major erosion is occurring close to the property. A large middle channel bar has formed in the stream at this site creating two smaller streams to form. During flooding, it is evident that storm flows are cutting into the existing hillside and removing more and more of the bank. The instream habitat within the existing channel scored in the marginal to suboptimal range overall. The epifaunal substrate is consisting of 40-70% stable habitat well suited for full colonization with some new fall substrate not ready for colonization yet. Embeddedness throughout the stream is low with only 25-50% of the stream particles being covered and/or surrounded by sediment. The velocity/depth regime of the channel is suboptimal with three of the four velocities present throughout the stream. Sediment deposition throughout the channel is evident with some deposition occurring creating bar formations and affecting the stream bed. The channel flow status is marginal with water filling only 50-75% of the channel and some of the riffle substrate exposed. The right stream bank is moderately unstable with 30-60% of the stream bank having little cover and erosional scars at the upstream end of the stream, but as the stream flows downstream both banks become more stable with only 5-30% of the bank showing signs of active erosion. Vegetative protection along both banks is suboptimal with 70% of the stream bank surface being covered by vegetation. The shading within this area is optimal with 70% of the stream being shaded.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-32

Site Name: Bowling Brook Farms

Contractor: Biohabitats

Watershed: Little Patuxent River

Facing upstream, erosion occurring on the right bank (looking downstream) with homes and properties close to the stream.

Facing downstream at the right bank.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-32
Site Name: Bowling Brook Farms
Contractor: Biohabitats
Watershed: Little Patuxent River

Constraints/Utilities:

The stream runs through county owned property; however, there are a lot of private properties near the stream. A sewer line runs along the stream which could pose problems with the restoration. Access would need to be from the sewer line easement or from Knights Bridge Road near the upstream end of the stream by the bridge.

Concept Description:

The objective for this project is to reduce bank erosion and improve sediment transport capacity in problem areas while preserving and enhancing the instream habitat for aquatic organisms. This will be accomplished by grading banks back to a stable angle and stabilizing them with native vegetation and/or boulders to hold soil in place. Adding woody debris, cobble riffles, pools, and other nature-like habitat structures will reinforce the stream bed and banks, improve the flow diversity and structural complexity of the stream bed, and uplift the instream habitat. The proposed channel restoration work would occur predominately on the existing channel alignment; however, some minor realignment may be necessary at the tight meander bends. An RSC outfall stabilization could help repair the outfall that is currently missing riprap and has exposed geotextile fabric. In addition, enhancing the existing riparian buffer will increase the shading to reduce the stream temperature and provide needed litter inputs and woody debris to the channel overtime to maintain the habitat complexity and quality. This channel restoration has the potential to reduce the sediment supply, improve habitat and provide opportunities for nutrient uptake. The site can be accessed from the sewer line easement that runs adjacent to the stream. Entrance to the sewer line easement is on Steeple Court near the cul-de-sac. The site could also be accessed from Knight Bridge Road at the upstream end of the stream to avoid private property. SR-30 and SR-31 are two project recommendations that are upstream from SR-32 that should be considered for concurrent implementation.

Nearby Opportunities:

SR-30, SR-31

Proposed Project Credit		Costs	
Length Restored (ft):	1,811	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	18.1	Estimated Construction Cost:	$814,950.00
Cost per Impervious Credit Acre:	$75,065.43	30% Contingency:	$244,485.00
		Estimated Total Cost:	$1,359,435.00

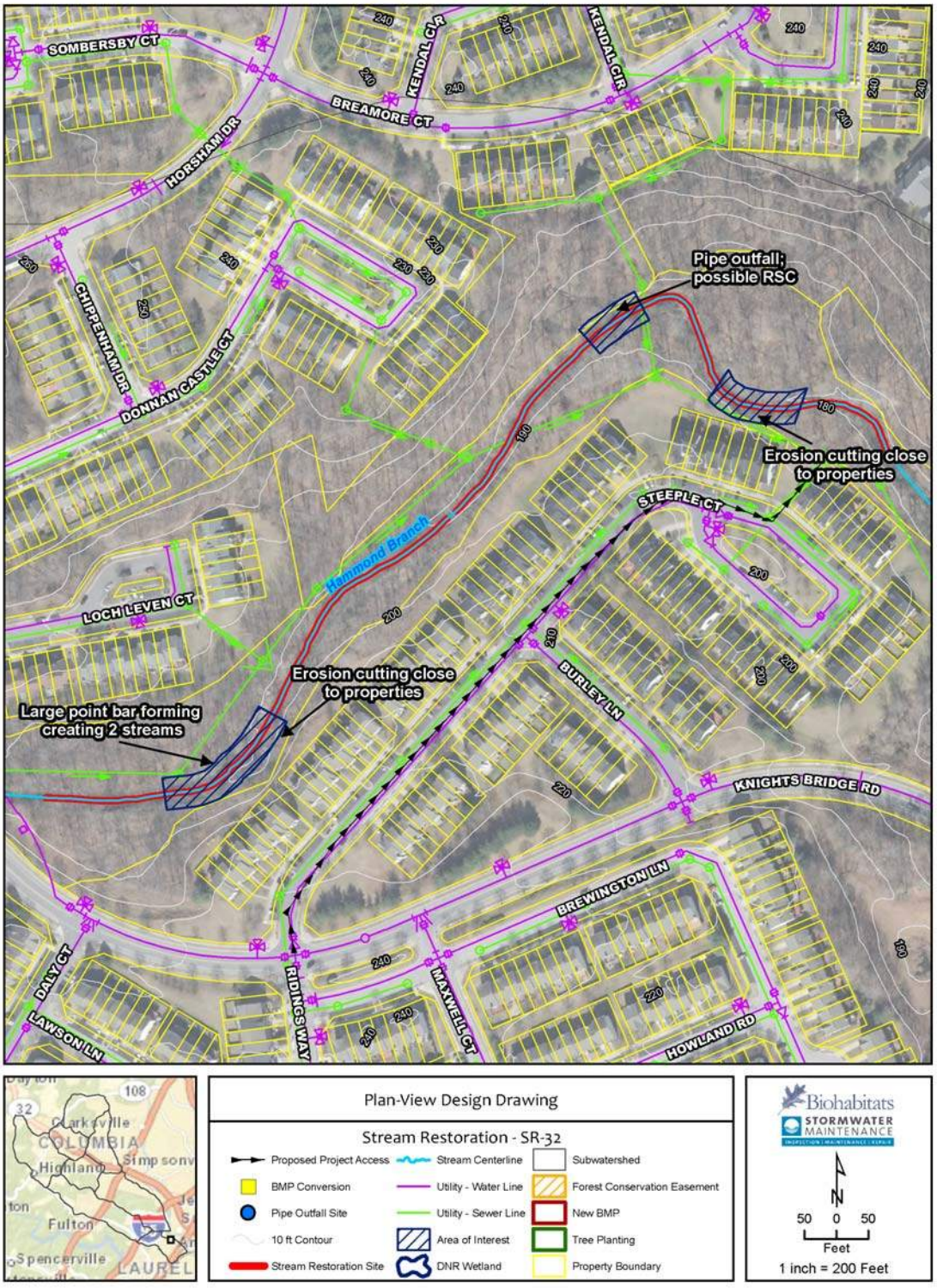
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-32

Site Name: Bowling Brook Farms

Contractor: Biohabitats

Watershed: Little Patuxent River



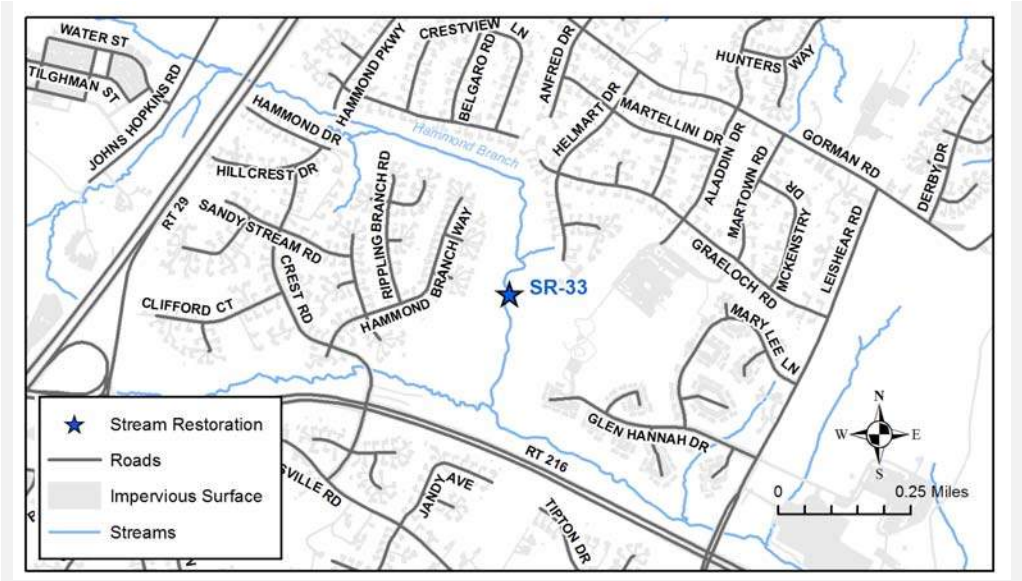
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-33
Site Name: Hammond Branch (a)
Contractor: Biohabitats
Watershed: Little Patuxent River

Ownership: County Park
Single Owner

Existing Conditions:

This project site consists of four separate stream assessment sites including: SMP-SR-F332A, SMP-SR-F332B, SMP-SR-F341A, AND SMP-SR-F341B. All four stream assessment sites are part of Hammond Branch near Hammond Branch Way where the stream takes a 90 degree turn going south towards MD-216. The project site is located on Howard County Department of Recreation and Parks property. As the stream flows downstream, it transitions from a relatively straight channel to a more meandering channel with tight bends. The stream is wide with point bars forming within the channel and along the banks. Several fallen trees are present within the stream causing debris jams, deep pools, and impacting stream bank erosion. Severely eroding banks (5 ft. or greater) were encountered throughout the stream. The instream habitat within the existing channel scored in the suboptimal range overall. The epifaunal substrates consists of greater than 70% stable habitat favorable for epifaunal colonization with a mix of unstable and stable substrate. Embeddedness throughout the stream becomes worse as the stream moves downstream, with 50-75% of gravel, cobble, and boulder particles surrounded by fine sediment. The velocity/depth regime of the channel is optimal with typically all velocities present throughout the stream. Sediment deposition throughout the channel is evident with moderate deposition occurring creating bar formations and some sediment deposition within the stream bed. The channel flow status is suboptimal with water filling on average 75% of the available channel and some of the riffle substrate exposed. Both stream banks are moderately unstable with 50% of the stream banks having little cover and increased erosion during floods. Vegetative protection along both banks is also poor, with only 50-70% of the stream bank surface being covered by vegetation. Shading along the existing channel is marginal (40%), but more shade (80%) is encountered as the stream moves downstream.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-33
Site Name: Hammond Branch (a)
Contractor: Biohabitats
Watershed: Little Patuxent River

Facing upstream, evident bank erosion on the left bank (looking downstream).

Facing downstream at a tight bend in the stream, a deep pool forming with little to no protection on the left bank (looking downstream).

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-33
Site Name: Hammond Branch (a)
Contractor: Biohabitats
Watershed: Little Patuxent River

Constraints/Utilities:

Sewer line easements could be used to access the stream, but access could impact vernal pools that are currently found along the easement and floodplain. Because this stream is located within a heavily forested area, moderate impacts to trees are expected. There are several places along the stream where the sewer line crosses.

Concept Description:

Hammond Branch is over-wide throughout this reach. The stream has become entrenched and disconnected from its surrounding floodplain. The objective for this project is to reduce bank erosion and improve instream habitat for aquatic organisms. The recommended approach for stream restoration in this reach is to raise the invert as much as possible using the existing alignment and creating a new base flow channel. This would involve adding woody debris, cobble riffles, pools, and other habitat nature-like structures to the stream bed. This approach would meet the objectives of improving water quality, reducing sediment loading to the downstream system, and improve instream habitat. The proposed channel restoration work would occur predominately on the existing channel alignment; however some minor realignment may be necessary at tight meander bends. Because Hammond Elementary and Middle School are adjacent, this site has potential to be integrated into the school curriculum. The site can be accessed via Helmart Drive through Howard County Recreation and Parks property. There are seven other project recommendations for concurrent implementation including two tree plantings sites and five stream restoration sites. These seven projects include: SR-34, SR-35, SR-36, SR-37, SR-38, SMP-TP-F405A, and SMP-TP-406.

Nearby Opportunities:

SR-34, SR-35, SR-36, SR-37, SR-38, SMP-TP-F405A, SMP-TP-406

Proposed Project Credit		Costs	
Length Restored (ft):	2,790	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	27.9	Estimated Construction Cost:	$1,255,950.00
Cost per Impervious Credit Acre:	$69,273.66	30% Contingency:	$376,785.00
		Estimated Total Cost:	$1,932,735.00

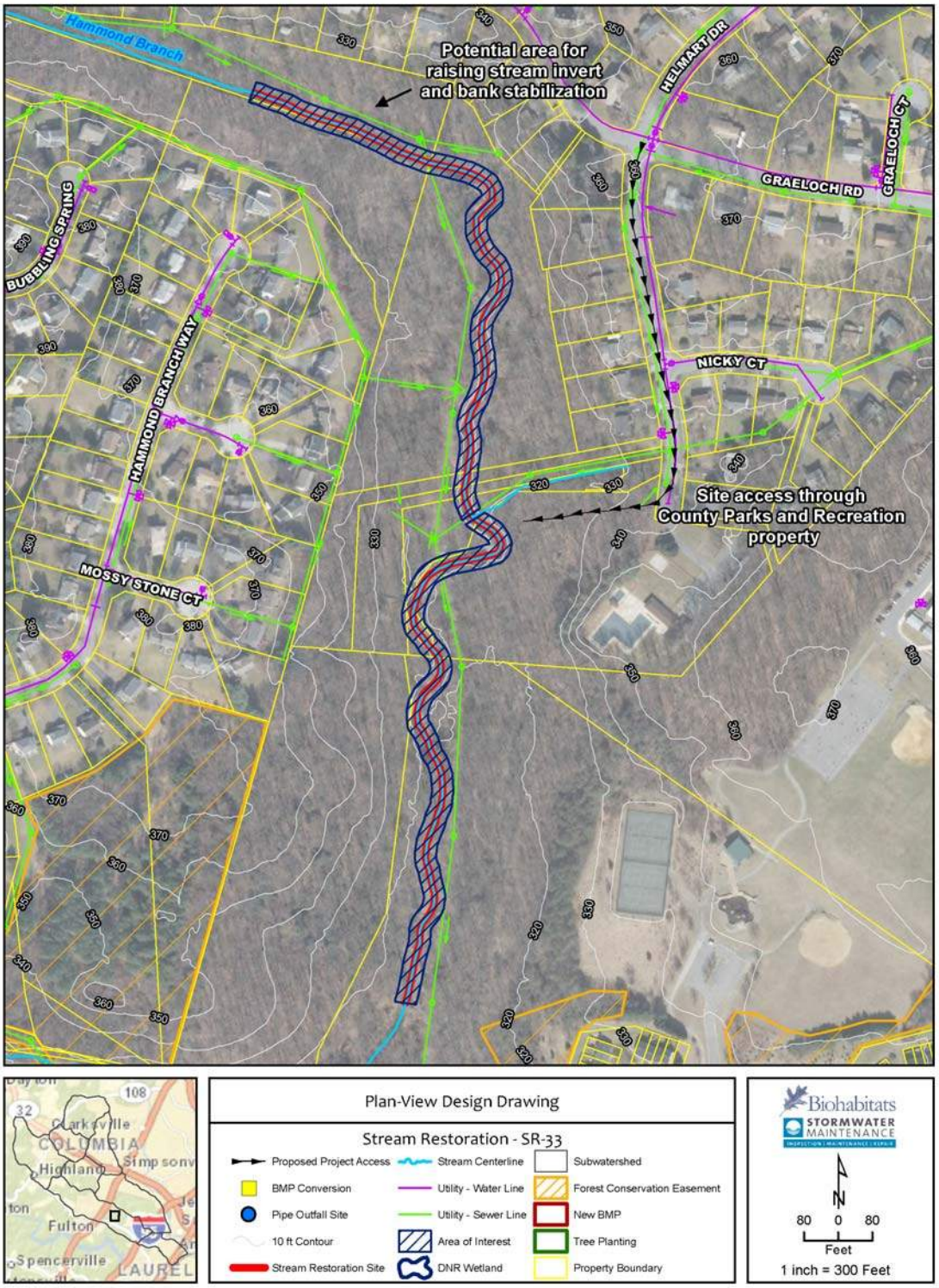
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-33

Site Name: Hammond Branch (a)

Contractor: Biohabitats

Watershed: Little Patuxent River



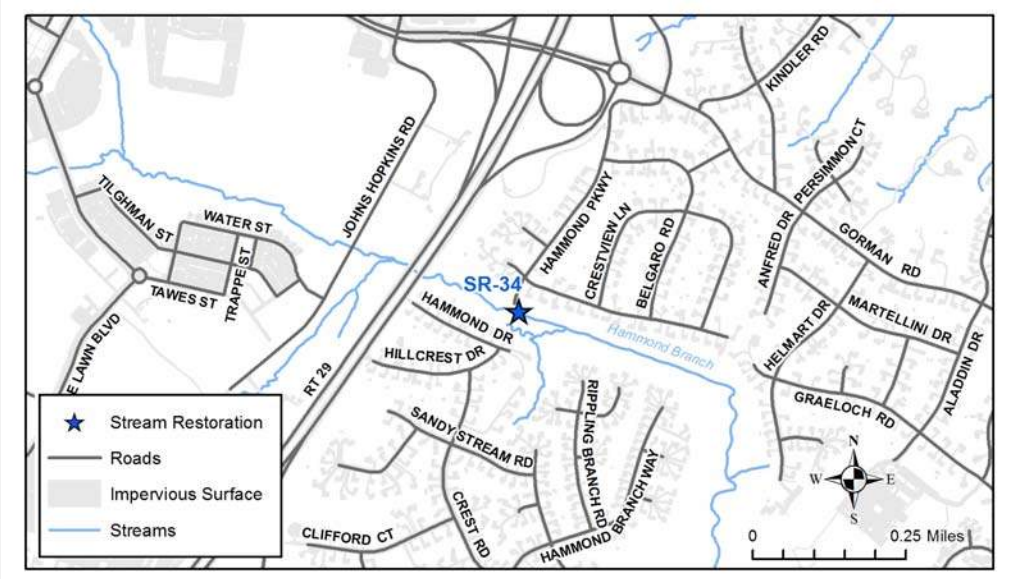
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-34
Site Name: Hammond Branch (b)
Contractor: Biohabitats
Watershed: Little Patuxent River

Ownership: Private- Mixed Use
Multiple Owners

Existing Conditions:

This project site, located on Hammond Branch, consists of two stream assessment sites: SMP-SR-F335A and SMP-SR-F335B. Multiple owners are involved in this section of Hammond Branch, including private property owners and the State of Maryland. Private property and homes surround the stream on both sides of the stream with homeowners mentioning frequent flooding occurring. Relatively moderate bank erosion was observed, with eroded bank heights averaging from 3-5 ft. high. Two locations along the stream showed eroded bank heights of greater than 5 ft. Residential lawns run directly to the stream, providing a poor riparian vegetative buffer. Concrete rubble was found along a portion of the project site; it was presumably placed there to act as bank protection. The instream habitat within the existing channel scored in the marginal range overall. The epifaunal substrates consists of 20-40% stable habitat favorable for epifaunal colonization with less than desirable habitat and frequently disturbed substrate increasing the embeddedness throughout the stream, with 50% of gravel, cobble, and boulder particles surrounded by fine sediment. The velocity/depth regime of the channel is suboptimal with typically three of four velocities present throughout the stream. More sediment deposition occurs within the upstream portion of this assessed part of Hammond Branch where moderate deposition occurring creating bar formations and some sediment deposition within the stream bed. The channel flow status is suboptimal with water filling on average 75% of the available channel and some of the riffle substrate exposed. Both stream banks are moderately unstable with 40% of the stream banks having some cover and increased erosion during floods. The right bank (looking downstream) is more unstable than the left bank. Vegetative protection along both banks is suboptimal with some areas being disturbed. There is little to no riparian vegetation along the right and left banks (looking downstream) due to encroachment on private properties. Shading along the existing channel is marginal (40%).



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-34

Site Name: Hammond Branch (b)

Contractor: Biohabitats

Watershed: Little Patuxent River

Facing upstream, concrete rubble presumably acting as bank protection.

Facing the left bank, an eroded bank height greater than 5 ft. with no protective vegetative cover.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-34
Site Name: Hammond Branch (b)
Contractor: Biohabitats
Watershed: Little Patuxent River

Constraints/Utilities:

Access to the stream can be from Hammond Parkway and/or along the existing sewer line easement. There are several locations along the stream where either a water line and/or sewer line crosses the stream. Impacts to trees would be moderate, but mainly due to access.

Concept Description:

The objective for this project is to reduce bank erosion and improve instream habitat for aquatic organisms. As homes are located within the floodplain, the stream invert cannot be raised without potentially creating more flooding within this area. A multistage channel should be created and the riparian buffer on the left bank enhanced. This will be accomplished by grading banks back to a stable angle and stabilizing them with native vegetation to hold soil in place. Adding woody debris, cobble riffles, pools, and other nature-like habitat structures will reinforce the stream bed and banks, improve the flow diversity and structural complexity of the stream bed, and uplift the instream habitat. The proposed channel restoration work would occur predominately on the existing channel alignment; however, some minor realignment may be necessary at the tight meander bends. In addition, establishing the maximum riparian buffer and improving tree understory will provide shading to reduce the stream temperature and needed litter inputs and woody debris. This channel restoration has the potential to reduce sediment supply, improve habitat and provide opportunities for nutrient uptake. The site can be accessed from Hammond Parkway. There are seven other project recommendations that can be concurrently implemented with this project including two tree planting sites and five stream restoration sites. These seven projects include: SR-33, SR-35, SR-36, SR-37, SR-38, SMP-TP-F405A, and SMP-TP-F406.

Nearby Opportunities:

SR-33, SR-35, SR-36, SR-37, SR-38, SMP-TP-F405A, SMP-TP-F406

Proposed Project Credit		Costs	
Length Restored (ft):	1,387	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	13.9	Estimated Construction Cost:	$624,600.00
Cost per Impervious Credit Acre:	$80,171.59	30% Contingency:	$187,380.00
		Estimated Total Cost:	$1,111,980.00

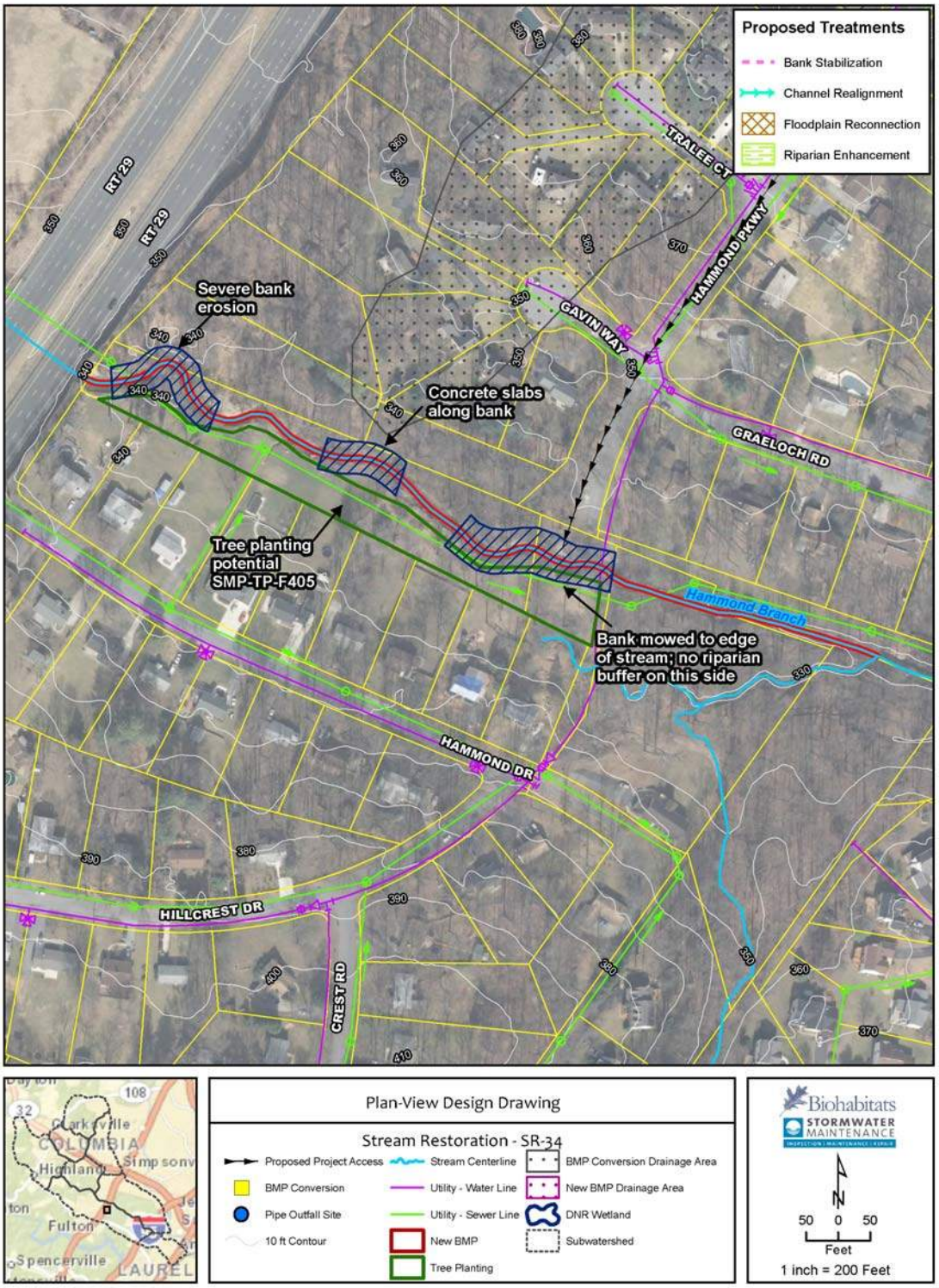
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-34

Site Name: Hammond Branch (b)

Contractor: Biohabitats

Watershed: Little Patuxent River



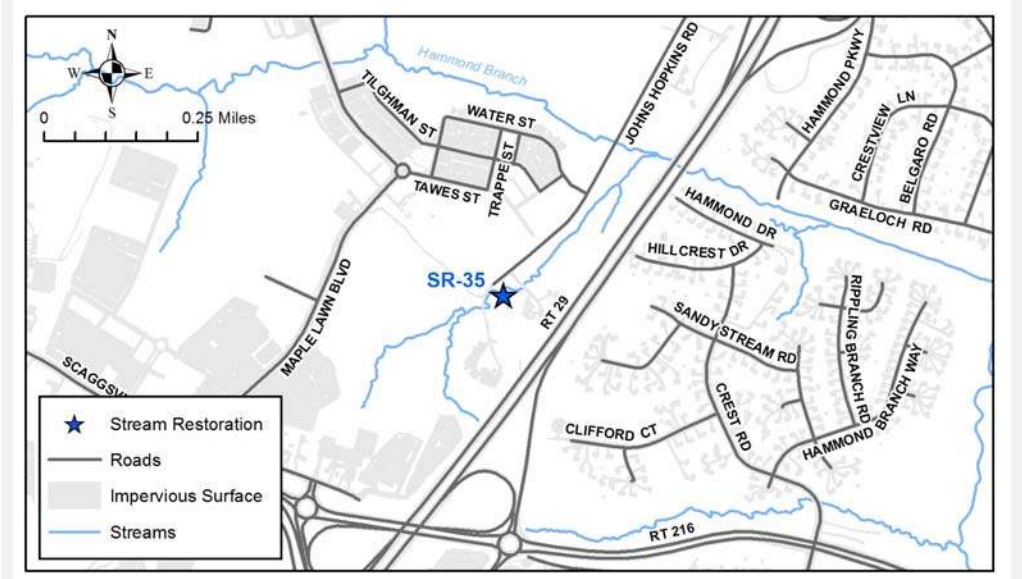
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-35
Site Name: Maple Lawn Farms
Contractor: Biohabitats
Watershed: Little Patuxent River

Ownership: County Owned
Multiple Owners

Existing Conditions:

This project site involves four different stream assessment sites: SMP-SR-F333B, SMP-SR-F333C, SMP-SR-F334A, and SMP-SR-F334B. The stream flows through multiple privately and publicly owned properties as well as a forest conservation easement named Maple Lawn Farms. The system had multiple headcuts moving upstream, creating a stream channel that is no longer connected to the surrounding floodplain. The headcuts are currently located in the upstream most reach. Most of the existing system is entrenched within the reaches indicated for restoration. Erosion throughout the stream shows varying eroded bank heights ranging from 3 to greater than 5 ft. The channel has been altered throughout the stream reach, presumably to stabilize the bank; however, the channel alteration has caused more erosion to occur downstream of the "fixed" area. The instream habitat within the existing channel scored in the marginal range overall. The epifaunal substrates consists of 20-40% stable habitat favorable for epifaunal colonization with less than desirable habitat and frequently disturbed substrate increasing the embeddedness throughout the stream, with 50% of gravel, cobble, and boulder particles surrounded by fine sediment. The velocity/depth regime of the channel is marginal with typically one or two velocities present throughout the stream. Less sediment deposition occurs within the assessed site where some deposition occurs throughout the stream creating bar formations and some sediment deposition. The channel flow status is optimal at the upstream end of the stream with water filling on average 75% of the available channel; however, as the stream moves downstream, the channel flow status becomes marginal with the channel only filling 50% of the available channel and more riffle substrate is exposed. Upstream bank stability is moderately stable, while as the stream moves downstream, stream banks on both the left and right side of the stream become unstable with 60% of the stream banks having some cover and increased erosion during floods. Vegetative protection upstream is great with 70-90% of the stream bank surface covered, while the downstream portion of the stream has little to no vegetative protection. Shading along the existing channel is suboptimal (60%).



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-35
Site Name: Maple Lawn Farms
Contractor: Biohabitats
Watershed: Little Patuxent River

Facing upstream, a recent bank failure along the right bank (looking downstream), leaving the bank raw with little to no vegetative protection.

Facing upstream, little protective cover on the right bank (looking downstream).

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-35
Site Name: Maple Lawn Farms
Contractor: Biohabitats
Watershed: Little Patuxent River

Constraints/Utilities:

Two sewer lines run along the stream before they converge into one sewer line after crossing the stream. No water lines cross the stream. Tree impacts are to be expected because of the location of the stream, but should be avoided to the extent possible during construction. The stream runs through a BGE ROW; therefore, overhead lines need to be avoided. The stream can be accessed using John Hopkins Road and using the existing sewer line easement.

Concept Description:

The objective for this project is to reduce bank erosion and improve instream habitat for aquatic organisms. This will be accomplished by raising the stream invert to connect the channel to the existing floodplain, grading banks back to a stable angle, and stabilizing the banks with native vegetation to hold soil in place. Adding woody debris, cobble riffles, pools, and other nature-like habitat structures will reinforce the stream bed and banks, improve the flow diversity and structural complexity of the stream bed, and uplift the instream habitat. The proposed channel restoration work would occur predominately on the existing channel alignment; however some minor realignment may be necessary at tight meander bends. A berm along John Hopkins Road should be removed to allow greater floodplain access during larger flows. In addition, maximizing the riparian buffer will increase shading, reduce the stream temperature and provide needed litter inputs and woody debris. This channel restoration has the potential to reduce sediment supply, improve habitat and provide opportunities for nutrient uptake. The site can be accessed from Johns Hopkins Road. Seven other project recommendations can be implemented concurrently with this project including two tree planting sites and five other stream restoration sites. These seven other projects include: SR-33, SR-34, SR-36, SR-37, SR-38, SMP-TP-F405A, and SMP-TP-F406.

Nearby Opportunities:

SR-33, SR-34, SR-36, SR-37, SR-38, SMP-TP-F405A, SMP-TP-F406

Proposed Project Credit		Costs	
Length Restored (ft):	2,773	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	27.7	Estimated Construction Cost:	$1,247,850.00
Cost per Impervious Credit Acre:	$69,318.61	30% Contingency:	$374,355.00
		Estimated Total Cost:	$1,922,205.00

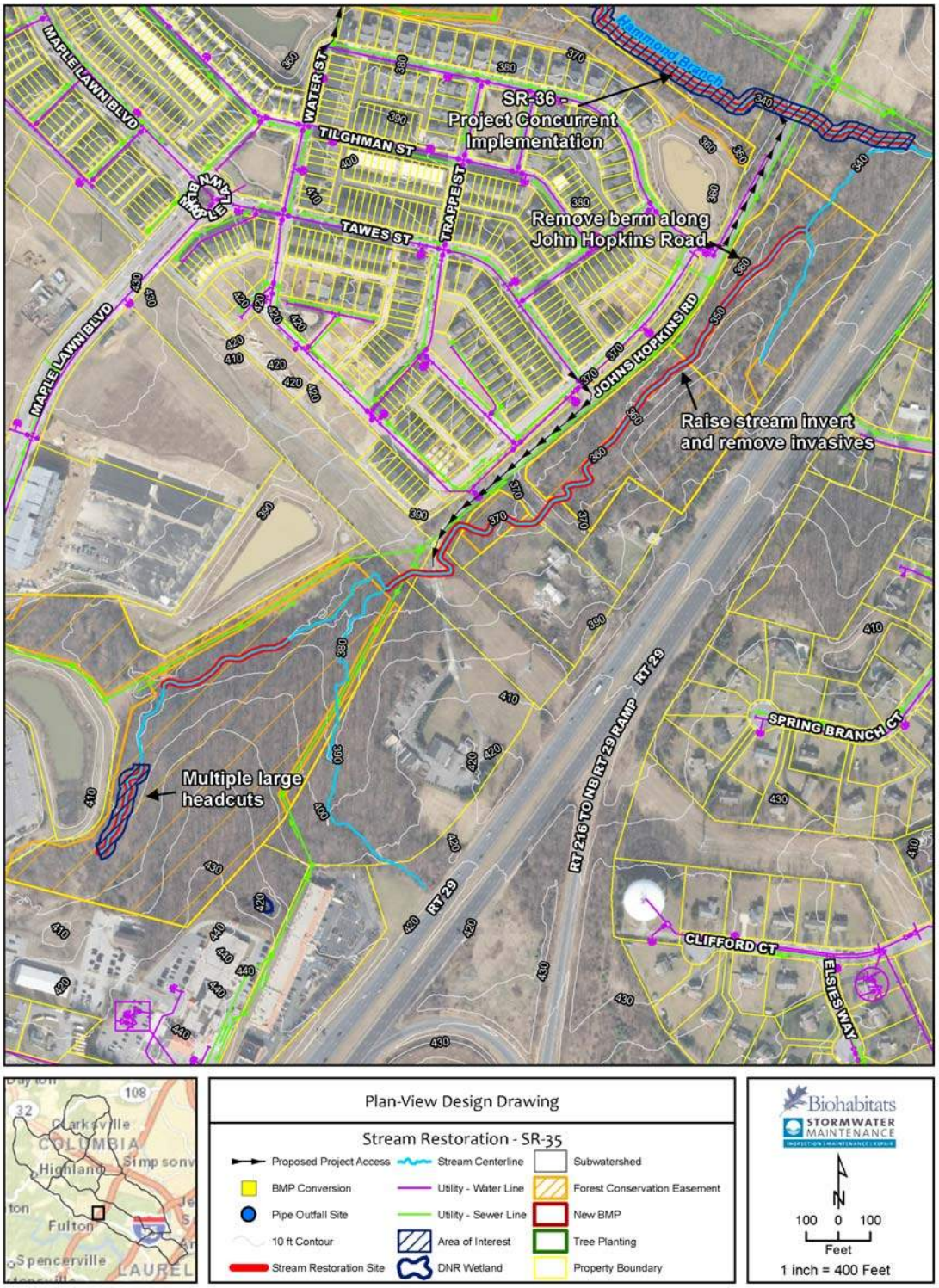
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-35

Site Name: Maple Lawn Farms

Contractor: Biohabitats

Watershed: Little Patuxent River



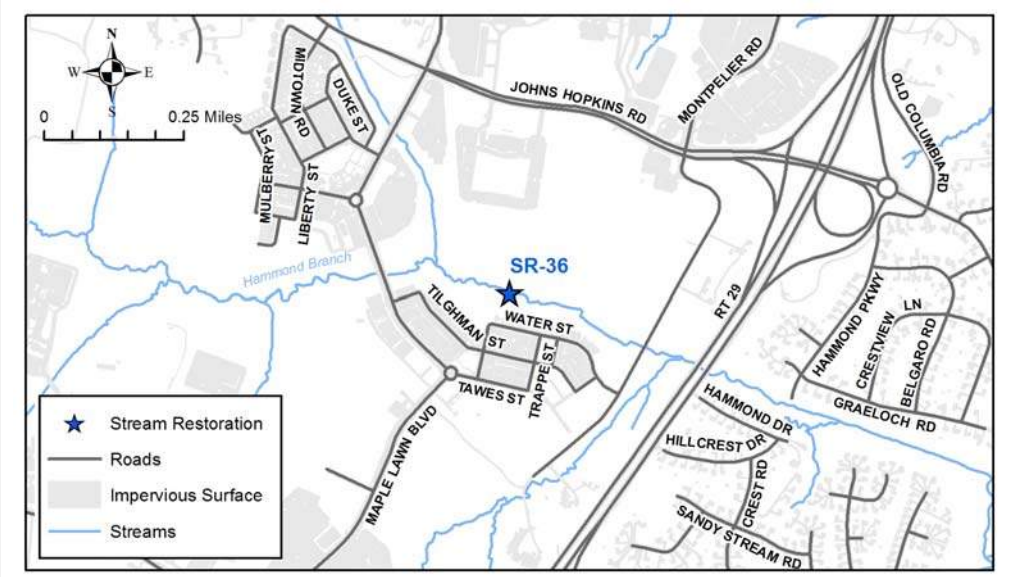
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-36
Site Name: Hammond Branch (c)
Contractor: Biohabitats
Watershed: Little Patuxent River

Ownership: County Owned
Single Owner

Existing Conditions:

This project site involves three stream assessment sites: SMP-SR-F337A, SMP-SR-F337B, and SMP-SR-F337C. The project site is on Hammond Branch and is upstream of project site SR-35. The stream runs parallel to Water Street and crosses Johns Hopkins Road as it flows downstream toward Route 29. Portions of the stream corridor are located within the Maple Lawn Farms Forest Conservation Easement. A large development with town homes is located along the right side of the stream. There are two wet ponds also near the stream that capture stormwater from the surrounding neighborhood. The outfalls from these wet ponds drain to the stream, and are starting to headcut back up the flow path from the stream banks. Severe bank erosion of 5 ft. or greater is occurring along the stream on both the left and right banks with the right bank being more severe due to the adjacent neighborhood. Point and mid-channel bars and debris jams were found throughout the stream that were hindering the health and flow of the stream. Instream habitat within the existing channel scored in the suboptimal range overall. The epifaunal substrates consists of 20-40% stable habitat favorable for epifaunal colonization with less than desirable habitat and frequently disturbed substrate affecting the embeddedness throughout the stream, with 25-50% of gravel, cobble, and boulder particles surrounded by fine sediment. Both stream banks are unstable with 30-60% of the stream banks having some cover and increased erosion during floods. Vegetative protection upstream is worse with only 50-70% of the stream bank surface covered; however, as moving downstream, vegetative protection increases with an average of 90% of the stream bank surface covered. Shading along the existing channel is suboptimal (70%).



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-36
Site Name: Hammond Branch (c)
Contractor: Biohabitats
Watershed: Little Patuxent River

Facing upstream, a tight bend with a raw left bank (looking downstream), a deep pool and a large mid channel bar forming upstream of the tight bend.

Facing downstream, a large debris jam and bank erosion occurring on both the left and right banks.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-36
Site Name: Hammond Branch (c)
Contractor: Biohabitats
Watershed: Little Patuxent River

Constraints/Utilities:

The site can be accessed from Johns Hopkins Road. There is also a sewer line easement that runs along the stream that could be used as access to avoid major tree impacts. The stream is located within a forest easement; therefore, more tree impacts are expected within the area.

Concept Description:

The objective for this project is to reduce bank erosion and improve instream habitat for aquatic organisms. This will be accomplished by grading banks back to a stable angle and stabilizing them with native vegetation to hold soil in place. If possible, the stream invert will be raised to increase floodplain access. Adding woody debris, cobble riffles, pools, and other nature-like habitat structures will reinforce the stream bed and banks, improve the flow diversity and structural complexity of the stream bed, and uplift the instream habitat. The proposed channel restoration work would occur predominately on the existing channel alignment; however, some minor realignment may be necessary at tight meander bends. In addition, establishing the maximum riparian buffer by improving the existing forest understory to increase shading, reduce stream temperature, and provide needed litter inputs and woody debris to the channel overtime to maintain the habitat complexity and quality. All invasive species should be removed and an invasive management program should be applied to this site. This channel restoration has the potential to reduce the sediment supply, improve habitat and provide opportunities for nutrient uptake. The site can be accessed from Johns Hopkins Road and by a sewer line easement that runs adjacent to the stream. There are six nearby project recommendations that could be implemented concurrently with this project, including five stream restoration sites and one tree planting site. These nearby projects include: SR-33, SR-34, SR-35, SR-37, SR-38, and SMP-TP-F405A.

Nearby Opportunities:

SR-33, SR-34, SR-35, SR-37, SR-38, SMP-TP-F405A, SMP-TP-F406

Proposed Project Credit		Costs	
Length Restored (ft):	2,748	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	27.5	Estimated Construction Cost:	$1,237,050.00
Cost per Impervious Credit Acre:	$69,438.32	30% Contingency:	$371,115.00
		Estimated Total Cost:	$1,908,165.00

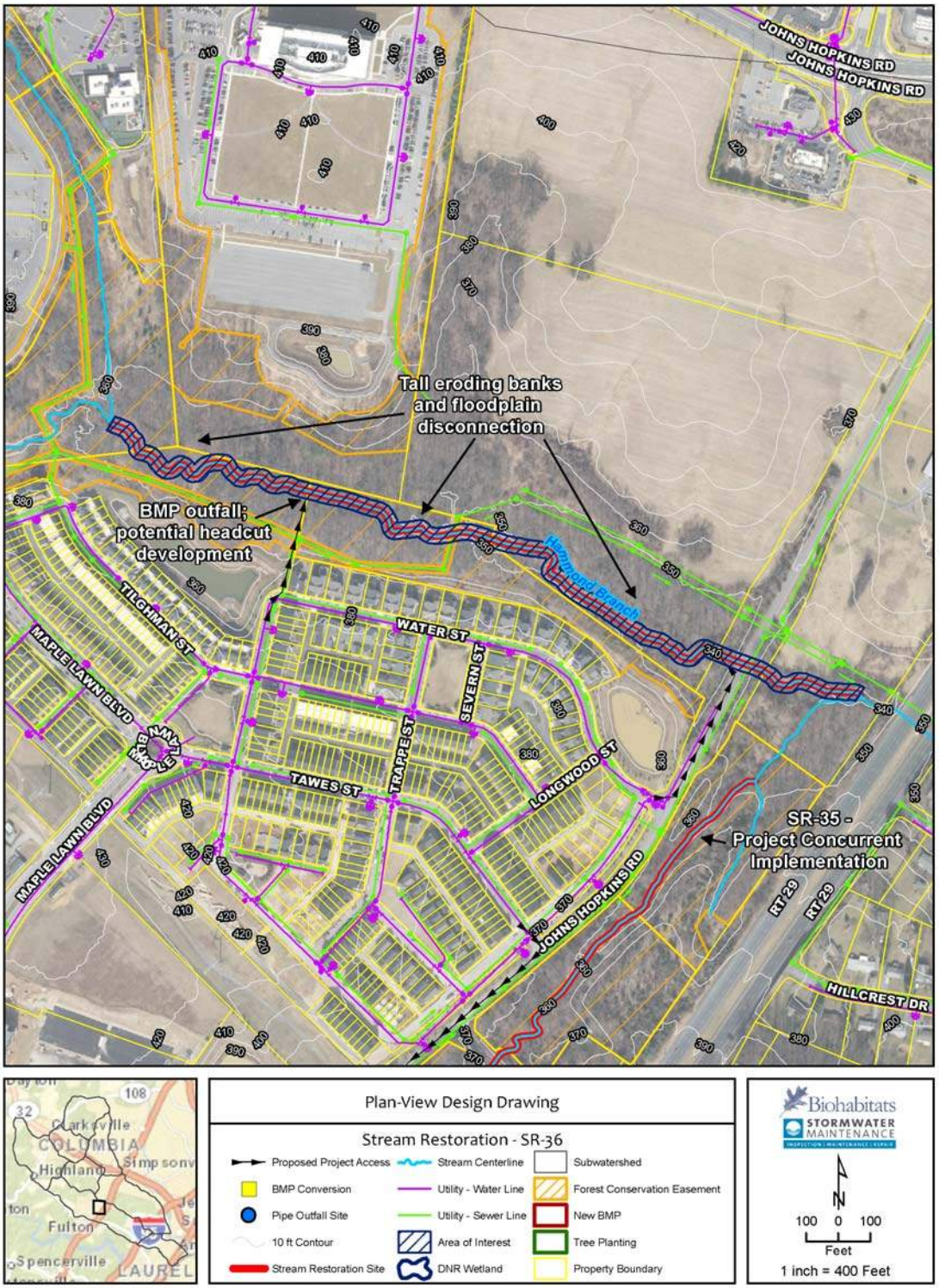
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-36

Site Name: Hammond Branch (c)

Contractor: Biohabitats

Watershed: Little Patuxent River



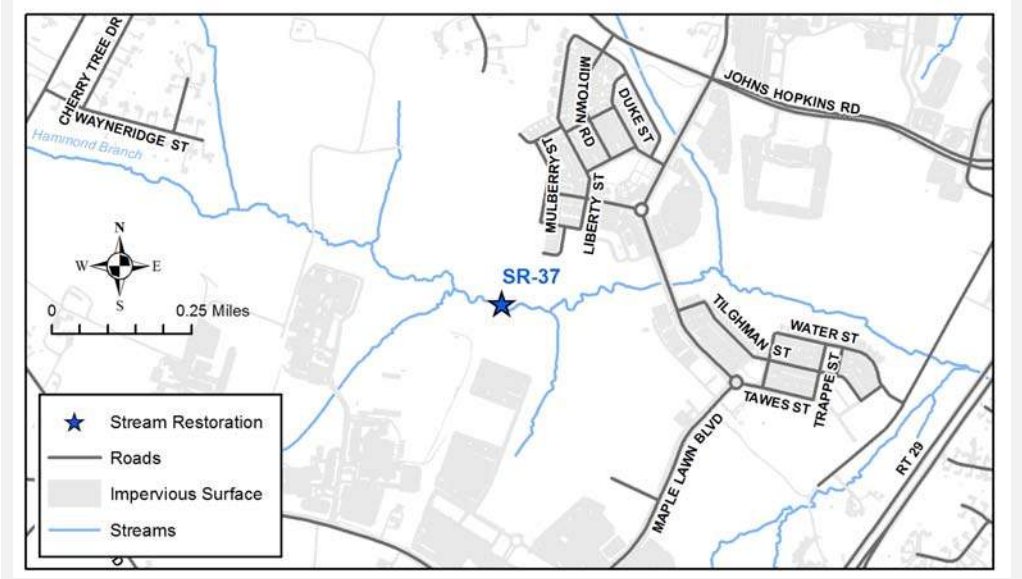
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-37
Site Name: Hammond Branch (d) - Reservoir High School
Contractor: Biohabitats
Watershed: Little Patuxent River

Ownership: Private- Commercial/Industrial
Multiple Owners

Existing Conditions:

This project site includes two stream assessment sites: SMP-SR-F336A and SMP-SR-F338A. SMP-SR-F338A is upstream of SMP-SR-F336A on Hammond Branch. A BGE ROW runs the length of the site, with very little overhead cover and shade. SMP-SR-338A is located near Cedar Lane School and Lime Kiln Middle School, while SMP-SR-F336A is near Reservoir High School. The stream has moderate erosion occurring along both the left and right banks ranging from 3 to 5 ft. in bank height for most of the length. The upstream reach (SMP-SR-F338A) has a long section of eroding bank over 9 ft. in height, the right bank has very high eroding banks cutting into the hillslope near the school. The instream habitat within the existing channel scored in the marginal range overall. The epifaunal substrate upstream is poor with less than 20% stable habitat; however, as the stream moves downstream the epifaunal substrate becomes better and consists of 40-70% stable habitat favorable for epifaunal colonization with desirable habitat and some disturbed substrate not ready for colonization yet. Embeddedness throughout the stream is higher at the upstream end and continues to decrease as the stream moves downstream with an average of 25-50% of gravel, cobble, and boulder particles surrounded by fine sediment. The velocity/depth regime of the channel is suboptimal with three velocities present throughout the stream. Severe sediment deposition occurs within the upstream portion of the stream with 50% of the bottom affected and bar formations are occurring along the stream banks. As the stream moves downstream, only 30% of the bottom is affected by sediment deposition. The channel flow status is suboptimal throughout the stream with water filling on average 75% of the available channel and some riffle substrate exposed. Bank stability is moderately unstable on both the left and right side of the stream with 30-60% of the stream banks having some cover and increased erosion during floods. Vegetative protection along the left and right bank is marginal with an average of 70% of the stream bank surface covered. Shading along the existing channel is poor (10%).



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-37

Site Name: Hammond Branch (d) - Reservoir High School

Contractor: Biohabitats

Watershed: Little Patuxent River

Facing downstream, an average 4 ft. recently eroded bank.

Facing downstream, very high eroded banks cutting into the hillslope near the school.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-37
Site Name: Hammond Branch (d) - Reservoir High School
Contractor: Biohabitats
Watershed: Little Patuxent River

Constraints/Utilities:

Both site assessments are mainly within a BGE ROW and are in close proximity to multiple schools. There are electrical power lines overhead and transmission poles along the stream that can make the site hazardous during construction. A sewer line does cross the stream and runs along a small portion of the stream. Very minimal tree impacts are anticipated due to a lack of overhead cover.

Concept Description:

The objective for this project is to reduce bank erosion and improve instream habitat for aquatic organisms. To improve instream habitat, either the stream invert can be raised or a new floodplain can be graded to reduce bank erosion and promote floodplain reconnection. In addition, grading banks back to a stable angle and stabilizing them with native vegetation to hold soil in place will help reduce bank erosion. Adding woody debris, cobble riffles, pools, and other nature-like habitat structures will reinforce the stream bed and banks, improve the flow diversity and structural complexity of the stream bed, and uplift the instream habitat. The proposed channel restoration work would occur predominately on the existing channel alignment; however, some minor realignment may be necessary where the stream is cutting into the hillslope. Maximizing riparian buffer will increase the shading to reduce the stream temperature and provide needed litter inputs and woody debris. This channel restoration has the potential to reduce the sediment supply, improve habitat, provide opportunities for nutrient uptake, and serve as an outdoor learning laboratory for the surrounding schools. The site can be accessed from the BGE access road and/or the nearby school. There are seven other nearby project recommendations that should be concurrently implemented with this site including five stream restoration sites and two tree planting site. These nearby projects include: SR-33, SR-34, SR-35, SR-36, SR-38, SMP-TP-F405A, and SMP-TP-F406. The outfalls from the area being developed on the reach between here and SR-38 should be modified so that the flow passes to the stream through a channel, not sheet flow so as to limit future headcutting up to the outfall.

Nearby Opportunities:

SR-33, SR-34, SR-35, SR-36, SR-38, SMP-TP-F405A, SMP-TP-F406

Proposed Project Credit		Costs	
Length Restored (ft):	1,749	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	17.5	Estimated Construction Cost:	$787,500.00
Cost per Impervious Credit Acre:	$75,686.11	30% Contingency:	$236,250.00
		Estimated Total Cost:	$1,323,750.00

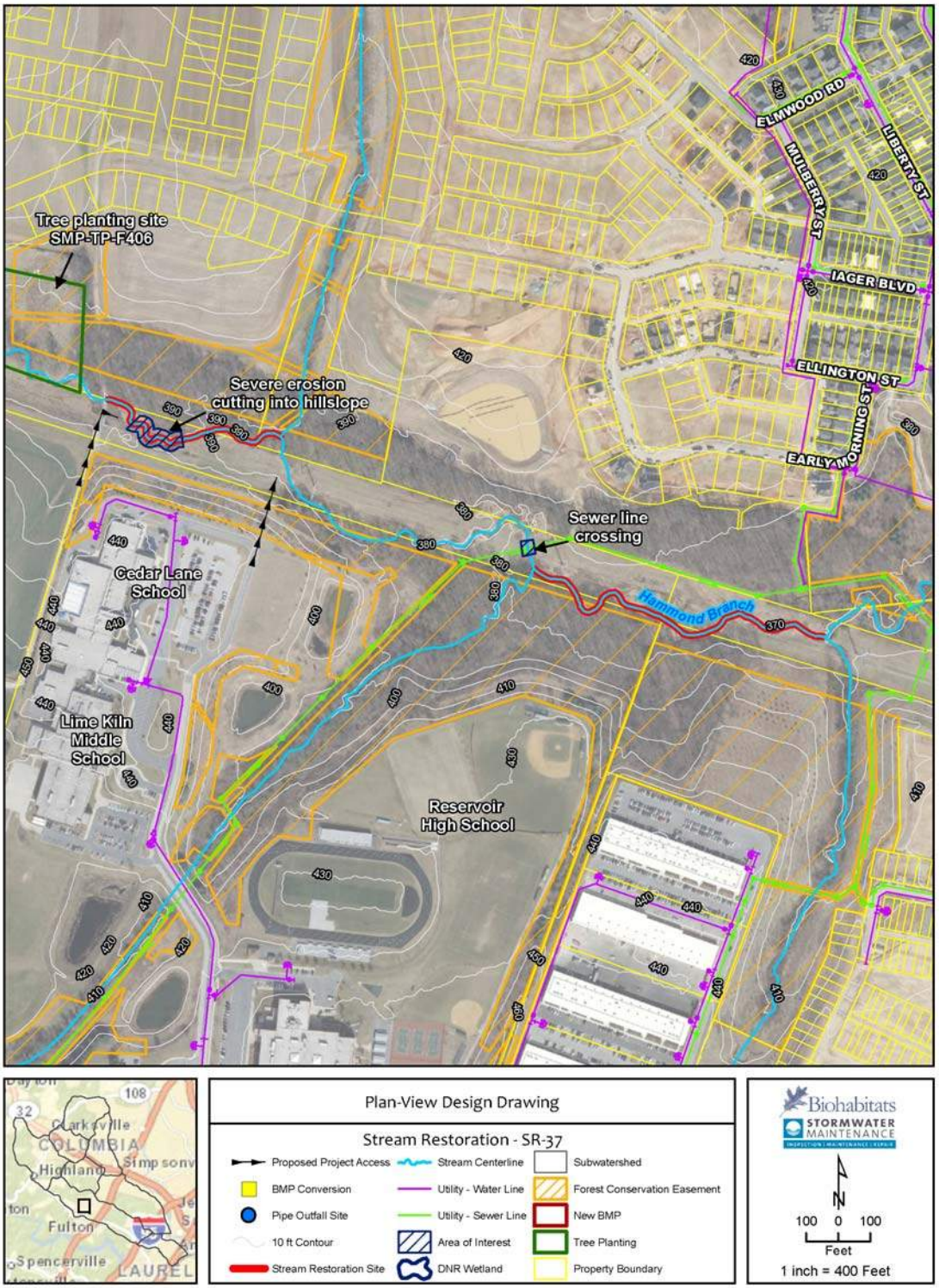
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-37

Site Name: Hammond Branch (d) - Reservoir High School

Contractor: Biohabitats

Watershed: Little Patuxent River



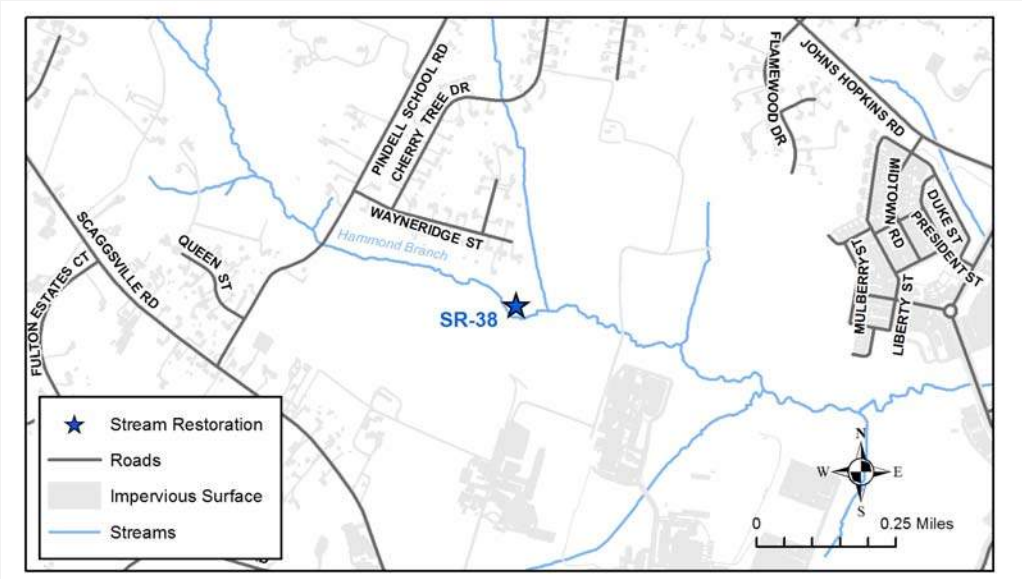
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-38
Site Name: Hammond Branch (e) - The Home Farm LLC
Contractor: Biohabitats
Watershed: Little Patuxent River

Ownership: County Owned
Multiple Owners

Existing Conditions:

This project site involves two stream assessment sites: SMP-SR-F339A and SMP-SR-F339B. The project site is on Hammond Branch and is located upstream of SR-37. The stream flows through three separate properties, including county owned, private-commercial (BGE ROW), and private-residential (The Home Farm LLC). Most of the project site is located on county land. The stream has moderate erosion occurring along both the left and right banks, ranging from 3 to 5 ft. in eroded bank height. The instream habitat within the existing channel scored in the marginal range overall. The epifaunal substrate upstream is suboptimal with 40-70% stable habitat; however, as moving downstream the epifaunal substrate becomes worse and consists of less than 20% stable habitat favorable for epifaunal colonization with undesirable habitat and unstable substrate. Embeddedness throughout the stream is lower at the upstream end and continues to increase as the stream moves downstream with an average of 50% of gravel, cobble, and boulder particles surrounded by fine sediment. The velocity/depth regime of the channel is optimal with two velocities present throughout the stream. Severe sediment deposition occurs within the downstream portion of the stream with more than 50% of the bottom affected and bar formations are occurring along the stream banks. As the stream moves upstream, only 30% of the bottom is affected by sediment deposition. The channel flow status is suboptimal throughout the stream with water filling on average 75% of the available channel and some riffle substrate exposed. Bank stability is moderately stable on both the left and right side of the stream with 30% of the stream banks having some cover and increased erosion during floods. Vegetative protection along the left and right bank is marginal with an average of 70% of the stream bank surface covered. Shading along the existing channel is poor (10%).



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-38
Site Name: Hammond Branch (e) - The Home Farm LLC
Contractor: Biohabitats
Watershed: Little Patuxent River

Facing upstream at the right bank.

Facing upstream at the right bank showing average bank erosion for the site.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-38
Site Name: Hammond Branch (e) - The Home Farm LLC
Contractor: Biohabitats
Watershed: Little Patuxent River

Constraints/Utilities:

This portion of Hammond Branch is located on three separate properties including county owned property, private property for commercial use (BGE), and private property for residential and commercial use (The Home Farm LLC). No utilities were observed in the area except for BGE lines over the stream. Transmission poles are along the stream and could create a hazardous work site during construction. The site can be accessed through the BGE ROW.

Concept Description:

The objective for this project is to reduce bank erosion and improve instream habitat for aquatic organisms. To improve instream habitat, the stream invert can be raised, reducing bank erosion and promoting floodplain reconnection. Removing failing fences, grading banks back to a stable angle and stabilizing them with native vegetation to hold soil in place will also help reduce bank erosion. Adding woody debris, cobble riffles, pools, and other nature-like habitat structures will reinforce the stream bed and banks, improve the flow diversity and structural complexity of the stream bed, and uplift the instream habitat. The proposed channel restoration work would occur predominately on the existing channel alignment; however, some minor realignment may be necessary. In areas where power lines are not a constraint, tree planting and establishing the maximum riparian buffer will increase shading, reduce stream temperature and provide needed litter inputs and woody debris. This channel restoration has the potential to reduce sediment supply, improve habitat, and provide opportunities for nutrient uptake. The site can be accessed from the BGE access road. There are six nearby project recommendations that could be concurrently implemented with this project, including five stream restoration sites and one tree planting site. These nearby projects include: SR-33, SR-34, SR-35, SR-36, SR-37, and SMP-TP-F405A. The outfalls from the area being developed on the reach between this project site and SR-37 should be modified so that the flow passes to the stream through a channel, not as sheet flow so as to limit future headcutting up to the outfall.

Nearby Opportunities:

SR-33, SR-34, SR-35, SR-36, SR-37, SMP-TP-F405A, SMP-TP-F406

Proposed Project Credit		Costs	
Length Restored (ft):	1,671	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	16.7	Estimated Construction Cost:	$752,400.00
Cost per Impervious Credit Acre:	$76,488.33	30% Contingency:	$225,720.00
		Estimated Total Cost:	$1,278,120.00

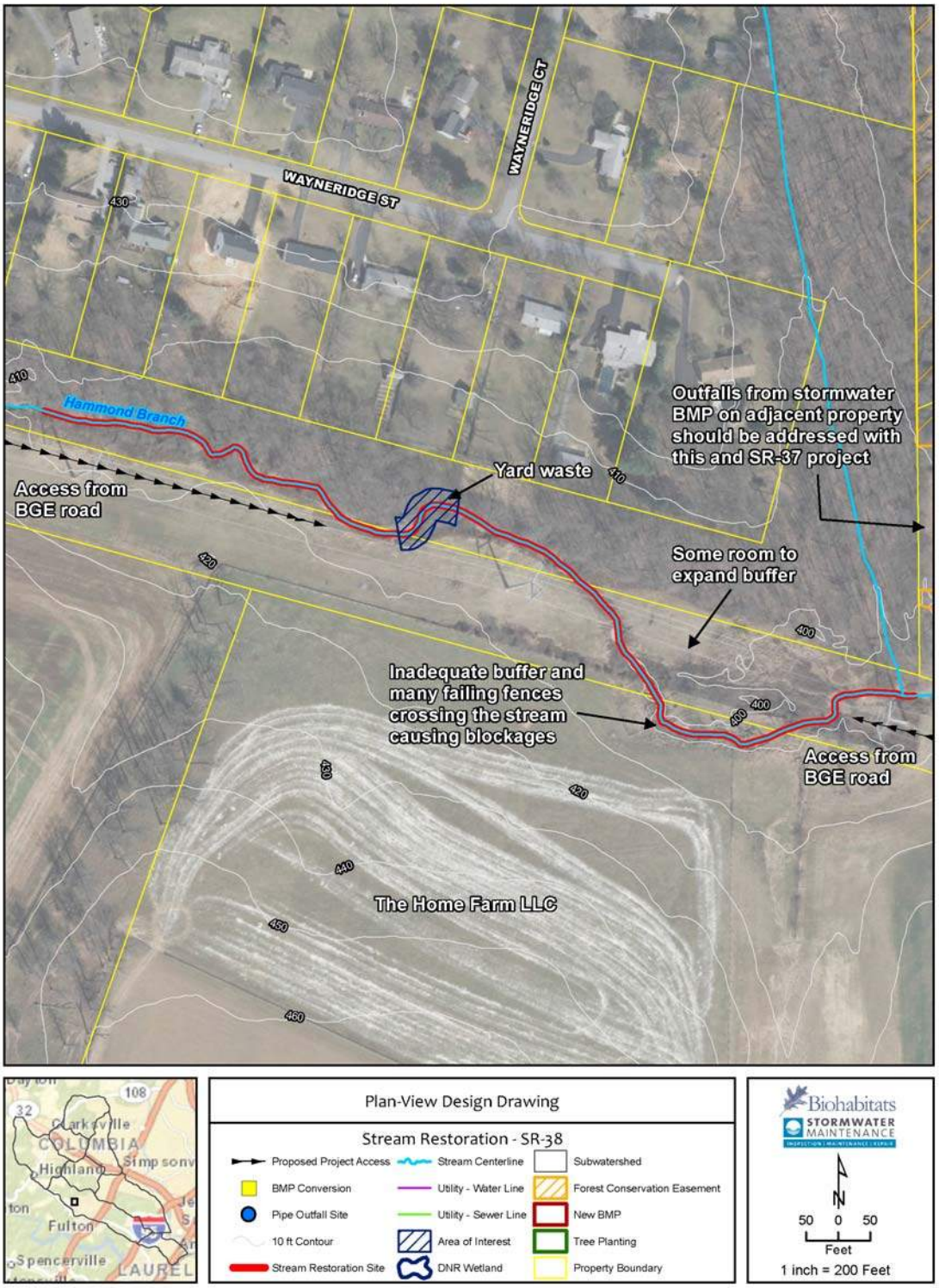
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-38

Site Name: Hammond Branch (e) - The Home Farm LLC

Contractor: Biohabitats

Watershed: Little Patuxent River



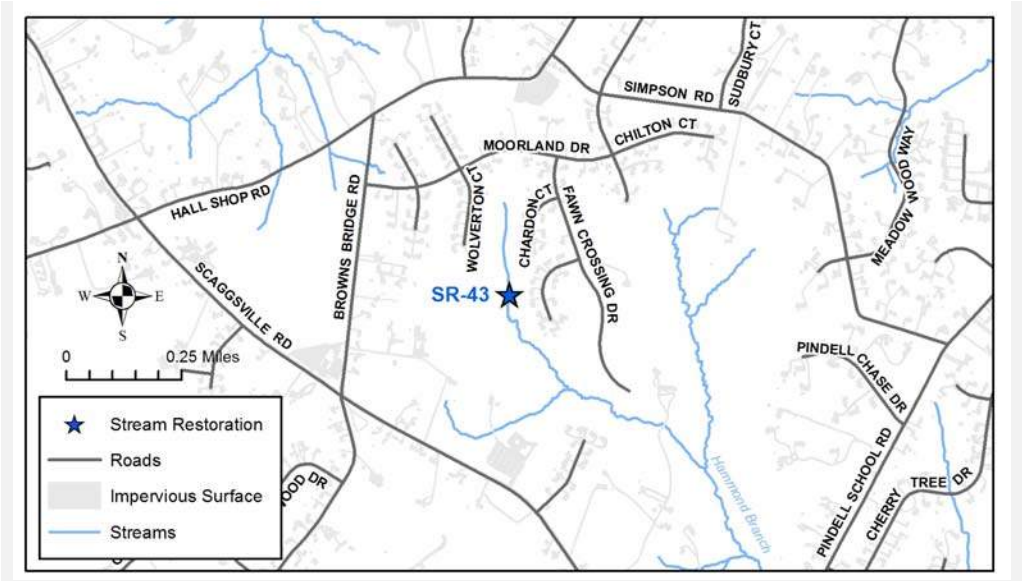
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-43
Site Name: Ashleigh Knolls Homeowners Association
Contractor: Biohabitats
Watershed: Little Patuxent River

Ownership: Private- Residential
Single Owner

Existing Conditions:

This project site involves two stream assessment sites: SMP-SR-F340B and SMP-SR-F340C. The stream is located on a wooded parcel that is privately owned by Ashleigh Knolls Homeowners Association. The stream runs adjacent to Wolverton Court in Clarksville, MD, is located within a Department of Natural Resources Wetland, Class PFO1A and is adjacent to the VanNoy Property Forest Conservation Easement. SMP-SR-F340C has minor erosion with two to three eroding banks throughout; however, as the stream moves downstream from SMP-SR-F340C to SMP-SR-F340B there is a 4 ft. head cut. After this head cut, more moderate erosion occurs with an average eroding bank height between 3 and 5 ft. There are several tight meanders throughout the stream causing raw and undercut banks to occur on both the left and right banks. The instream habitat within the existing channel scored in the marginal range overall. The epifaunal substrates consists of more than 70% stable habitat favorable for epifaunal colonization with desirable habitat and little disturbed substrate. Embeddedness throughout the stream is marginal with an average of 50-75% of gravel, cobble, and boulder particles surrounded by fine sediment. The velocity/depth regime of the channel is suboptimal with three to four velocities present throughout the stream. Heavy sediment deposition occurs within the stream where over 50% of the bottom affected and bar formations are occurring along the stream banks. The channel flow status is suboptimal at the upstream end of the stream with water filling on average 75% of the available channel. Bank stability is moderately unstable on both the left and right side of the stream with 60% of the stream banks having little cover and increased erosion during floods. Vegetative protection along the left and right bank is marginal with an average of 50-70% of the stream bank surface covered. Shading along the existing channel is optimal (90%).



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-43

Site Name: Ashleigh Knolls Homeowners Association

Contractor: Biohabitats

Watershed: Little Patuxent River

Facing upstream showing 4 ft. a headcut causing more extensive erosion downstream.

Facing upstream showing a high, raw eroded left bank (looking downstream).

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-43
Site Name: Ashleigh Knolls Homeowners Association
Contractor: Biohabitats
Watershed: Little Patuxent River

Constraints/Utilities:

Tree and wetland impacts due to the location are a major constraint to this project. The stream can be accessed from Moorland Drive between Wolverton Court and Fawn Crossing Drive. There were no observed utilities near this stream.

Concept Description:

The objective for this project is to reduce bank erosion and improve instream habitat for aquatic organisms. This will be accomplished by raising the stream invert to reconnect the stream with its floodplain as well as grading banks back to a stable angle and stabilizing them with native vegetation to hold soil in place. Adding woody debris, cobble riffles, pools, and other nature-like habitat structures will reinforce the stream bed and banks, improve the flow diversity and structural complexity of the stream bed, and uplift the instream habitat. The proposed channel restoration work would occur predominately on the existing channel alignment; however, some minor realignment may be necessary at tight meander bends. Maximizing the riparian buffer will increase the shading to reduce the stream temperature and provide needed litter inputs and woody debris to the channel. An invasive species management plan should be developed for the area. This channel restoration has the potential to reduce sediment supply, improve habitat and provide opportunities for nutrient uptake. The site can be accessed from Moorland Drive between Wolverton Court and Fawn Crossing Drive. There will be some tree impacts in order to access the stream. SMP-TP-F307A is an adjacent project recommendation that can be concurrently implemented with this project.

Nearby Opportunities:

SMP-TP-F307

Proposed Project Credit		Costs	
Length Restored (ft):	1,364	**Estimated Design Cost:**	$300,000.00
Impervious Area Treated Credit (ac.):	13.6	**Estimated Construction Cost:**	$613,800.00
Cost per Impervious Credit Acre:	$80,494.13	**30% Contingency:**	$184,140.00
		Estimated Total Cost:	$1,097,940.00

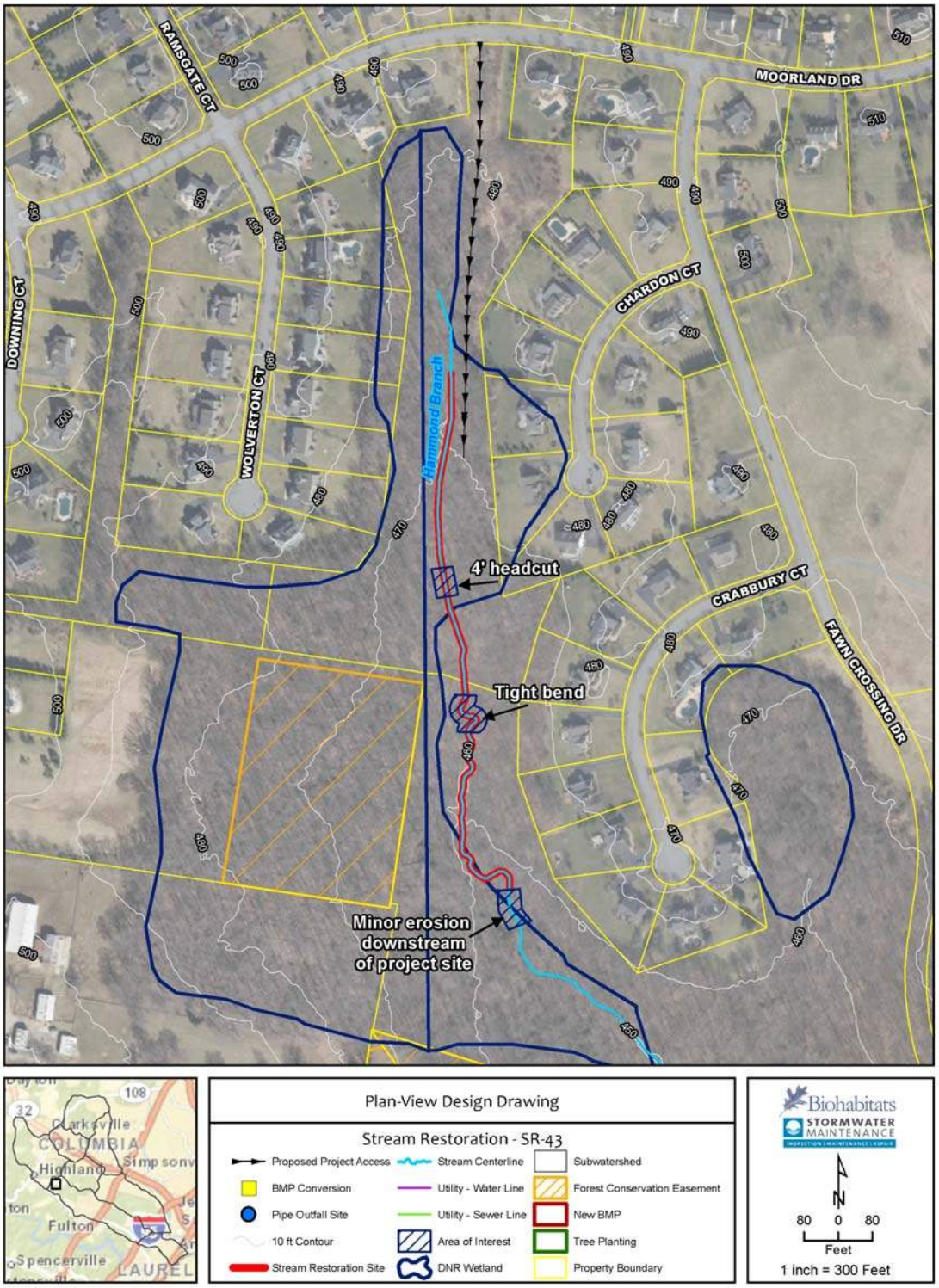
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-43

Site Name: Ashleigh Knolls Homeowners Association

Contractor: Biohabitats

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-45
Site Name: Boones Lane Tributary and Little Patuxent River
Contractor: KCI
Watershed: Little Patuxent River

Ownership: County Owned
Multiple Owners

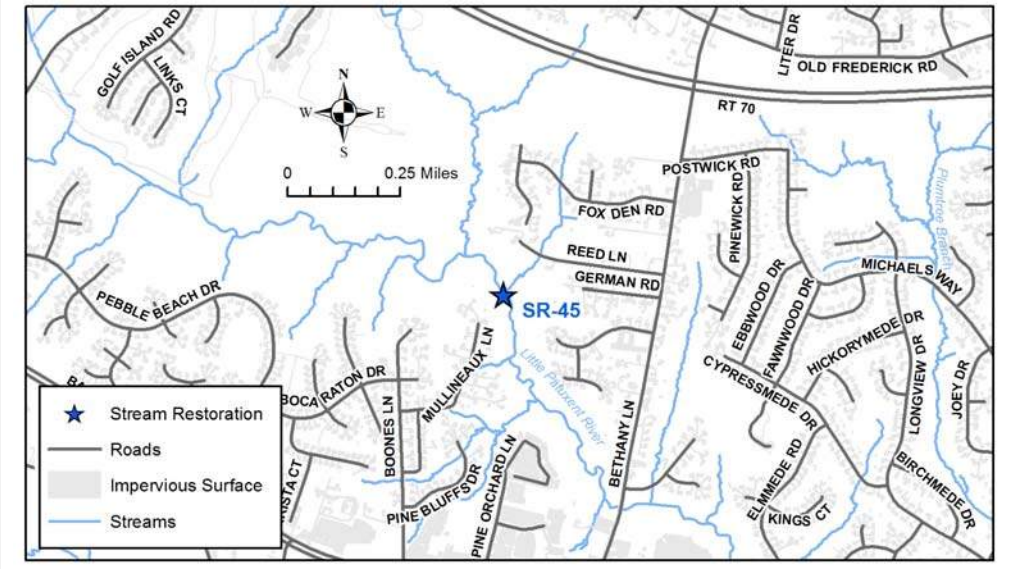
Existing Conditions:

The site consists of two reaches, Reach 1 consisting of approximately 1,000 lf. of an unnamed tributary to the Little Patuxent River and Reach 2 consisting of approximately 1,800 lf. of the Little Patuxent River. The confluence of Reach 1 occurs at the start of Reach 2, which is also at the downstream end of a stable bedrock reach of the Little Patuxent. The site also includes approximately 200 lf. of an unnamed tributary to the Little Patuxent River.

Reach 1 has approximately 4 ft. high banks that are a silty material that is easily erodible due to the vertical banks, moderate root depths, and moderate surface protection. Near bank stresses were found to be very high due to the bankfull indicator at 1.5 ft. above the bed. The reach has approximately 500 ft. of moderately eroded and undercut banks. Reach 1 is moderately embedded with fines, the bed material is composed of mostly silt sand and gravel with some cobbles, and moderate deposition was observed in the channel. Riffle spacing is characterized as being approximately five to seven channel widths. No channel alterations were observed.

Reach 2 has approximately 5 to 6 ft. high banks which are a silty material that is easily erodible due to the vertical banks, low to moderate root depths, and moderate surface protection. Near bank stresses were found to be high to very high due to the bankfull indicator at 1 to 2.5 ft. above the bed. This reach has approximately 900 ft. of severely eroded and undercut banks. Reach 2 is moderately embedded with fines, the bed material is composed of mostly silt, sand and gravel with some cobbles, and moderate to high bar formation is observed in the channel. Riffle spacing is characterized as being approximately five to seven channel widths.

The riparian buffer width for Reach 1 and Reach 2 is greater than 60 ft. on both banks and the quality of the riparian vegetation is good, at approximately 90% cover. A sanitary sewer line runs parallel and crosses both Reaches 1 and 2. In some localized areas the stream banks have eroded to a degree that they are within close proximity to the sanitary sewer line and manholes.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-45

Site Name: Boones Lane Tributary and Little Patuxent River

Contractor: KCI

Watershed: Little Patuxent River

Erosion facing left bank.

Erosion on left bank, vertical bank with moderate root depth. Moderate epifaunal habitat availability.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-45
Site Name: Boones Lane Tributary and Little Patuxent River
Contractor: KCI
Watershed: Little Patuxent River

Constraints/Utilities:

The entire project site is located within Howard County Parks and Recreations property. A sewer line runs parallel to both reaches with a number of crossings throughout. A maintained easement associated with the parallel sewer exists and could potentially be used for access. Wetlands were noted on site, requiring special consideration to the design, permitting and construction access.

The easements running parallel to the channel could provide access; however, the location of the wetlands may determine construction access. In addition, due to the wide riparian buffer, a long access path will likely be necessary to reach the channel, causing a significant impact to trees. The use of the maintained easement should help to reduce the impact to the trees.

Concept Description:

The proposed stream restoration includes a natural channel design throughout this site, where a new floodplain can be graded at a new, lower elevation. This approach will be applied to both reaches. Some minor channel realignment may be proposed to shift the channel away from the parallel sanitary sewer line. Proposed bank protection will include bioengineering techniques such as alternating roughness protection, branch layering, and other vegetative stabilization, but stone protection and other harder bank treatments may be necessary in a few isolated locations, especially in areas that are in close proximity to the parallel sanitary sewer line. Existing bed materials are likely salvageable, but larger cobble material will be necessary to provide better riffle habitat. Grade control structures will be used as necessary to stabilize the sanitary sewer crossings.

A comprehensive planting plan will be developed for the various landscape zones throughout the site that will allow for the establishment of native plant species.

Nearby Opportunities:

None recommended

Proposed Project Credit		Costs	
Length Restored (ft):	2,992	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	29.9	Estimated Construction Cost:	$1,346,400.00
Cost per Impervious Credit Acre:	$68,526.74	30% Contingency:	$403,920.00
		Estimated Total Cost:	$2,050,320.00

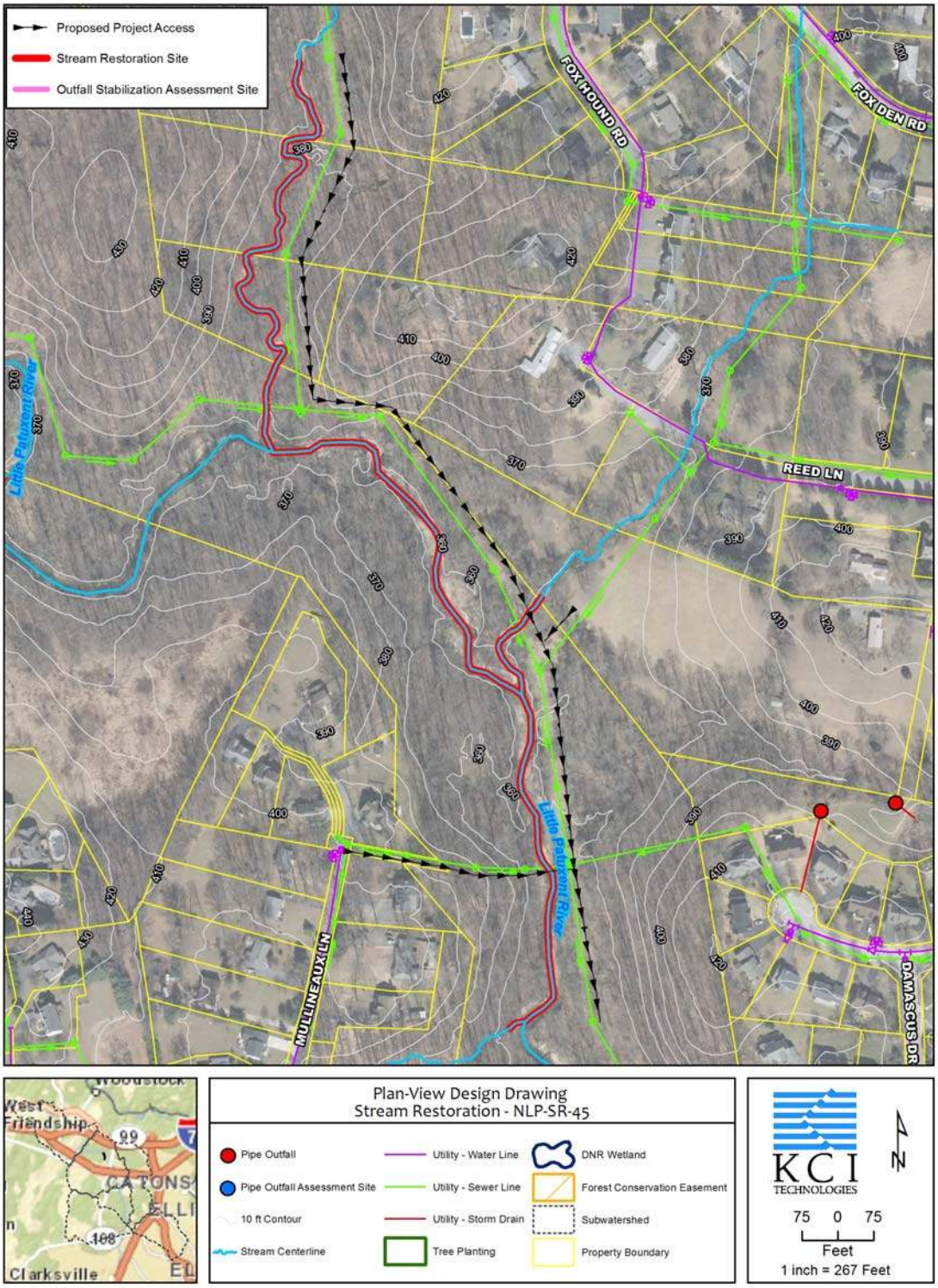
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-45

Site Name: Boones Lane Tributary and Little Patuxent River

Contractor: KCI

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Stream Restoration

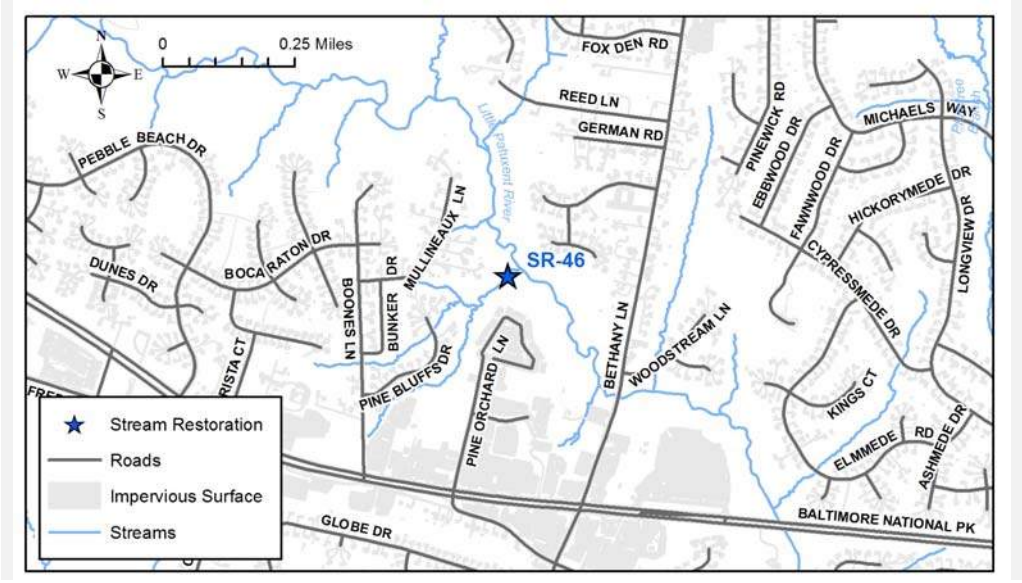
Site ID: SR-46
Site Name: Boones Lane, Tributaries and Little Patuxent River
Contractor: KCI
Watershed: Little Patuxent River

Ownership: County Owned
Multiple Owners

Existing Conditions:

The restoration site consists of three reaches. Reach 1 includes a network of three small, unnamed tributaries to the Little Patuxent River, where Reach 2 begins. Reach 2 is located on the Little Patuxent River and continues to the confluence with the unnamed tributary located between Corporate Ct and Bethany Ln. The lower portion of this unnamed tributary is Reach 3. Reach 1 contains three tributaries and reach has approximately 2,400 lf. of moderately eroded banks that are approximately 3 to 5 ft. high. Eroded segments tend to alternate from one bank to the other and overall the length of erosion is occurring equally on each bank. Banks are comprised of silt material that is easily erodible due to the vertical bank angle, moderate root depths, and moderate surface protection. The presence of bankfull indicators at 1 to 2 ft. above the bed suggests that the near bank stresses are very high. The riparian buffer width for Reach 1 is approximately 125 ft. on both banks until the furthermost upstream portions where the buffer decreases to 50 ft. on both banks and the quality of the riparian vegetation is good, at approximately 90% cover.

Reach 2, located on the Little Patuxent River, is a much larger channel with approximately 4.5 to 5 ft. high banks which are silty and vertical. Root depths and surface protection are moderate to high, providing greater protection than other areas. However, the channel is incised with moderate near bank stresses, as determined by bankfull indicators at 3 ft. above the bed. This reach has approximately 1,800 lf. of eroded banks. The riparian buffer width for Reach 2 is approximately 300 ft. on both banks and the quality of the riparian vegetation is good, at approximately 70 to 80% cover. This site may have good potential for biological uplift as it is not currently in a severely degraded state. Reach 3 is a small, unnamed tributary to the Little Patuxent that has approximately 225 lf. of erosion upstream of its confluence with the Little Patuxent. The erosion begins at the corner of a commercial parking lot on Bethany Lane. The banks are approximately 4 ft. high and easily erodible due to their silty composition and vertical angle. The channel is highly incised with high near bank stress. The riparian buffer width for Reach 3 is approximately 40 ft. on both banks and the quality of the riparian vegetation is good, at approximately 80% cover.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-46

Site Name: Boones Lane, Tributaries and Little Patuxent River

Contractor: KCI

Watershed: Little Patuxent River

Erosion on left bank, vertical bank with poor root depth. Poor epifaunal habitat availability.

Reach 1, erosion on right bank.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-46
Site Name: Boones Lane, Tributaries and Little Patuxent River
Contractor: KCI
Watershed: Little Patuxent River

Constraints/Utilities:

A majority of the restoration area is within Howard County Parks and Recreations property; however, surrounding property at the most upstream portions or Reach 1 and 3 is private. A sewer line runs parallel to the channel with two crossings through the stream. Wetlands and specimen trees were also noted on site. The sewer crossing, wetlands, and specimen trees will require special consideration to the design and construction access.

The easements running parallel to the channel could provide access; however, the location of the wetlands may determine construction access. Although the design would attempt to limit tree impacts, a significant impact to trees would likely result during construction, due to the existing wide riparian buffer.

Concept Description:

The proposed stream restoration includes a natural channel design throughout the site, where a new secondary floodplain can be graded at a lower elevation. The width of the proposed secondary floodplain will be determined by distance to private property, wetlands, and specimen trees. Proposed bank protection will include bioengineering techniques such as coir logs and vegetative stabilization, but stone protection and other harder bank treatments may be necessary in a few isolated locations. Riffle grade controls may be necessary at sewer crossings. Existing bed materials are likely salvageable, but larger cobble material will be necessary to provide better riffle habitat.

A comprehensive planting plan will be developed for the various landscape zones throughout the site that will allow for the establishment of native plant species.

Nearby Opportunities:

None recommended

Proposed Project Credit		Costs	
Length Restored (ft):	4,451	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	44.5	Estimated Construction Cost:	$2,003,400.00
Cost per Impervious Credit Acre:	$65,253.20	30% Contingency:	$601,020.00
		Estimated Total Cost:	$2,904,420.00

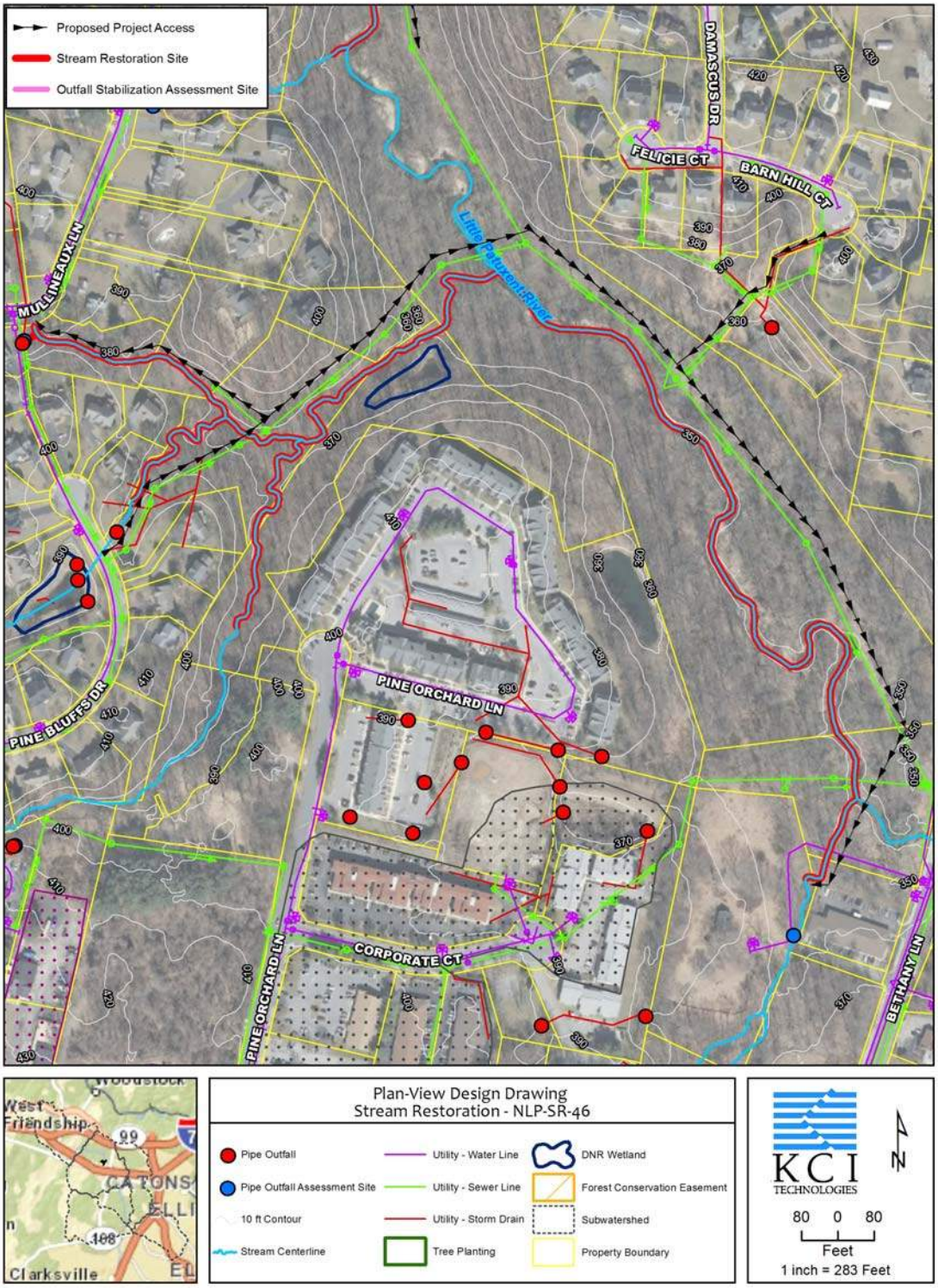
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-46

Site Name: Boones Lane, Tributaries and Little Patuxent River

Contractor: KCI

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-47
Site Name: Font Hill, Tributary to Little Patuxent River
Contractor: KCI
Watershed: Little Patuxent River

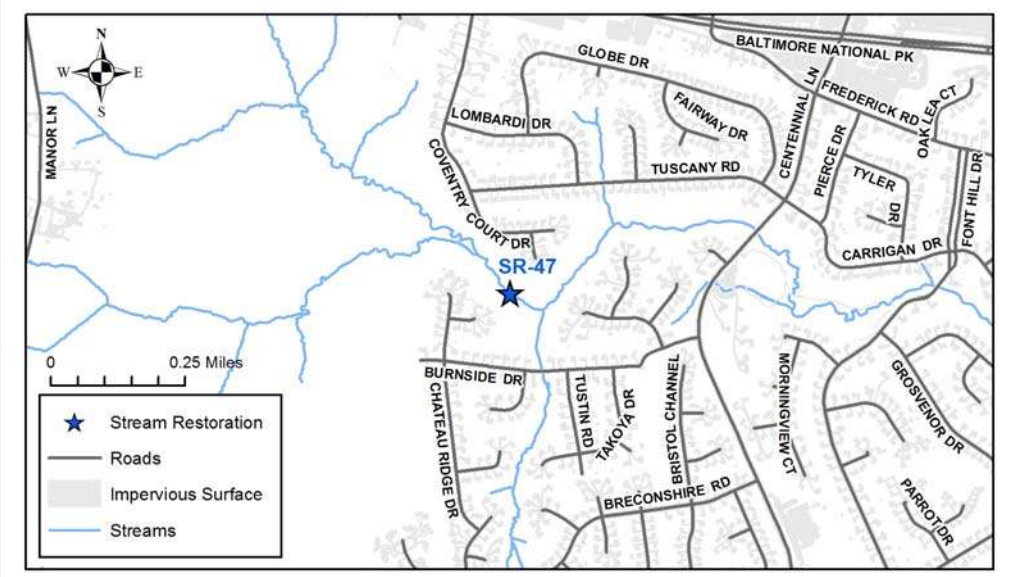
Ownership: County Owned
Single Owner

Existing Conditions:

The site contains three reaches on unnamed tributaries upstream of the confluence with the Little Patuxent River. The mainstem, termed the Font Hill Tributary to the Little Patuxent, contains approximately 1,530 lf. of channel. The first tributary enters the mainstem approximately 1,000 lf. downstream of the start of the mainstem restoration reach and includes approximately 870 lf. of channel. The second tributary enters the mainstem at the downstream most extent of the mainstem restoration reach and includes approximately 370 lf. of stream.

The mainstem reach has 3 to 4.5 ft. high banks with a silt material that is easily erodible due to the vertical banks, shallow to moderate root depths and very little surface protection. Near bank stresses were found to range from low to high with benches present throughout the site that appear to be bankfull indicators at 2 to 3 ft. in height above the bed. Banks are undercut with fallen and falling trees. The channel appears to be widening with higher bank heights progressing downstream. The channel is moderately embedded with fines. Riffle spacing is ideal, with the spacing characterized as being approximately five to seven channel widths. The riparian buffer width along the mainstem is substantial on both the right and left bank, with greater than 60 ft. of forest cover.

The upstream most tributary contains similar conditions as the mainstem, with bank heights ranging from 3 to 4.5 ft. The banks are vertical, exposed and undercut in many areas. The riparian buffer is wide in this area; however, the adjacent forest is sparse in the lower extents of the tributary. In this area, the bank erosion is more severe as the presence of roots needed to help stabilize the bank is limited. The downstream most tributary contains banks that are 2.5 to 3.5 ft. in height that are vertical and contain bank erosion. This tributary contains a wide riparian buffer, with greater than 60 ft. of forest cover. A sanitary sewer line runs parallel with the mainstem and its tributaries and contains a crossing on each reach. While no exposures were noted during the assessments, there are a few areas where the channel has eroded towards and is located within close proximity to the sanitary sewer line.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-47

Site Name: Font Hill, Tributary to Little Patuxent River

Contractor: KCI

Watershed: Little Patuxent River

Reach 2, erosion on right bank. Undercut tree and point bar formation.

Reach 1, facing downstream.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-47
Site Name: Font Hill, Tributary to Little Patuxent River
Contractor: KCI
Watershed: Little Patuxent River

Constraints/Utilities:

This reach is located within various Howard County open space properties, making property access easy from Coventry Court Drive and Burnside Drive. The sewer line runs parallel to the channel on the right bank with six stream crossings throughout the proposed restoration area, which may pose some minor constraint to the design. Although the design would attempt to limit tree impacts, a moderate impact to trees would likely result during construction due to the existing wide riparian buffer in most areas. However, access along the sewer easement when available will limit tree impacts in some locations. A full tree evaluation has not been conducted, but no specimen trees were noted during initial investigations.

Concept Description:

The proposed stream restoration includes a natural channel design throughout the site, where a secondary floodplain can be graded at a new, lower elevation, or a bench can be established at the current bankfull elevation. Minor channel realignment may be proposed in a few areas to shift the channel away from the sanitary sewer line where the channel is currently in close proximity. Bank protection is expected to be composed primarily of bioengineering techniques such as coir logs, alternating roughness protection, and vegetative stabilization; however, stone protection and other harder bank treatments may be necessary in a few isolated locations, mainly to stabilize the parallel sanitary sewer line. Existing bed materials are likely salvageable, but larger cobble material will be necessary to provide better riffle habitat. In addition, grade control structures may be necessary to stabilize the channel bed at the sanitary sewer crossings, depending on the depth of the structures.

A comprehensive planting plan will be developed for the various landscape zones throughout the site that will allow for the establishment of native plant species.

Nearby Opportunities:

None recommended

Proposed Project Credit		Costs	
Length Restored (ft):	3,054	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	30.5	Estimated Construction Cost:	$1,374,750.00
Cost per Impervious Credit Acre:	$68,342.34	30% Contingency:	$412,425.00
		Estimated Total Cost:	$2,087,175.00

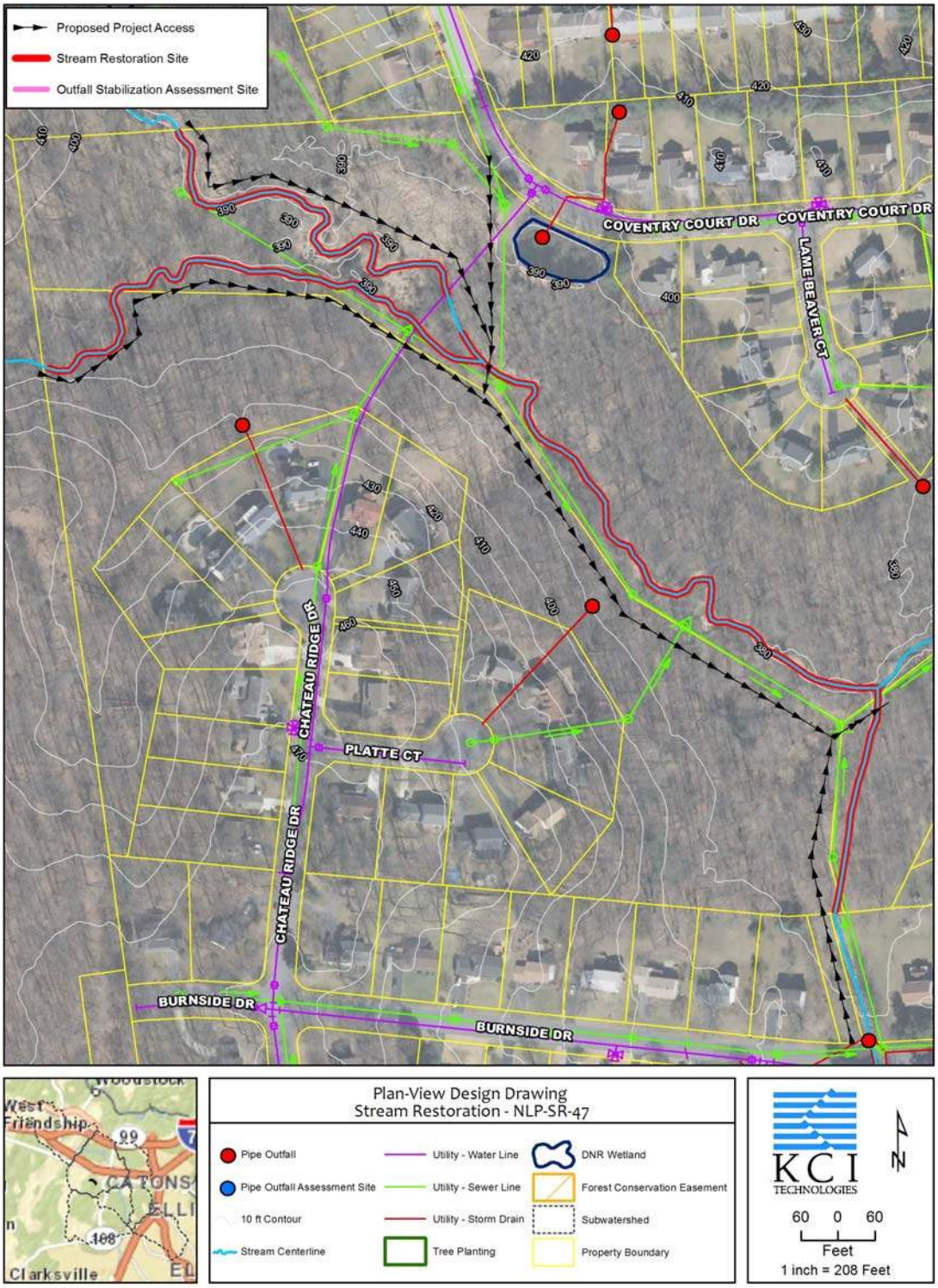
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-47

Site Name: Font Hill, Tributary to Little Patuxent River

Contractor: KCI

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-48

Site Name: Font Hill, Tributary to Little Patuxent River, Upstream Centennial Lake

Contractor: KCI

Watershed: Little Patuxent River

Ownership: County Owned
Single Owner

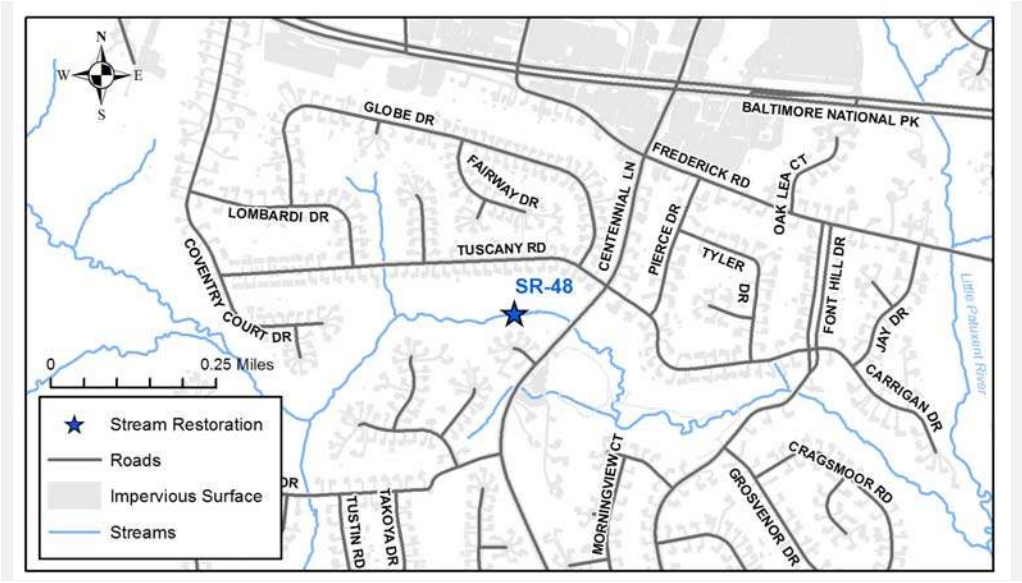
Existing Conditions:

Restoration potential at this site is segmented into three reaches. Two reaches are located along the Mainstem, with 200 lf. separating the two. A third reach is located on an outfall channel to this Mainstem. The third reach is a much smaller channel and contains approximately 160 lf. of eroded channel. The Mainstem is an unnamed tributary to the Little Patuxent River, termed the Font Hill Tributary to the Little Patuxent, located upstream of Centennial Lane and Font Hill Park. The banks are 4.5 ft. high, with bankfull indicators at 2.5 ft. above the bed. These banks are composed of silt and appear easily erodible due to vertical bank angles, shallow root depths, and very little surface protection. The channel is incised, as determined by the near-bank height to mean bankfull depth, indicating that near bank stresses are high. Banks are severely undercut with fallen and falling trees as the channel is in the process of widening.

Bed materials are composed of mostly sand, gravel and cobble, with some silt. The habitat assessment indicates that this channel may be partially supporting of aquatic habitat: epifaunal substrate habitat and coverage is optimal quality, a variety of flow regimes were apparent, and riffle spacing was in good condition.

The riparian buffer is very wide on the left bank, with greater than 60 ft. of forest cover; however, the maintained sewer easement along the right bank interrupts the forested buffer.

The outfall channel has approximately 170 lf. of eroded banks. The channel originates from Tuscany Rd with no apparent stormwater management currently in place, and has eroded banks of 2 ft. Minor erosion was observed during the field visit.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-48

Site Name: Font Hill, Tributary to Little Patuxent River, Upstream Centennial Lake

Contractor: KCI

Watershed: Little Patuxent River

Reach 2 facing downstream, vertical banks with moderate root depth.

Reach 1 facing downstream, vertical banks and minor bar formation.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-48
Site Name: Font Hill, Tributary to Little Patuxent River, Upstream Centennial Lake
Contractor: KCI
Watershed: Little Patuxent River

Constraints/Utilities:

The reach is within several Howard County Parks and Recreations properties, making property access feasible. Construction access may be possible along Centennial Lane or through sewer easements from Tuscany Rd, Char Lil Ct, and Shirley Meadow Ct. A sanitary sewer line runs parallel to the channel on the right bank with a stream crossing at the upstream and downstream ends of the site. Wetlands were also noted within the site and would need special considerations during design and permitting. Although the design would attempt to limit tree impacts, a significant impact to trees would likely result during construction due to the existing wide riparian buffer in most areas. However, access along the sewer easement when available may limit tree impacts.

Concept Description:

The proposed stream restoration includes a natural channel design throughout the site, where a new floodplain can be graded at a secondary, lower elevation. Bank protection is expected to be composed primarily of bioengineering techniques such as coir logs and vegetative stabilization, but stone protection and other harder bank treatments may be necessary in a few isolated locations. Existing bed materials are likely salvageable, but larger cobble material will be necessary to provide better riffle habitat.

A comprehensive planting plan will be developed for the various landscape zones throughout the site that will allow for the establishment of native plant species.

Nearby Opportunities:

None recommended

Proposed Project Credit		Costs	
Length Restored (ft):	1,515	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	15.2	Estimated Construction Cost:	$682,200.00
Cost per Impervious Credit Acre:	$78,340.59	30% Contingency:	$204,660.00
		Estimated Total Cost:	$1,186,860.00

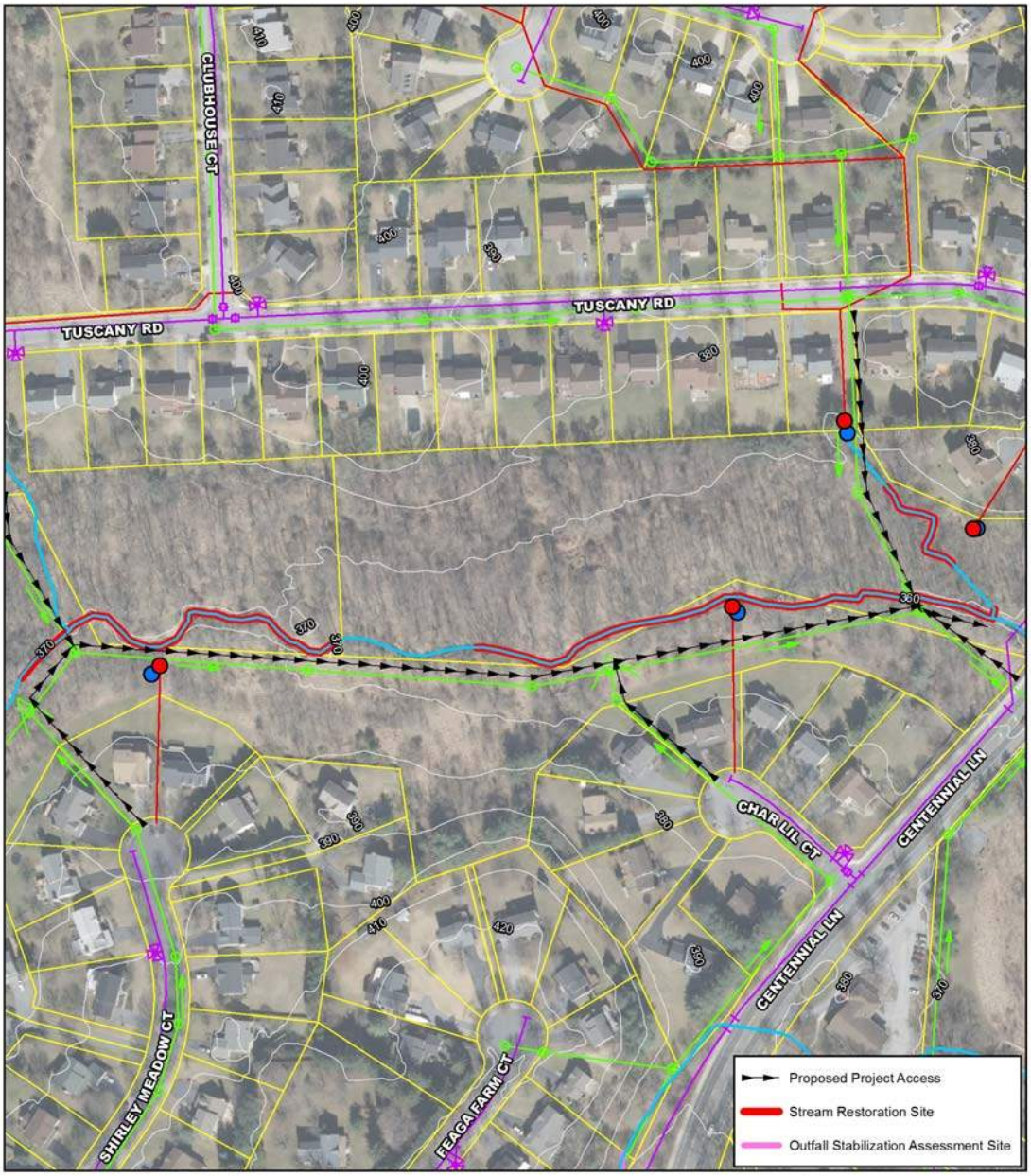
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-48

Site Name: Font Hill, Tributary to Little Patuxent River, Upstream Centennial Lake

Contractor: KCI

Watershed: Little Patuxent River



Plan-View Design Drawing
Stream Restoration - NLP-SR-48

- Pipe Outfall
- Pipe Outfall Assessment Site
- 10 ft Contour
- Stream Centerline
- Utility - Water Line
- Utility - Sewer Line
- Utility - Storm Drain
- Tree Planting
- DNR Wetland
- Forest Conservation Easement
- Subwatershed
- Property Boundary

KCI TECHNOLOGIES

N

50 0 50

Feet

1 inch = 200 Feet

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-49
Site Name: Dunloggin Middle School
Contractor: KCI
Watershed: Little Patuxent River

Ownership: County Park
Multiple Owners

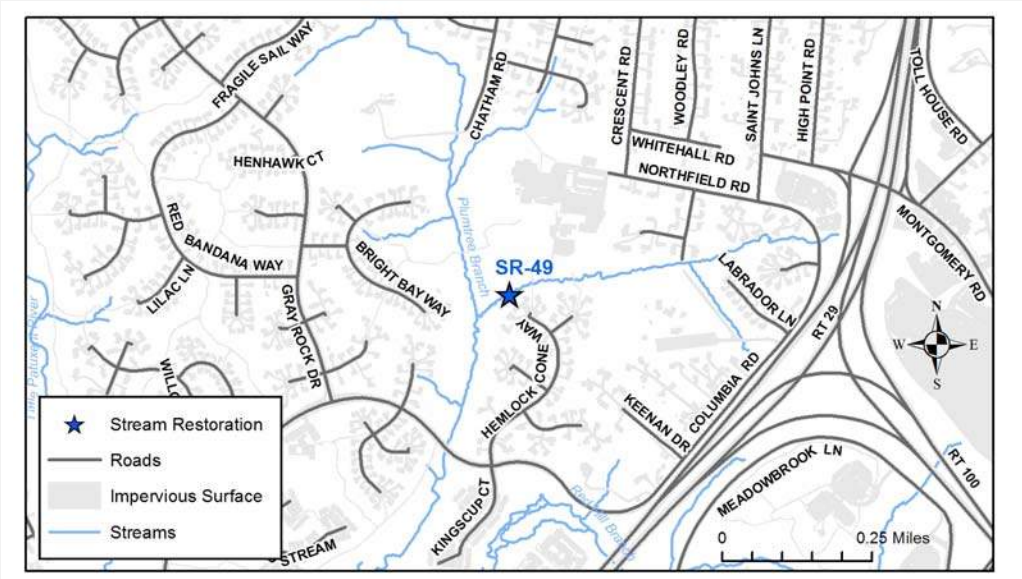
Existing Conditions:

The site is on an unnamed tributary near the confluence with Plumtree Branch. The reach has 2.5 to 4 ft. high banks with silty to clay material that is easily erodible due to the vertical banks, shallow root depths and very little surface protection. Near bank stresses were found to be moderate due to benches present throughout the site that appear to be bankfull indicators at 2 ft. in height above the bed. Banks are undercut with fallen and falling trees.

The channel is incising and widening, with higher banks towards the upstream extent of the site. A footbridge crosses the channel for access from Hemlock Cone Way to Dunloggin Middle School. The channel widening has caused the riprap beneath the footbridge to become destabilized.

The channel is extremely embedded with fines. Bed material is composed of mostly gravel, sand, and silt, and some deposition was observed in the channel. The presence of available and good quality epifaunal substrate habitat and coverage is moderate. Two velocity/depth regimes are apparent and baseflow occupies approximately 75% of the channel width at the bottom of the banks. Riffle spacing is in good condition, with the spacing characterized as being approximately seven channel widths.

The riparian buffer width is good on the right bank, with greater than 60 ft. of forest cover; however, a sewer easement along the left bank interrupts the potential for a forest buffer, and private property extends toward this easement.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-49
Site Name: Dunloggin Middle School
Contractor: KCI
Watershed: Little Patuxent River

Eroding and undercut banks with falling trees.

Failing riprap under footbridge.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-49
Site Name: Dunloggin Middle School
Contractor: KCI
Watershed: Little Patuxent River

Constraints/Utilities:

This reach is within various Howard County Park and Board of Education properties, making property access feasible. Construction access may be possible through the Dunloggin Middle School parking lot. A sewer line runs parallel to the channel on the left bank with a stream crossing at the downstream end of the site, which poses some minor constraint to the design. Wetlands were also noted within the site and would need special considerations during design and permitting. Although the design would attempt to limit tree impacts, a moderate to high impact to trees would likely result during construction due to the existing wide riparian buffer. However, access along the sewer easement will limit tree impacts. A full tree evaluation has not been conducted, but no specimen trees were noted during initial investigations.

Concept Description:

The proposed stream restoration includes a natural channel design throughout the site, where a new floodplain can be graded at a secondary, lower elevation. Proposed bank protection will include bioengineering techniques such as coir logs and vegetative stabilization, but stone protection and other harder bank treatments may be necessary in a few isolated locations. Existing bed materials are likely salvageable, but larger cobble material will be necessary to provide better riffle habitat.

A comprehensive planting plan will be developed for the various landscape zones throughout the site that will allow for the establishment of native plant species.

This site has potential for educational outreach, as it is adjacent to Northfield Elementary and Dunloggin Middle Schools.

Nearby Opportunities:

None recommended

Proposed Project Credit		Costs	
Length Restored (ft):	1,261	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	12.6	Estimated Construction Cost:	$567,900.00
Cost per Impervious Credit Acre:	$82,337.03	30% Contingency:	$170,370.00
		Estimated Total Cost:	$1,038,270.00

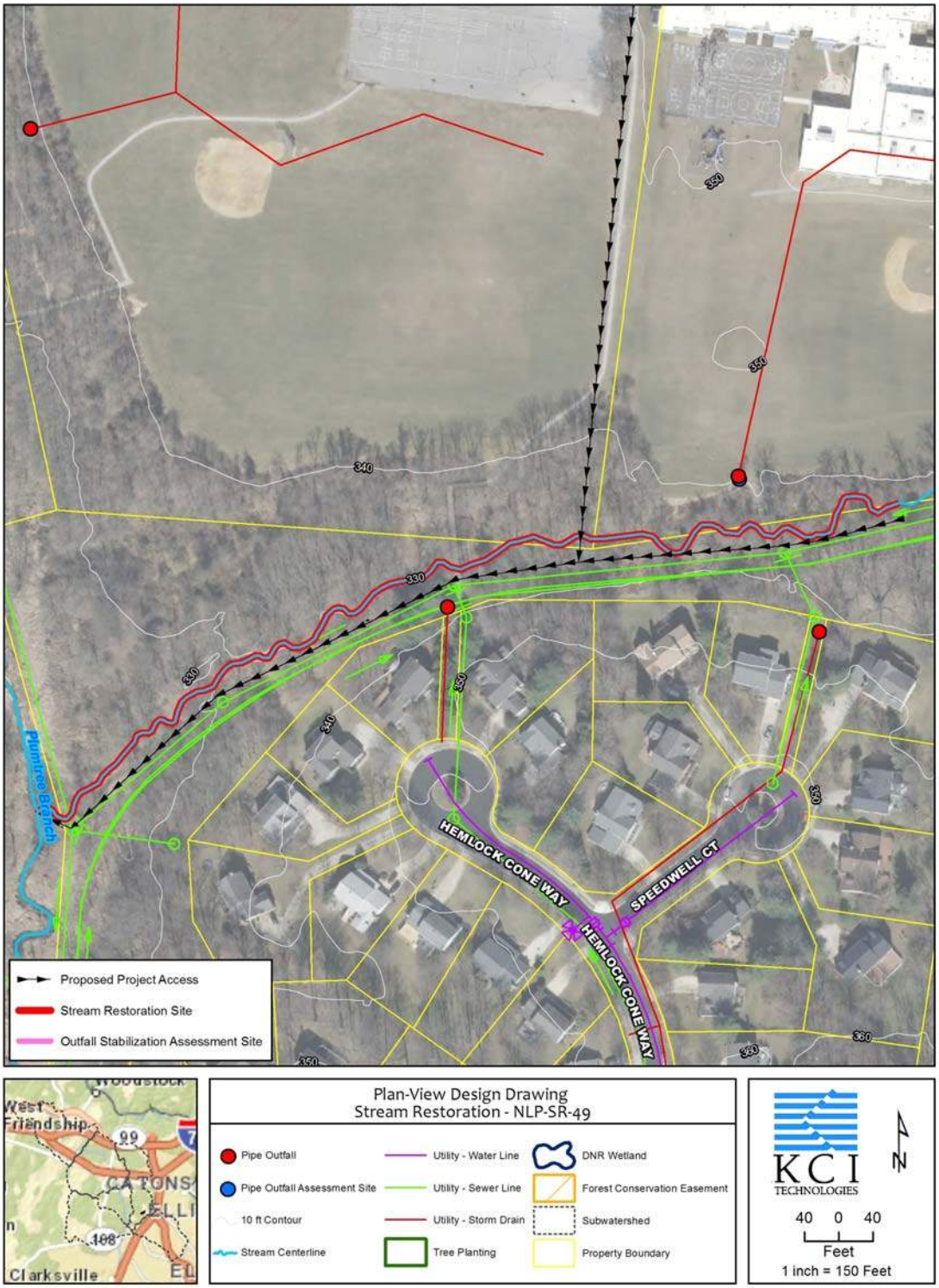
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-49

Site Name: Dunloggin Middle School

Contractor: KCI

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Stream Restoration

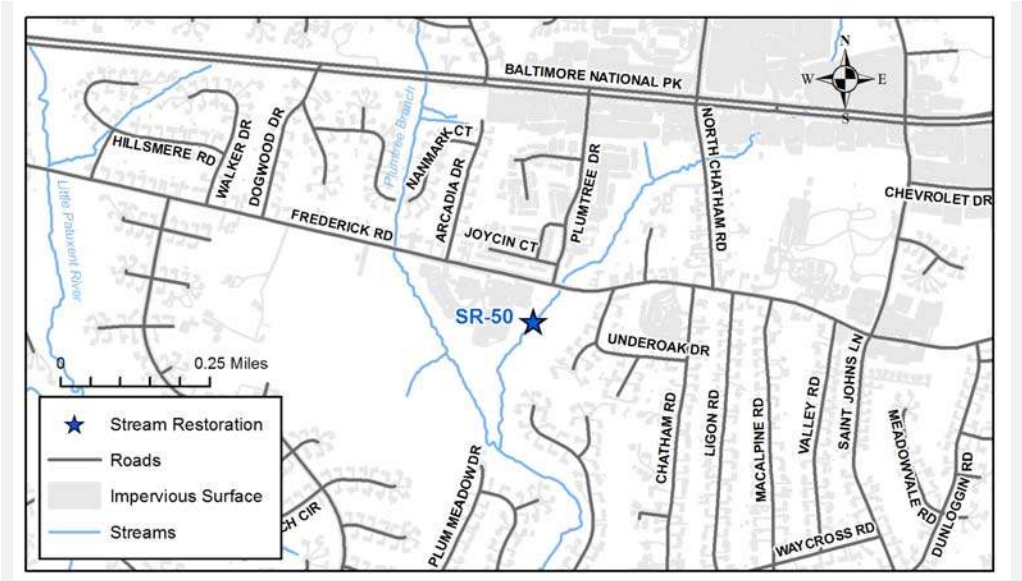
Site ID: SR-50
Site Name: Lutheran Village South, tributary to Plumtree Branch
Contractor: KCI
Watershed: Little Patuxent River

Ownership: County Owned
Multiple Owners

Existing Conditions:

The project site is bounded to the north by Frederick Road and ends at the confluence with Plumtree Branch. Reach 1 is comprised of the first 1050 lf. of channel from the upstream end at Frederick Road, which includes approximately 190 lf. of channel within the Howard County Public Works property, and continues through approximately 860 lf. of channel through abandoned agricultural land currently owned by the Miller Land Company. Banks are generally 4 to 5 ft. in height and approximately 15 ft. wide at the top of bank. Reach 1 is characterized by vertical and raw clay-silt banks and highly mobile sand-cobble substrate with good riparian buffer along the left bank and a maintained sewer easement along the right bank. The sewer line crosses the channel in several locations, through which the banks are protected by concreted gabion stones. Erosion around this protection has occurred, as these segments are narrowed and appear to be constricting flow. Eroding banks include undercut trees, compressed meanders, and debris jams. A wetland begins along the left bank at the lower half of this reach and continues through the first half of Reach 2.

Reach 2 is approximately 650 lf. and is located within Howard County property. Banks are lower and wider in this reach (generally 3 ft. high and 20 ft. in width across the top of bank). Substrate continues to be highly mobile through this reach. This reach contains more sand deposition and bar formation than Reach 1, with bar heights generally being 1 ft. high. Fresh sand deposits were also noted on top of the banks, as this reach has better floodplain access. Nonetheless, bankfull appears to be located at a height closer to 1.5 to 2-ft. in height, making this channel slightly incised. The bottom of this restoration reach end at the confluence with Plumtree Branch; however, the eroding banks continue on the Mainstem of Plumtree Branch.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-50

Site Name: Lutheran Village South, tributary to Plumtree Branch

Contractor: KCI

Watershed: Little Patuxent River

Eroded banks, good riffle material.

Close proximity to sewer line.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-50
Site Name: Lutheran Village South, tributary to Plumtree Branch
Contractor: KCI
Watershed: Little Patuxent River

Constraints/Utilities:

The maintained sewer easement provides good access through this site, while access can also be gained to the site from Frederick Road and/or one of the parking lots adjacent to the Senior Center. The channel runs through three properties, two of which are owned by Howard County, and the third may have potential to be acquired, as it is landlocked and undeveloped. The existence of wetlands and specimen trees will require special considerations to the design, but given the width of the buffer, and the fact that this is not a mature forest, alternative alignments may be feasible in order to pull the channel away from the sewer line, and minimize wetland disturbance.

Concept Description:

The proposed stream restoration includes a natural channel design throughout this site, where a new, secondary floodplain can be graded at a lower elevation. The width of the proposed secondary floodplain will be determined by distance to wetlands, and specimen trees. Bank protection is expected to be composed primarily of bioengineering techniques such as coir logs and vegetative stabilization, but stone protection and other harder bank treatments may be necessary in a few isolated locations, particularly in close proximity to the sewer line. Existing bed materials are likely salvageable, but larger cobble material will be necessary to provide better riffle habitat. Riffle Grade Controls are also proposed at the sewer crossings to provide vertical control of the channel bed to protect the sanitary sewer. A comprehensive planting plan will be developed for the various landscape zones throughout the site that will allow for the establishment of native plant species. This project site may also provide opportunity for community education given its proximity to the library and senior center.

Nearby Opportunities:

NLP-SR-F599

Proposed Project Credit		Costs	
Length Restored (ft):	1,678	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	16.8	Estimated Construction Cost:	$755,550.00
Cost per Impervious Credit Acre:	$76,413.29	30% Contingency:	$226,665.00
		Estimated Total Cost:	$1,282,215.00

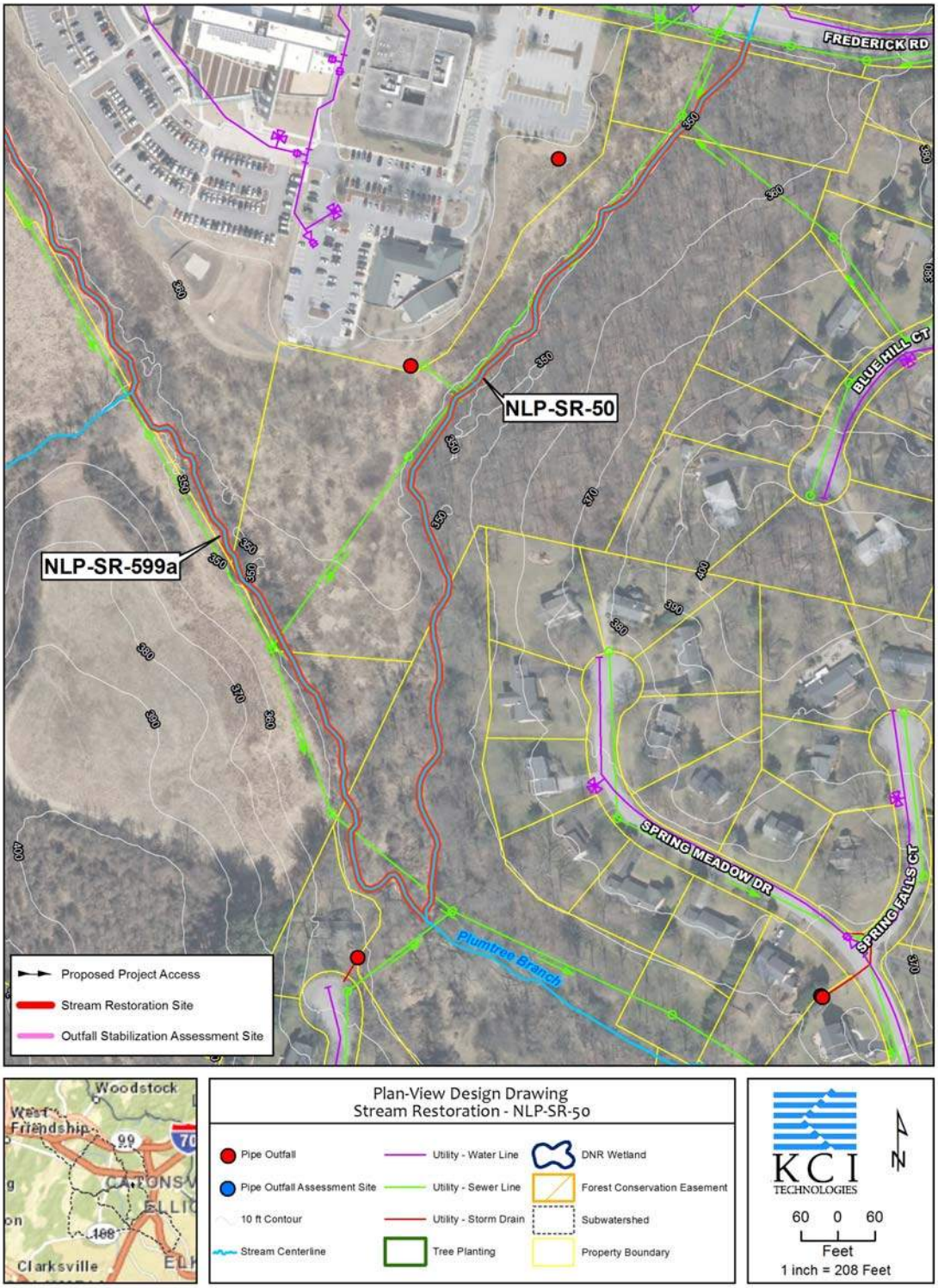
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-50

Site Name: Lutheran Village South, tributary to Plumtree Branch

Contractor: KCI

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-51
Site Name: North Chatham Road
Contractor: KCI
Watershed: Little Patuxent River

Ownership: Private- Mixed Use
Multiple Owners

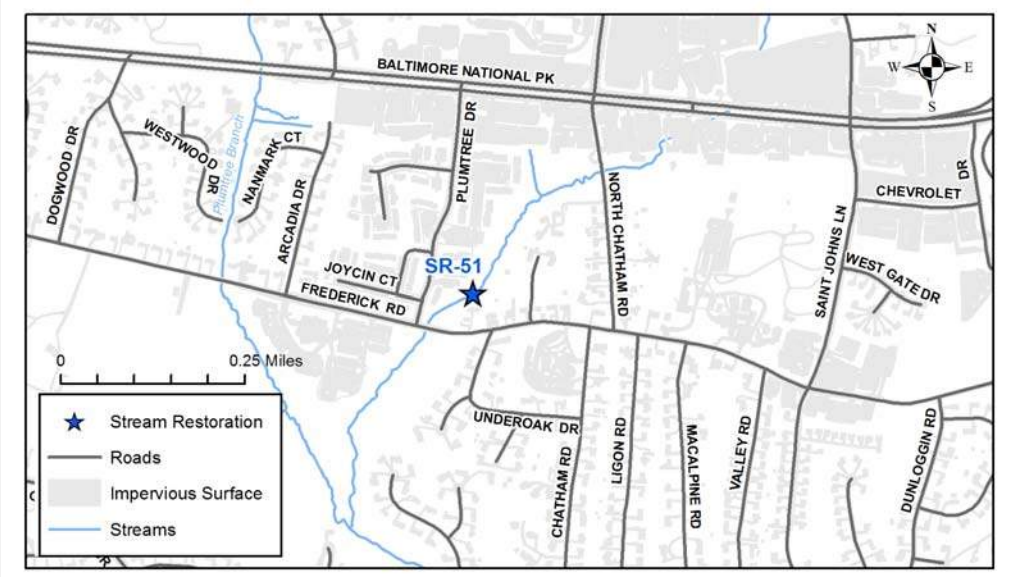
Existing Conditions:

The site is composed of three reaches on a tributary to Plumtree Branch between Route 40 and Frederick Road. Reach 1 is comprised of the first 470 lf. of channel from the outfall of the pipe under Route 40 to North Chatham Road. Banks are generally 3 to 4 ft. in height and less than 15 ft. wide at the top of bank. The reach is characterized by vertical and raw silty banks with good riparian buffer along the left bank and a sewer easement along the right bank. Erosion is segmented into two areas within the reach, each approximately 150 lf. in length, with a short section of banks (approx. 80 lf.) in good condition between the eroded segments and another prior to the road crossing at North Chatham Road. A wetland begins along the left bank at the lower half of the reach and continues through the first half of Reach 2.

Reach 2 is approximately 550 lf. and runs from the crossing at North Chatham Rd to the confluence with the outfall channel on the right bank. Banks are generally highest (4 to 5 ft.) and most undercut in this reach, despite having the widest and most heavily treed riparian buffer. The bed substrate contains mostly sand with gravels and cobbles in the riffles.

The outfall channel is approximately 350 lf. The channel is located on the right bank of the Mainstem tributary and is extremely incised with up to 6 ft. high banks. Trees are heavily undercut, and banks are vertical with very shallow root depths and little to no surface protection.

Reach 3 is approximately 1,310 lf. The reach begins at the confluence with the outfall channel and ends at Frederick Road. Banks are generally 3.5 ft. in height and 15 to 20 ft. in width at the top of bank. The reach is backed by the Plum Tree Apartments on the right bank, with a sewer easement in close proximity to the channel. The area is mowed and maintained with a narrow forest buffer adjacent to the channel on the right bank. The left bank has a well vegetated forest buffer.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-51
Site Name: North Chatham Road
Contractor: KCI
Watershed: Little Patuxent River

Tributary is very incised with vertical silty banks with shallow root depth and no surface protection.

Mainstem has steep silty banks with moderate root depth and very little surface protection. Sand deposition as lateral and central bars 0.5 to 1 ft. in height.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-51
Site Name: North Chatham Road
Contractor: KCI
Watershed: Little Patuxent River

Constraints/Utilities:

The sewer easement provides good access through this site, particularly in Reach 3, where it is partially mowed. Potential access can be acquired through the Plum Tree Apartments parking lot and from the U-turn area on North Chatham Road. The channel runs through multiple commercial and residential properties, including two HOA properties, through which access will need to be coordinated. The existence of wetlands will require special considerations to the design and permitting. Tree removals will also be required, particularly for the upper reaches (Reaches 1, 2, and the outfall channel), but many of those are in poor health.

Concept Description:

The proposed stream restoration includes a natural channel design throughout the site, where the floodplain is widened at the existing bed elevation. Proposed bank protection will include bioengineering techniques such as coir logs and vegetative stabilization, but stone protection and other harder bank treatments may be necessary in a few isolated locations, particularly in close proximity to the sewer line. Existing bed materials are likely salvageable, but larger cobble material will be necessary to provide better riffle habitat.

Riffle Grade Controls are also proposed at the sewer crossings in Reach 2 to provide vertical control of the channel bed to protect the sanitary sewer. A comprehensive planting plan will be developed for the various landscape zones throughout the site that will allow for the establishment of native plant species.

This project site may also provide passive opportunity for community education given the higher density residential property that would be impacted. However, since this community is comprised of few landowners, community involvement may be limited to casual observation of the project without targeted community outreach efforts.

Nearby Opportunities:

None recommended

Proposed Project Credit		Costs	
Length Restored (ft):	2,680	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	26.8	Estimated Construction Cost:	$1,206,000.00
Cost per Impervious Credit Acre:	$69,694.03	30% Contingency:	$361,800.00
		Estimated Total Cost:	$1,867,800.00

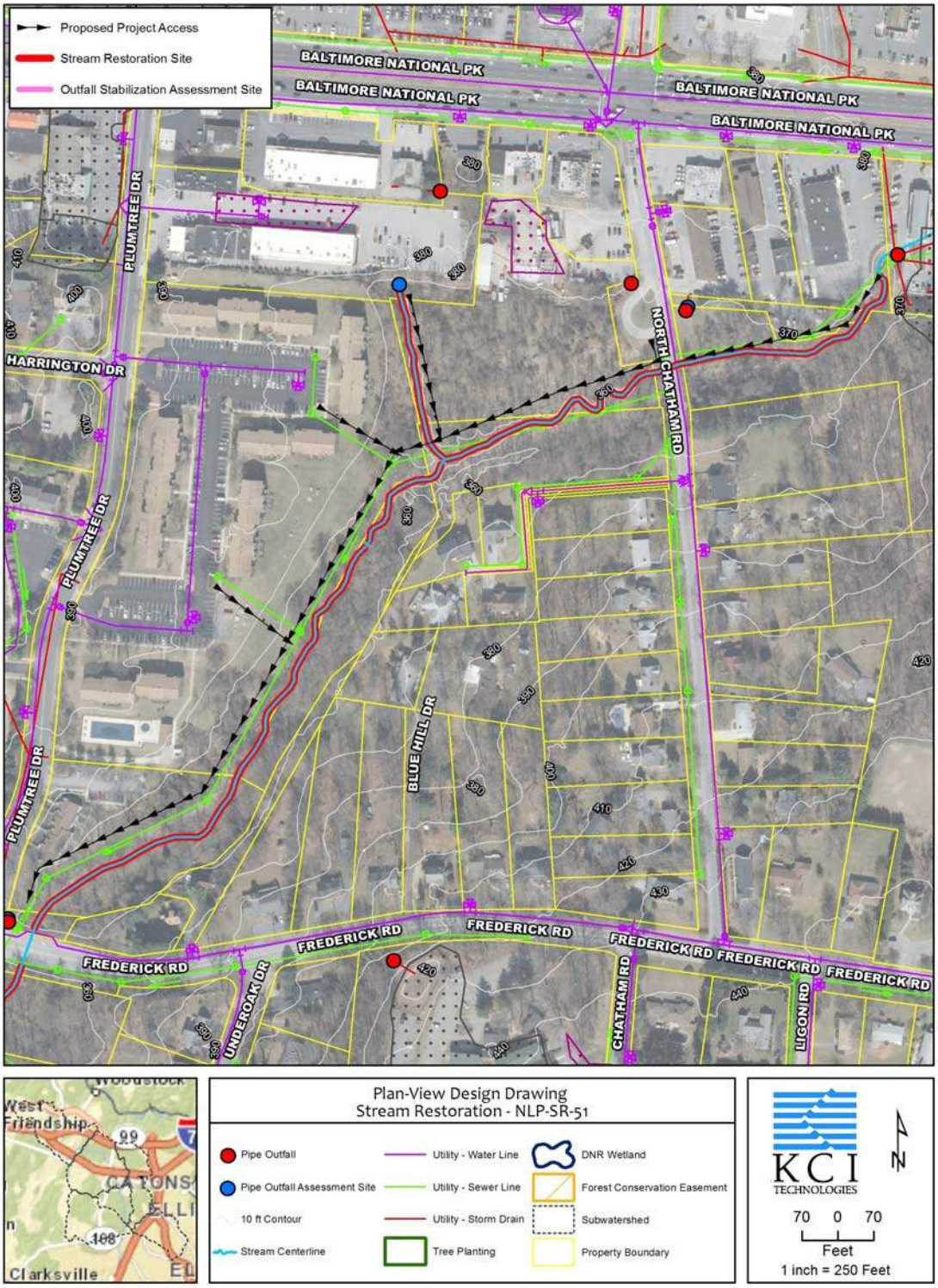
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-51

Site Name: North Chatham Road

Contractor: KCI

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-52
Site Name: Gray Sea Way
Contractor: McCormick Taylor
Watershed: Little Patuxent River

Ownership: Private- Mixed Use
Multiple Owners

Existing Conditions:

SR-52 consists of two stream assessment reaches (DOR-SR-F908A and DOR-SR-F912A) associated with an unnamed tributary of Dorsey Run. Land use surrounding the project site is primarily commercial and residential land with adjacent riparian forest. The stream is located within one commercial property and one parcel owned by the Columbia Association. The stream restoration site begins at three outfalls of a stormwater pond facility that is associated with commercial properties off of Dobbin Road. The upstream extent of the project (DOR-SR-F908A) begins as an ephemeral channel that changes to a perennial stream near the confluence area at the upstream end of the project site. The stream channels are experiencing channel degradation by downcutting of the channel bed and by bank erosion throughout the entire project site. A majority of the stream banks are nearly vertical, lack surface protection or vegetation, and have heights ranging between 2 to 5 ft. There are two significant headcuts located at the upstream end of the tributaries that appear to be actively migrating upstream and associated with flow draining from the pond facility outfalls. There is another headcut associated with drainage from the pipe outfall of the dry pond facility located on the south side of the channel just west of Snowden River Parkway. Another 2.5 ft. headcut located on the downstream reach just east of Snowden River Parkway is causing additional channel instability. There are two storm drain outlets located at the toe of slope on the east side of Snowden River Parkway on each side of the channel that are creating some minor erosion.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-52
Site Name: Gray Sea Way
Contractor: McCormick Taylor
Watershed: Little Patuxent River

SR-52 facing upstream at erosion along the ephemeral reach.

SR-52 facing upstream at bank erosion adjacent to the community trail.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-52
Site Name: Gray Sea Way
Contractor: McCormick Taylor
Watershed: Little Patuxent River

Constraints/Utilities:

Constraints with the project include existing sanitary sewer utilities, potential impacts to trees and forested areas and disruption of pedestrian traffic along the community trail.

Concept Description:

The proposed stream restoration project includes approximately 1,547 lf. of stream restoration to an unnamed tributary of Dorsey Run. The stream restoration primarily includes bank stabilization measures and opportunities to improve floodplain connection throughout the entire extent of the project site. Channel stabilization and BMP opportunities could also include treatments to five existing headcut identified along the project. Two of the headcuts are located on the mainstem of the channel. The other three headcuts are associated with drainage coming from pipe outfalls that will continue to erode and increase sediment loads to the stream system. Proposed access to the site includes maintained sewer line utility easements and the community trail located between Gray Sea Way and April Brook Circle. The project has potential to provide education value due to an existing community trail along the downstream extent of the site. The project would include additional stream assessment and design phases to determine specific channel treatments and construction sequence.

Nearby Opportunities:

DOR-SR-F912a-PO102; DOR-SR-F912a-PO101

Proposed Project Credit		Costs	
Length Restored (ft):	1,547	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	15.5	Estimated Construction Cost:	$696,150.00
Cost per Impervious Credit Acre:	$77,892.37	30% Contingency:	$208,845.00
		Estimated Total Cost:	$1,204,995.00

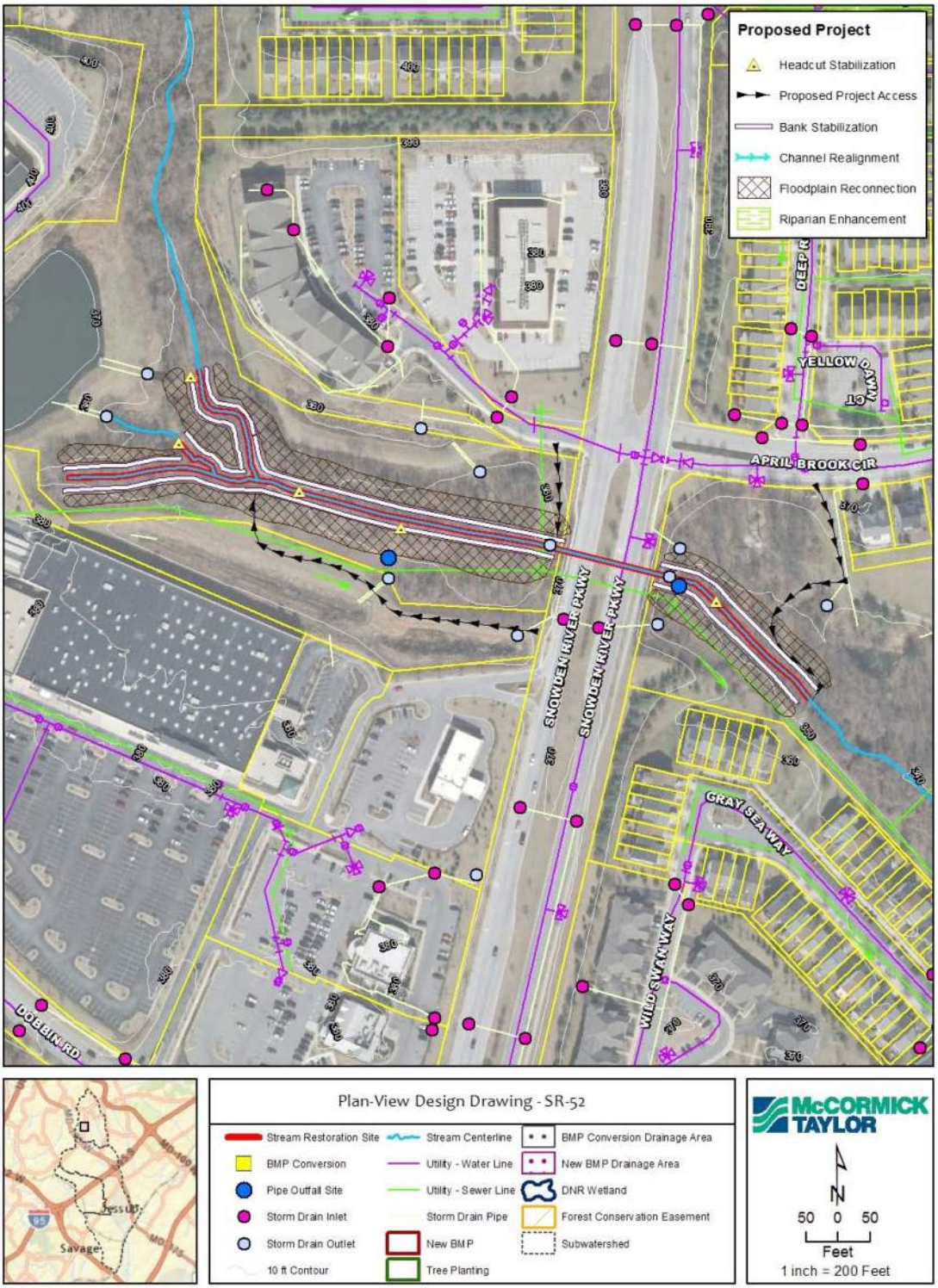
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-52

Site Name: Gray Sea Way

Contractor: McCormick Taylor

Watershed: Little Patuxent River



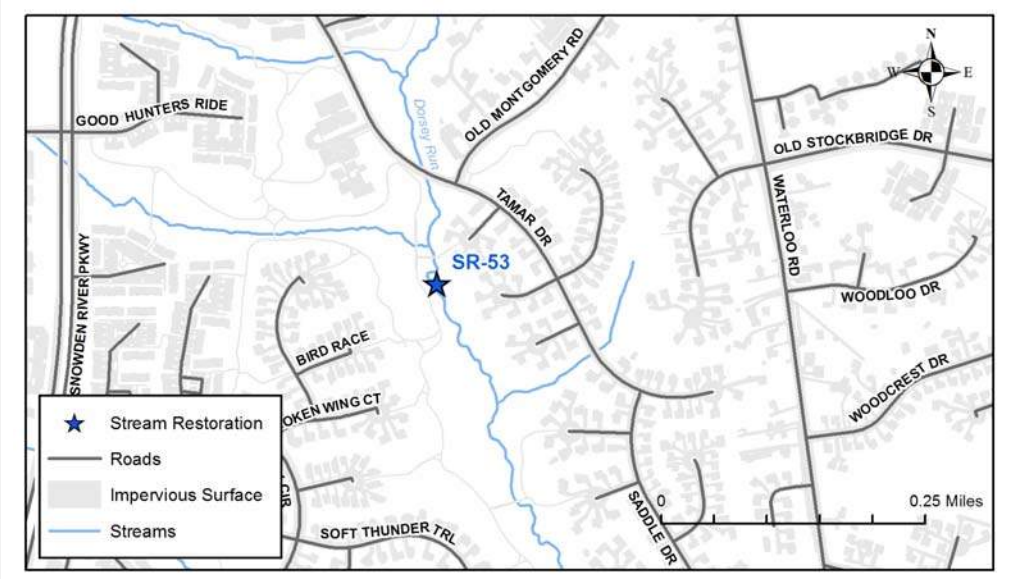
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-53
Site Name: Broken Wing Court
Contractor: McCormick Taylor
Watershed: Little Patuxent River

Ownership: Private- Mixed Use
Multiple Owners

Existing Conditions:

SR-53 consists of four stream assessment reaches (DOR-SR-F910A, DOR-SR-F910B, DOR-SR-F911A, DOR-SR-F911B) associated with Dorsey Run. Land use surrounding the project site is primarily forested and residential land that is mainly owned by the Columbia Association. The stream restoration site begins 460 lf. north of the culvert at Tamar Drive, northwest of the intersection of Tamar Drive and Old Montgomery Road, and extends downstream (south) approximately 1,903 lf. In general, the stream has a predominantly sand/silt channel substrate with bank heights ranging from 2-7 ft. The upstream reaches of the project (DOR-SR-F911A, DOR-SR-F911B) have some areas of channel degradation caused by downcutting of the channel bed and bank erosion. Two significant knickpoints are located at the upstream end of the project and associated with debris jams. The channel is predominately composed of silt/sand/gravel material with bank heights ranging between 2.5 to 7 ft. that are nearly vertical, lack surface protection or vegetation. The channel does have floodplain access along the upstream reaches. As the project site continues downstream of the crossing with Tamar Drive (DOR-SR-F910A and DOR-SR-F910B), the stream banks are eroding and causing widening of the channel. A majority of the eroded banks are nearly vertical with heights between 5 to 6 ft., lack surface protection or vegetation, and are comprised of a large percentage of silt and clay. An extensive wetland system is located on the right bank floodplain. One of the wetland outlets in this area has started to degrade and could be stabilized with the project to maintain the hydrology of the wetlands.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-53
Site Name: Broken Wing Court
Contractor: McCormick Taylor
Watershed: Little Patuxent River

SR-53 facing upstream at moderate bank erosion.

SR-53 facing upstream at a 4 ft. tall headcut.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-53
Site Name: Broken Wing Court
Contractor: McCormick Taylor
Watershed: Little Patuxent River

Constraints/Utilities:

Constraints with the project include access, existing sanitary sewer utilities, potential impacts to trees and forested areas and disruption of pedestrian traffic along the community trail.

Concept Description:

The proposed stream restoration project consists of four reaches associated with approximately 1,903 lf. of Dorsey Run. The project primarily includes bank stabilization, one area for potential floodplain reconnection, one channel realignment, and grade control structures to address existing headcuts and stabilize the channel bed. Headcut stabilization is proposed in the reaches upstream of Tamar Drive. Some areas of the upstream reaches could include some bank stabilization. However, this segment of the project may benefit by just including supplemental tree plantings on the right floodplain and installation of woody vegetation or live stakes along portions of the stream banks. Bank stabilization is primarily proposed along reaches downstream of Tamar Drive. Channel realignment is proposed along the tight meander bend just downstream of the existing pipe outfall site. The realignment will focus on correcting tight planform geometry and providing some floodplain relief. The stream restoration project could include closer investigation of smaller drainage channels with stabilization measures or BMP's. Stabilization on one of the wetland drainage outlets located on the right floodplain is proposed and could be included with the bank stabilization treatments. Proposed access to the site includes several access points along existing community trails and sanitary sewer right of ways. The project would likely include some impacts to existing trees and forested areas in order to access the channel. The project has potential to provide education value due to an existing community trail along the downstream reaches of the site. The project would include additional stream assessment and design phases to determine specific channel treatments and construction sequence.

Nearby Opportunities:

SR-54; SR-55; DOR-BC-F915

Proposed Project Credit		Costs	
Length Restored (ft):	1,903	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	19.0	Estimated Construction Cost:	$856,350.00
Cost per Impervious Credit Acre:	$74,264.58	30% Contingency:	$256,905.00
		Estimated Total Cost:	$1,413,255.00

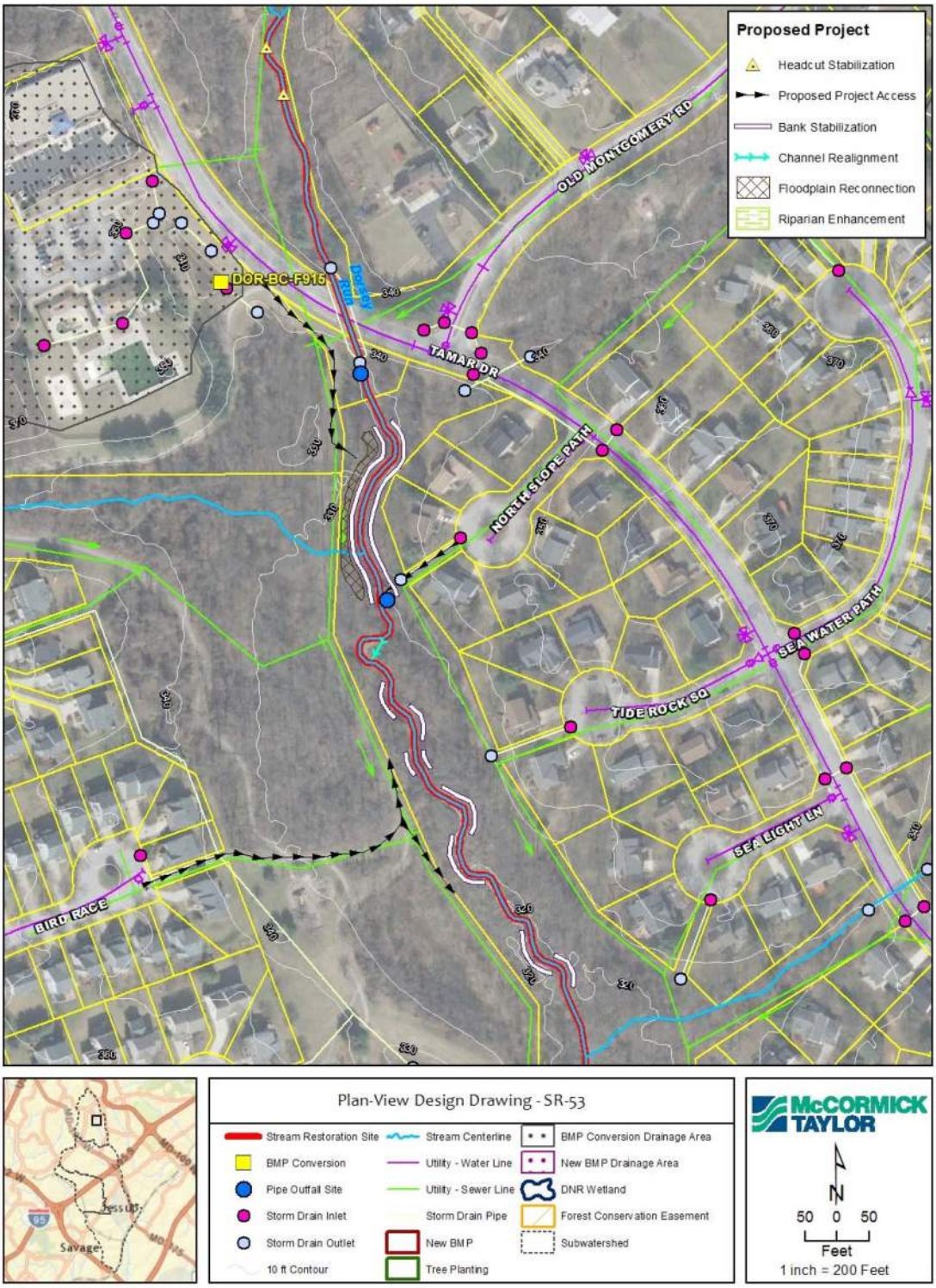
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-53

Site Name: Broken Wing Court

Contractor: McCormick Taylor

Watershed: Little Patuxent River



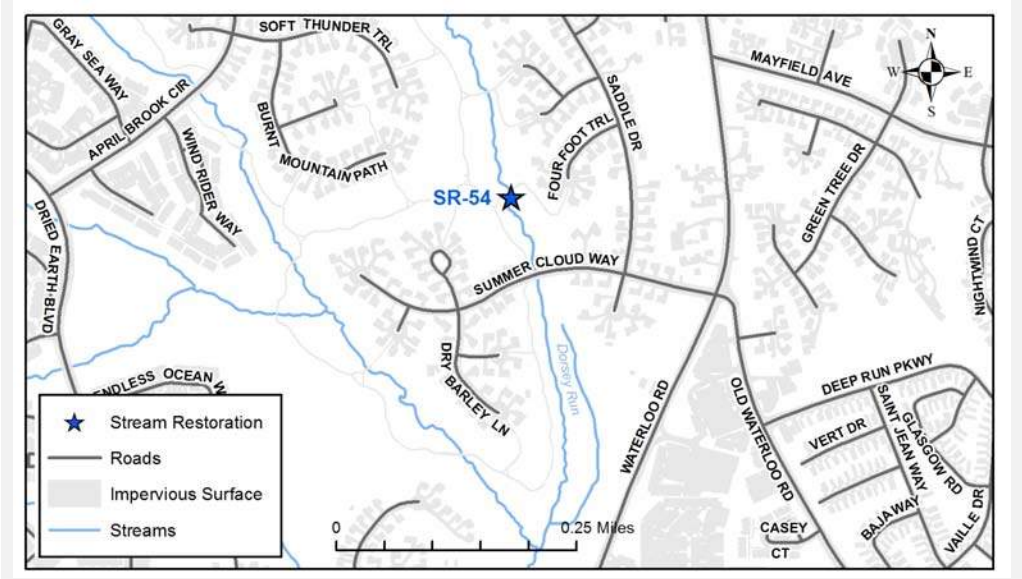
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-54
Site Name: Distant Rock Path
Contractor: McCormick Taylor
Watershed: Little Patuxent River

Ownership: Private- Mixed Use
Multiple Owners

Existing Conditions:

SR-54 consists of four stream assessment reaches (DOR-SR-F909C, DOR-SR-F909D, DOR-SR-909E, DOR-SR-F909F) associated with Dorsey Run. Land use surrounding the project site is primarily residential and forested land that is mainly owned by the Columbia Association. The stream restoration site begins 20 lf. north of the culvert at Summer Cloud Way, approximately 500 ft. west of the intersection of Summer Cloud Way and Saddler Drive, and extends upstream (north) about 2,356 lf. The majority of the channel contains a significant amount of depositional features and pools that are filled with fine sediments, which indicate large sediment loads from upstream sources. The upstream reaches of the project (DOR-SR-F909E and DOR-SR-F909F) generally has a sand/silt channel substrate with bank heights ranging from 3 to 4.5 ft. Several areas of the channel are associated with bank erosion that is causing lateral migration and widening of the channel. Many areas of the eroded banks are nearly vertical, lack surface protection or vegetation, and are comprised primarily of silt and clay material. The downstream reaches of the project (DOR-SR-F909C and DOR-SR-F909D) generally have a cobble/gravel/sand substrate with bank heights ranging from 2.5 to 5 ft. These reaches also have multiple areas of bank erosion. However, overall bank erosion throughout the entire site is sporadic and not as severe compared to some of the other stream restoration sites identified in the study areas. There are two exposed pipes within the channel bed. One pipe is located at the downstream extent of reach DOR-SR-F909E, but is not shown from existing utility data mapping. The other exposed pipe is located within reach DOR-SR-F909D which coincides with existing GIS utility data designated as either a water line or a storm drain pipe.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-54
Site Name: Distant Rock Path
Contractor: McCormick Taylor
Watershed: Little Patuxent River

SR-54 facing downstream at severe bank erosion.

SR-54 facing upstream at a 3 ft. tall headcut.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-54
Site Name: Distant Rock Path
Contractor: McCormick Taylor
Watershed: Little Patuxent River

Constraints/Utilities:

Constraints with the project include access, existing sanitary sewer utilities, potential impacts to trees and forested areas and disruption of pedestrian traffic along the community trail.

Concept Description:

The proposed stream restoration project consists of four reaches associated with approximately 2,356 lf. of Dorsey Run. The project mainly includes bank stabilization treatments located primarily on the outside of meander bends. There is one opportunity for a minor channel realignment to correct tight planform geometry and provide relief for high energy storm flows. The channel realignment is proposed along a tight meander bend located just downstream from the pedestrian bridge that crosses the channel in the vicinity of Young Buck Circle. The stream restoration could also include protection of the two existing utility pipes that are exposed in the channel with a grade control structure such as a constructed riffle. The project could potentially include a tree planting area east of the channel in the vicinity of Dry Stone Gate and Young Buck Circle. This area is currently mowed and maintained with turf grass. Proposed access to the site includes several access points along existing community trails and sanitary sewer right of ways. The project would likely include some impacts to existing trees and forested areas in order to access the channel. The project has potential to provide education value due to an existing community trail along the downstream reaches of the site. The project would include additional stream assessment and design phases to determine specific channel treatments and construction sequence.

Nearby Opportunities:

SR-53 and SR-55

Proposed Project Credit		Costs	
Length Restored (ft):	2,356	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	23.6	Estimated Construction Cost:	$1,060,200.00
Cost per Impervious Credit Acre:	$71,233.45	30% Contingency:	$318,060.00
		Estimated Total Cost:	$1,678,260.00

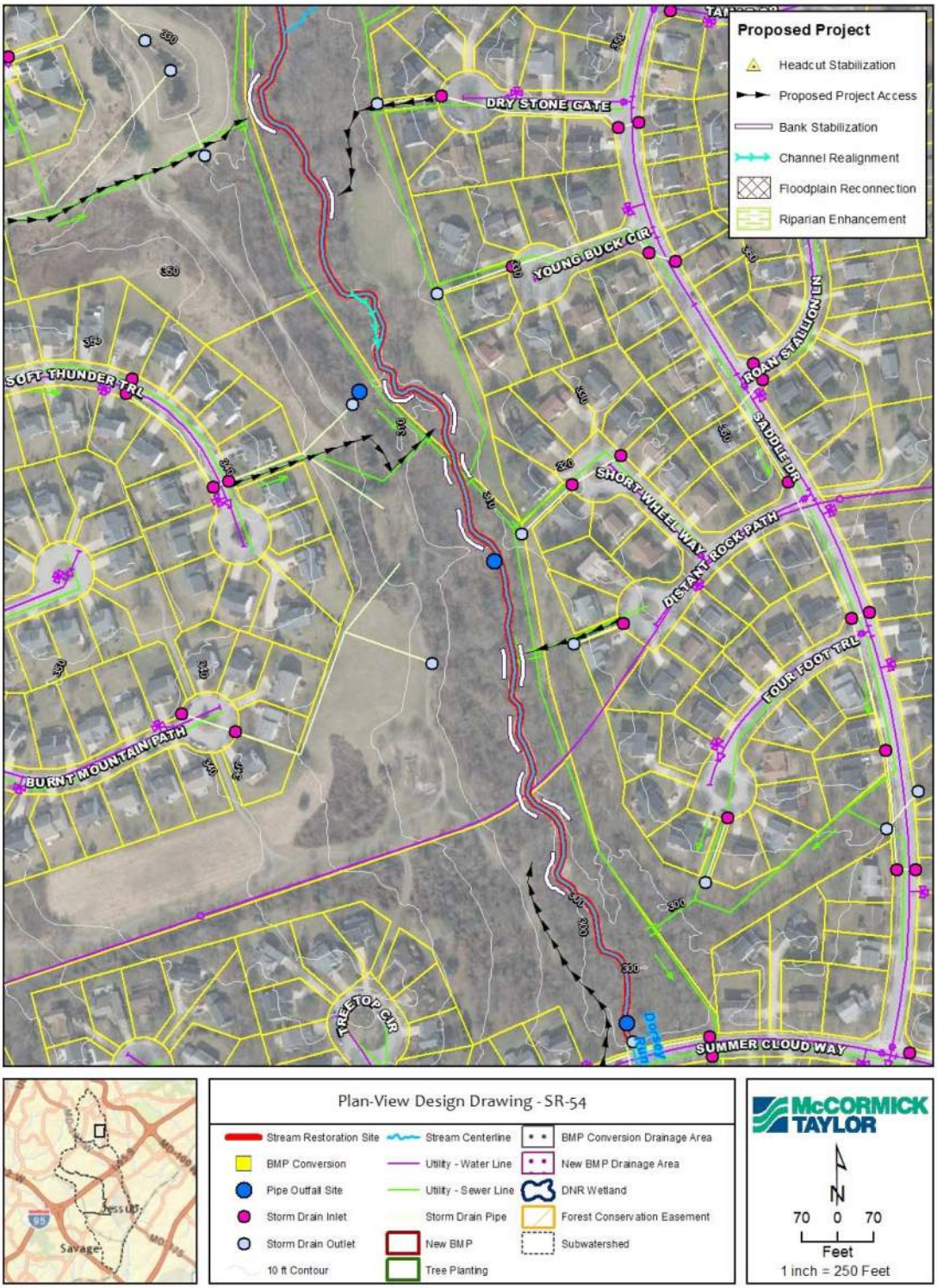
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-54

Site Name: Distant Rock Path

Contractor: McCormick Taylor

Watershed: Little Patuxent River



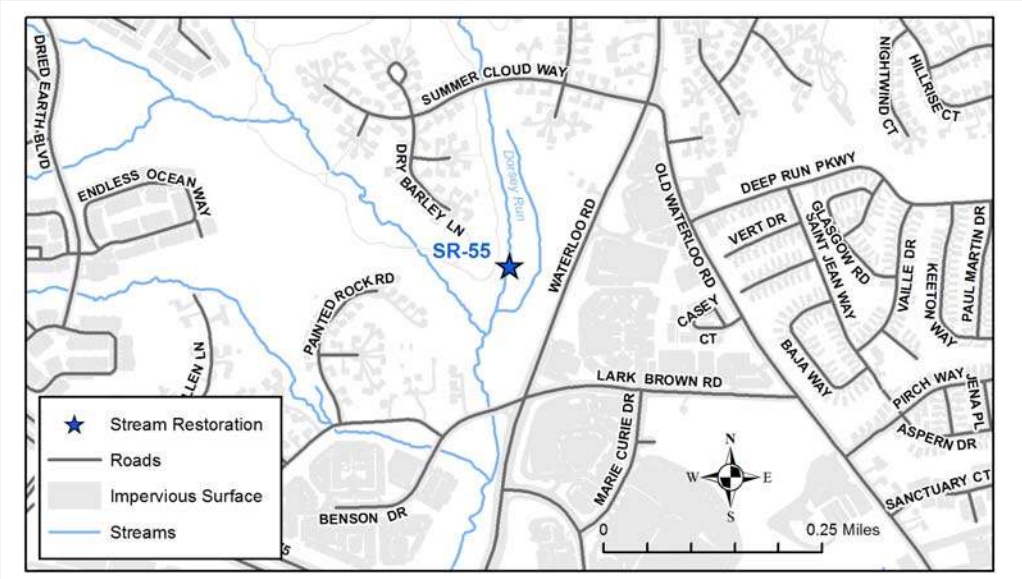
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-55
Site Name: Summer Cloud Way
Contractor: McCormick Taylor
Watershed: Little Patuxent River

Ownership: Columbia Association
Single Owner

Existing Conditions:

SR-55 consists of two stream assessment reaches (DOR-SR-F909A and DOR-SR-F909B) associated with Dorsey Run and another unnamed tributary of Dorsey Run that was added to the project site. Land use surrounding the project site is forested and residential land, with the entire project being owned by the Columbia Association. The stream restoration site begins approximately 40 lf. south of the culvert at Summer Cloud Way, approximately 500 ft. west of the intersection of Summer Cloud Way and Saddler Drive, and extends downstream about 1,986 lf. The channel has several areas of bank erosion with bank heights ranging from 2.5 to 5 ft. The stream bed is predominantly composed of gravel/sand/silt substrate and many of the pool features are filled with fine sand and silt sediments. Approximately 750 lf. of Dorsey Run are currently eroding, causing lateral migration and widening of the channel. A large portion of the eroded banks are nearly vertical, lack surface protection or vegetation, and are comprised of larger percentages of silt and clay. A debris jam downstream of the first sewer line crossing was noted during the initial assessment in Spring 2015, which has now caused a majority of the channel flow to avulse onto the left floodplain. The segment of stream downstream of the debris jam has filled with sediment and the cross section area is significantly smaller with a very low baseflow. Flow from the channel avulsion area is spread on the left floodplain and providing hydrology to existing wetland areas. Below these wetland areas flow becomes concentrated and is draining to an area of the unnamed tributary of Dorsey Run just upstream of a sanitary sewer crossing. There is a significant headcut associated with concentrated flow draining from the floodplain wetlands to the tributary. The unnamed tributary of Dorsey Run is severely incised and characterized with vertical eroding banks that are composed of silt and clay material and lack vegetation.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-55
Site Name: Summer Cloud Way
Contractor: McCormick Taylor
Watershed: Little Patuxent River

SR-55 facing upstream at riprap channel alteration and 3.5 ft. tall headcut.

SR-55 facing upstream at severe bank erosion.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-55
Site Name: Summer Cloud Way
Contractor: McCormick Taylor
Watershed: Little Patuxent River

Constraints/Utilities:

Constraints with the project include access, existing sanitary sewer utilities, potential impacts to trees and forested areas and disruption of pedestrian traffic along the community trail.

Concept Description:

The proposed stream restoration project consists of approximately 1,400 lf. of Dorsey Run and approximately 550 lf. of the unnamed tributary of Dorsey Run downstream of Summer Cloud Way. The project mainly includes bank stabilization treatments along areas of the upstream reach of Dorsey Run and at the downstream extent of the lower reach of Dorsey Run. No work is proposed at this time along approximately 500 lf. of Dorsey Run that corresponds with the segment of stream below the channel avulsion area. Bank stabilization is also proposed along a majority of stream channel associated with the unnamed tributary of Dorsey Run, which may be able to be extended farther upstream. The stream restoration would include stabilization of the headcut that has formed on the right bank of the unnamed tributary where flow has concentrated from drainage of the existing wetlands located between the two stream systems. Proposed access to the site is proposed off of Summer Cloud Way along the existing community trail and some areas of the sanitary sewer right of ways. The project would likely include some impacts to existing trees and forested areas in order to access the channel. The project has potential to provide education value due to an existing community trail along the downstream reaches of the site. The project would include additional stream assessment and design phases to determine specific channel treatments and construction sequence.

Nearby Opportunities:

SR-53 and SR-54

Proposed Project Credit		Costs	
Length Restored (ft):	1,986	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	19.9	Estimated Construction Cost:	$893,700.00
Cost per Impervious Credit Acre:	$73,605.74	30% Contingency:	$268,110.00
		Estimated Total Cost:	$1,461,810.00

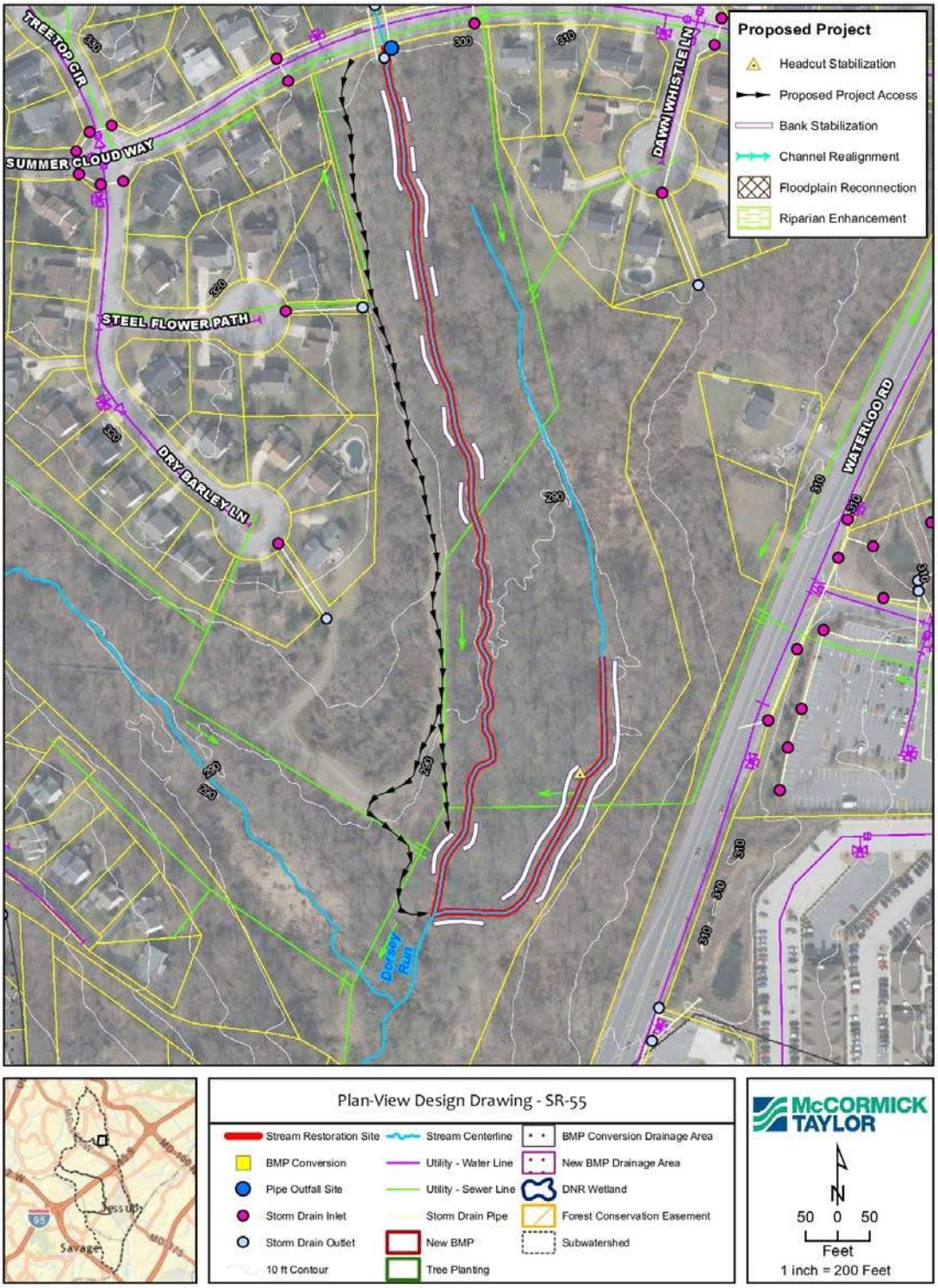
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-55

Site Name: Summer Cloud Way

Contractor: McCormick Taylor

Watershed: Little Patuxent River



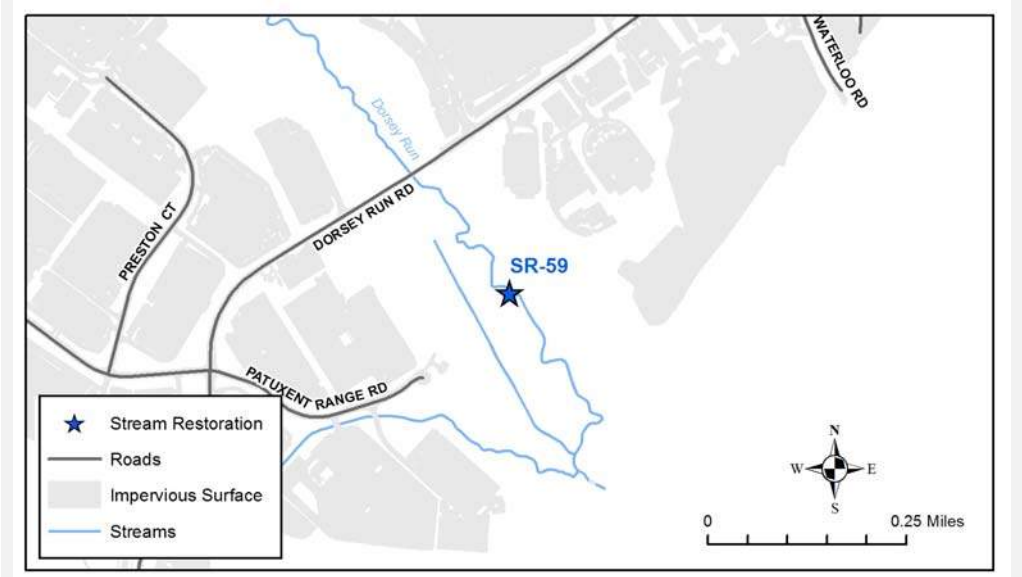
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-59
Site Name: Jessup Correctional
Contractor: McCormick Taylor
Watershed: Little Patuxent River

Ownership: Private- Mixed Use
Single Owner

Existing Conditions:

SR-59 consists of four stream assessment reaches (DOR-SR-F904A, DOR-SR-F904B, DOR-SR-F904C, DOR-SR-F904D) associated with Dorsey Run. Land use surrounding the project site is mostly forested, with a CSX railroad located along the east side of the stream. The entire project site property is owned by the Maryland State Department of Public Safety and Correctional Services. The project begins approximately 400 lf. downstream of the culvert at Dorsey Run Road and extends about 2,572 lf. downstream (south). In general, the stream has a predominantly gravel/sand/silt substrate with bank heights ranging from 4-6 ft. Approximately 1,500 lf. of the stream banks are currently eroding primarily causing lateral migration and widening of the channel. A majority of the eroding banks are nearly vertical with bank heights between 5 to 6 ft., lack surface protection and/or vegetation, and are comprised mainly of silt and loamy soil material. Two areas of the left bank are eroding into the CSX railroad track and threatening stability of the railroad. An existing concrete weir is located south of a proposed tree planting area (DOR-SR-F904C) and is approximately 40 ft. wide, extending 70 ft. from upstream to downstream. The weir has a significant amount of accumulated sediment and debris on the upstream side and also acts as a fish blockage. The site is also associated with beaver activity and evidence of old beaver dams. Forested and emergent wetlands are located primarily on the right side (west) of the channel in several areas of the project site. The site is also associated with an SHA project that was completed in 2013. The SHA project included stream and wetland restoration on the west side of Dorsey Run that mainly focused on treatments to the unnamed tributary located on the west side of the property.



Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-59
Site Name: Jessup Correctional
Contractor: McCormick Taylor
Watershed: Little Patuxent River

SR-59 facing upstream at failing dam structure.

SR-59 facing downstream at severe bank erosion.

Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-59
Site Name: Jessup Correctional
Contractor: McCormick Taylor
Watershed: Little Patuxent River

Constraints/Utilities:

Constraints with the site include existing sewer utilities, CSX railroad tracks, and potential impacts to trees, forested areas and wetlands.

Concept Description:

The proposed stream restoration project consists of approximately 2,572 lf. of Dorsey Run immediately upstream of the Howard County boundary with Anne Arundel County. The project mainly includes bank stabilization treatments along several areas of Dorsey Run. The majority of the proposed bank stabilization areas are associated with outside meander bends that are actively eroding and lack protection. The existing concrete weir could be considered for removal with the project, but this would greatly increase project costs. The concrete weir is slowly deteriorating and failure of the structure would be associated with significant channel degradation and release of sediment. Currently, the weir and old beaver dams that are located within the channel are highly influential on the amount of sediment deposition and floodplain connectivity characterizing the stream system. There are extensive floodplain wetlands located along the entirety of the project and receive large amounts of sediment deposits during storm events. The proposed project may need to include outfall stabilization associated with one of the bank stabilization areas located toward the downstream extent of the project. Trash and debris removal is also recommended for the project site. Proposed access to the site includes an existing sanitary sewer easement that was also utilized for the previous SHA project. The haul road is still relatively clear of vegetation. Coordination with SHA should be conducted to determine if there are any existing protective easements or covenants associated with the property. The project would include additional stream assessment and design phases to determine specific channel treatments and construction sequence.

Nearby Opportunities:

None recommended

Proposed Project Credit		Costs	
Length Restored (ft):	2,572	Estimated Design Cost:	$300,000.00
Impervious Area Treated Credit (ac.):	25.7	Estimated Construction Cost:	$1,157,400.00
Cost per Impervious Credit Acre:	$70,164.07	30% Contingency:	$347,220.00
		Estimated Total Cost:	$1,804,620.00

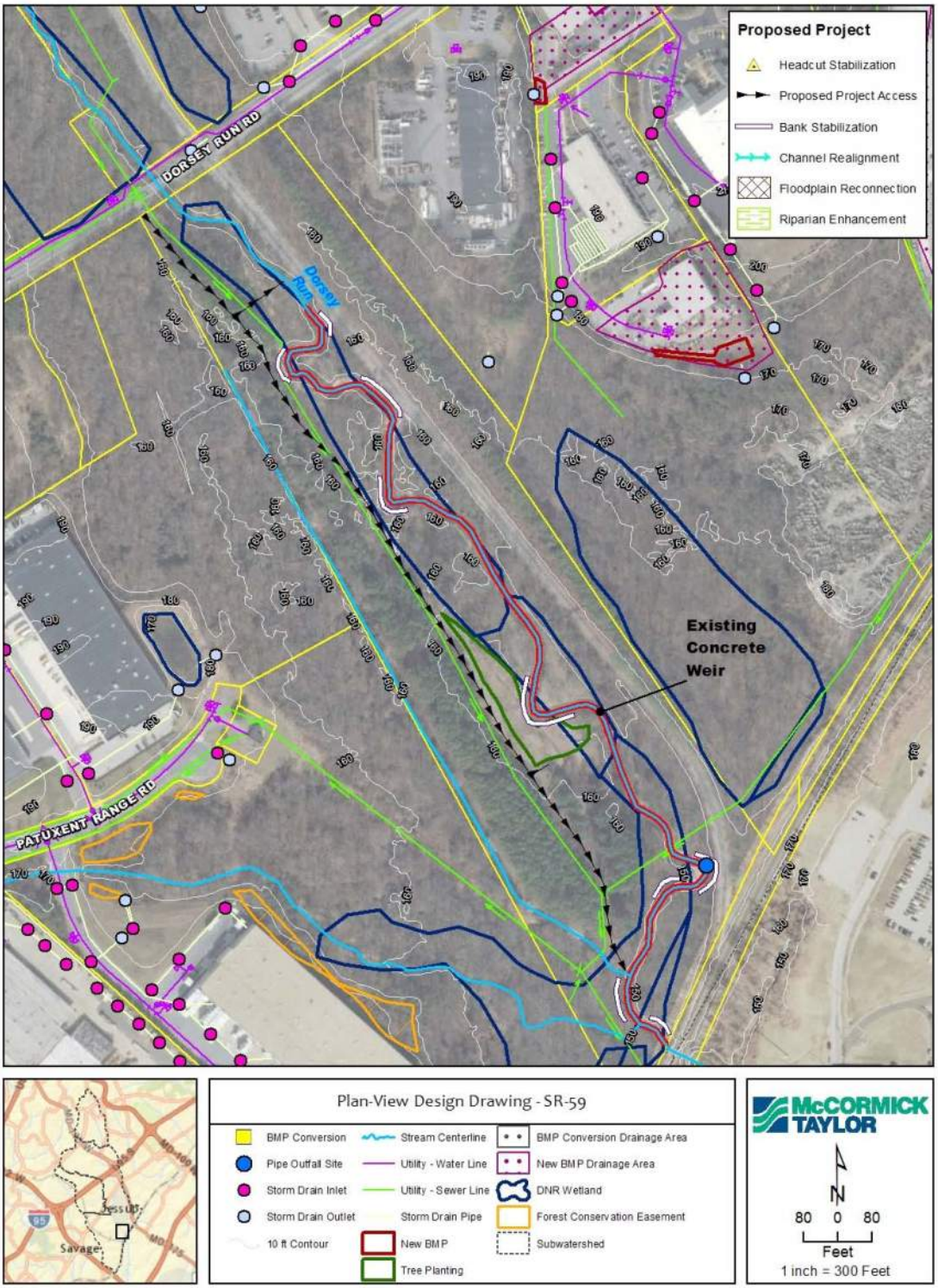
Howard County Watershed Assessment Concept Plan: Stream Restoration

Site ID: SR-59

Site Name: Jessup Correctional

Contractor: McCormick Taylor

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Tree Planting

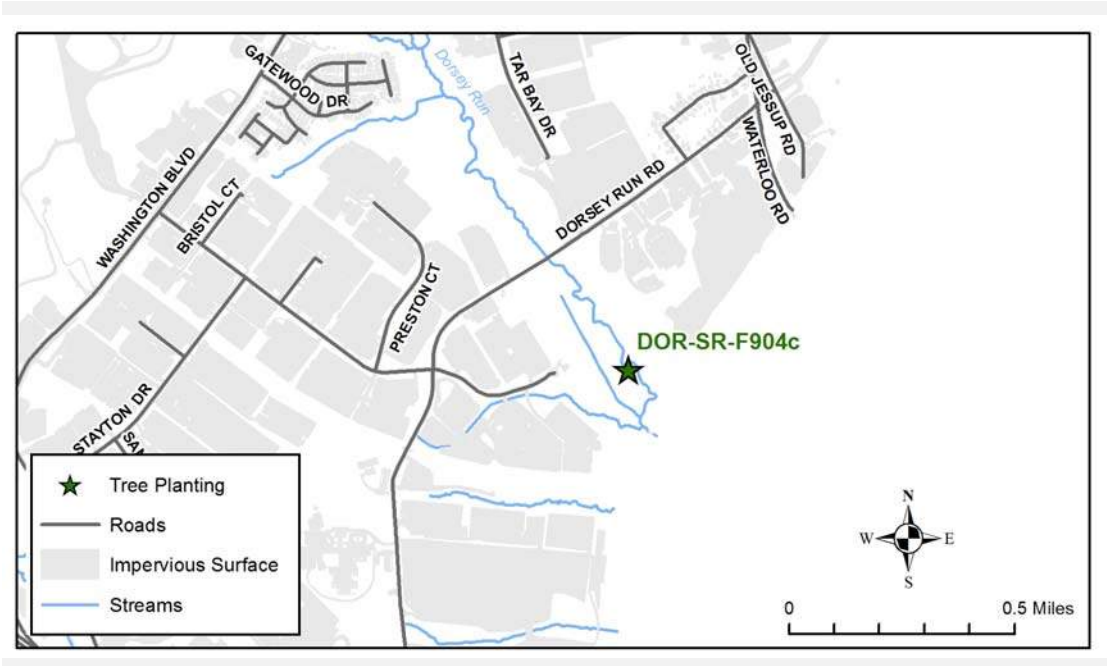
Site ID: DOR-SR-F904c
Site Name: Dorsey Run Road
Contractor: McCormick Taylor
Watershed: Little Patuxent River

Project Type: Tree Planting
Ownership: State
Single Owner

Existing Conditions:

The proposed tree planting site is located approximately 1,200 ft. southeast of the crossing of Dorsey Run Road and Dorsey Run in Jessup, MD. The property associated with the planting area is state owned by the Department of Public Safety and Correctional Services. The project site is within the riparian buffer zone of SR-59. A majority of the proposed planting area receives full sunlight except on the fringes with adjacent forested areas. About 60% of the site is comprised of herbaceous cover, with 10% trees and shrubs and 30% bare soil. Dominant tree species observed in adjacent areas of the site include box elder (Acer negundo), black walnut (Juglans nigra), and American sycamore (Platanus occidentalis). No invasive species are present within the planting area; however 25% invasive species coverage of Japanese honeysuckle (Lonicera japonica) is located in the adjacent area.

Soils within the project are primarily loam and are moderately compacted. Water sources other than rainfall include overbank flow from SR-59 and runoff from the surrounding land use, with a pervious contributing flow length of 50 ft. along a 5% slope. The site has some floodplain connection with SR-59, which has bank heights between 4-6 ft. There are multiple animal impacts to the site including heavy deer browse and beaver activity. The site is associated with an SHA project that focused on restoration treatment to the unnamed tributary to Dorsey Run on the west side of the property. The haul road utilized for the project is still accessible and is associated with some soil disturbance, compaction, and the presence of mulch. Recent tree plantings are located within the planting area; however, none of them were successful. Wetlands are located within adjacent areas of the planting site. The proposed planting area is also within a green infrastructure hub.



Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: DOR-SR-F904c
Site Name: Dorsey Run Road
Contractor: McCormick Taylor
Watershed: Little Patuxent River

Proposed tree planting site DOR-SR-F904c facing northwest.

Proposed tree planting site DOR-SR-F904c facing west at adjacent streambank erosion.

Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: DOR-SR-F904c
Site Name: Dorsey Run Road
Contractor: McCormick Taylor
Watershed: Little Patuxent River

Constraints/Utilities:

Constraints within the project include animal impacts, ownership, and possible wetland impacts. The planting area may require further coordination with SHA to determine if additional constraints or protective easements exist on the property.

Concept Description:

Approximately 0.57 ac. of riparian buffer will be planted with suitable tree species. Recent tree plantings are located within the planting area, but none appear to be surviving. It is recommended that American sycamore (Platanus occidentalis) be included as a suitable tree species since it is typically more resistant to deer browse. Selection of other suitable tree species will be determined in a planting plan if the project is selected for planting.

Access to the site is generally easy with foot and vehicle traffic able to enter through the sewer line easement off of Dorsey Run Road, which was previously utilized as a haul road for the SHA project. Space for temporary storage and onsite material delivery is available adjacent to the planting site.

Nearby Opportunities:

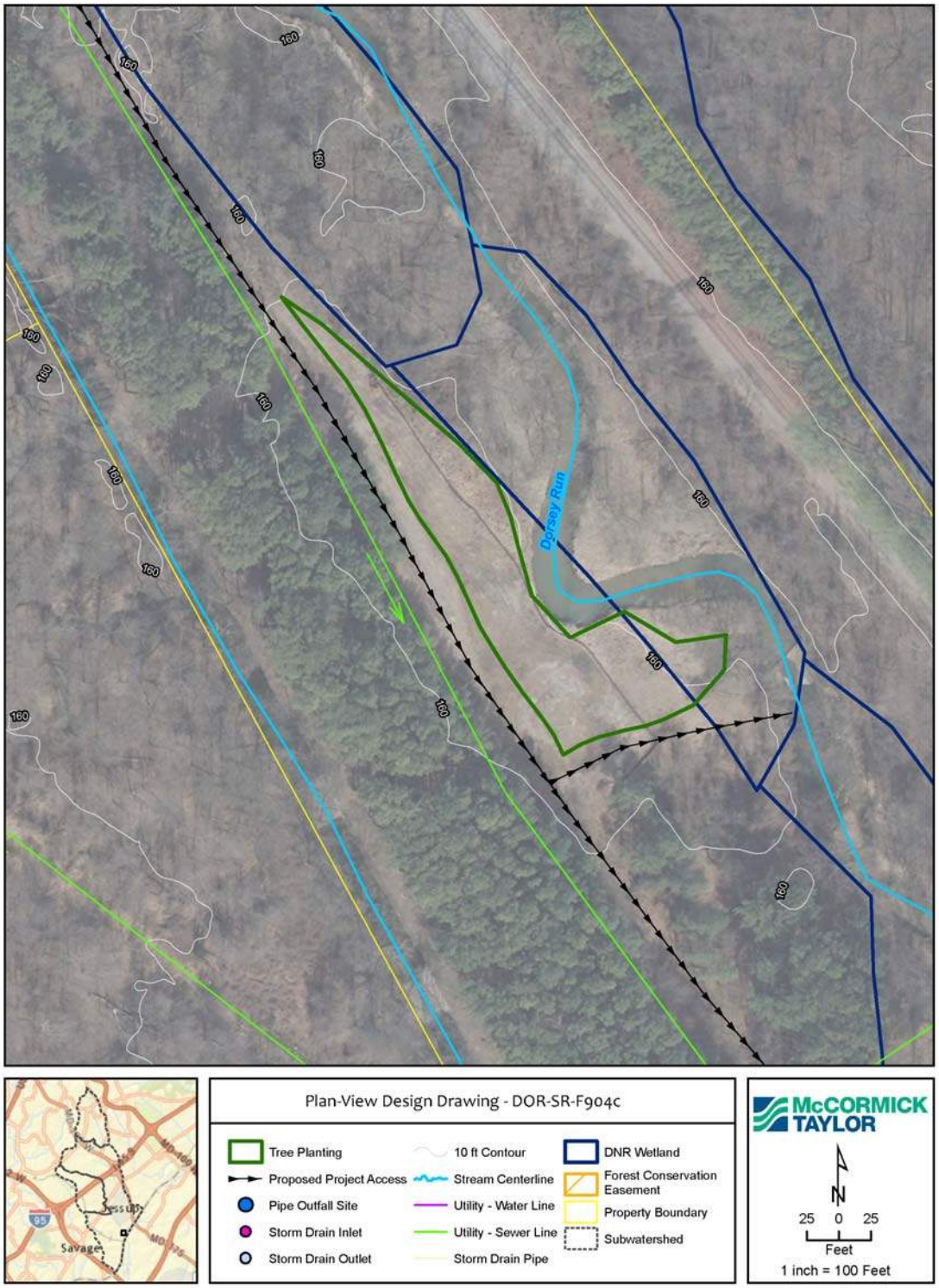
SR-59

Proposed Project Credit	
Planting Acres:	0.6
Impervious Area Treated Credit (ac.):	0.22
Cost per Impervious Credit Acre:	$153,236.36

Costs	
Estimated Design Cost:	$10,000.00
Estimated Construction Cost:	$18,240.00
30% Contingency:	$5,472.00
Estimated Total Cost:	$33,712.00

Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: DOR-SR-F904c
Site Name: Dorsey Run Road
Contractor: McCormick Taylor
Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Tree Planting

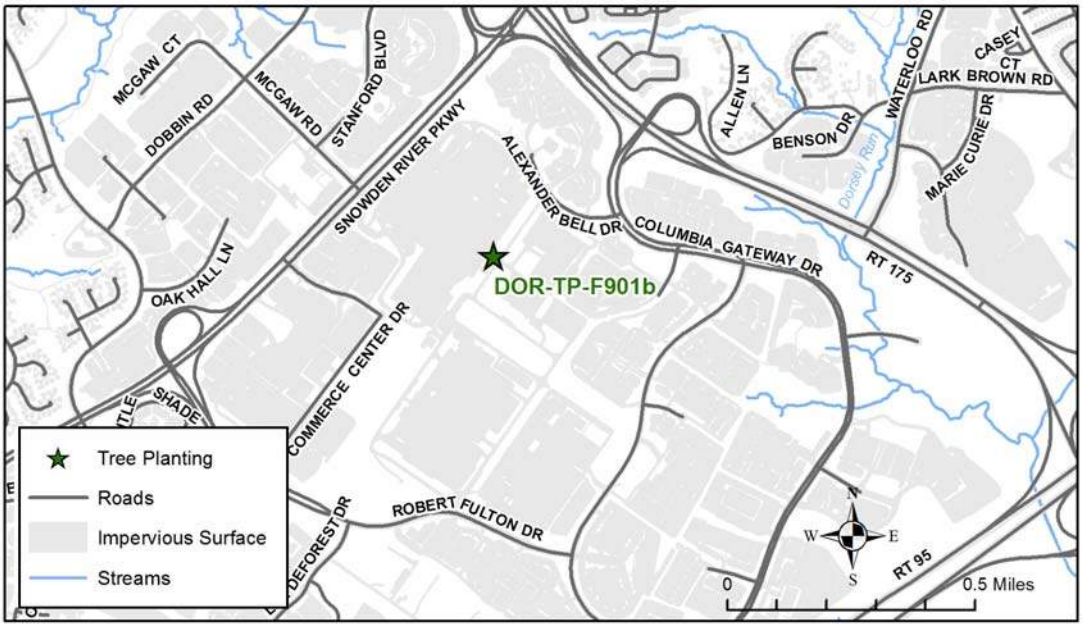
Site ID: DOR-TP-F901b
Site Name: Pepsi Delivery
Contractor: McCormick Taylor
Watershed: Little Patuxent River

Project Type: Tree Planting
Ownership: Private- Commercial/Industrial
Single Owner

Existing Conditions:

The proposed tree planting project consists of five planting assessments (DOR-TP-F901b, DOR-TP-F901c, DOR-TP-F901d, DOR-TP-F901e, and DOR-TP-F901g) located within an industrial/commercial property southeast of the intersection of Snowden River Parkway and McGaw Road. The property associated with the tree planting area is privately owned by Gateway A 74 & A 76 LLC. The project site is generally made up of multiple regularly mowed median strips which are within highly impervious areas that receive full sun. Planting areas within the site are comprised of 80-95% mowed turf, 1-10% trees and shrubs, and 3-10% bare soil.

Dominant tree species observed within some planting areas and in adjacent forested areas include red maple (Acer rubrum), sweet-gum (Liquidambar styraciflua), eastern white pine (Pinus strobus), and American sycamore (Platanus occidentalis). Invasive species cover 5% of the western planting area (DOR-TP-F901g) and include multiflora rose (Rosa multiflora), wine raspberry (Rubus phoenicolasius), and Japanese honeysuckle (Lonicera japonica). Soils within the project site are primarily loam and are moderately compacted. Water sources other than rainfall include runoff from adjacent land use, with both pervious and impervious flow lengths ranging from 15 to 50 ft. along a slope of 2 to 30%. Greater than 15% slopes can be found within the western planting area, the large middle planting area (DOR-TP-F901c), and the southeastern planting area (DOR-TP-F901b). There is no evidence of animal impacts.



Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: DOR-TP-F901b
Site Name: Pepsi Delivery
Contractor: McCormick Taylor
Watershed: Little Patuxent River

Proposed tree planting site DOR-TP-F901b facing east at the southernmost southeastern parcel.

Proposed tree planting site DOR-TP-F901b facing northeast at the large middle parcel.

Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: DOR-TP-F901b
Site Name: Pepsi Delivery
Contractor: McCormick Taylor
Watershed: Little Patuxent River

Constraints/Utilities:

Constraints within the project include ownership and regular mowing of planting areas. The small middle and northeastern planting areas also have 30 ft. high light posts along the edge of pavement that may limit the extent or type of tree species selected for planting. Based on available GIS data, it does not appear that the proposed planting areas include underground utilities but this will require verification.

Concept Description:

Approximately 7.27 ac. of industrial/commercial property will be planted with suitable tree species. No previous plantings have occurred on this property. Selection of suitable tree species will be determined in planting plans if the project is selected for planting.

Access to the site is generally easy, with foot and vehicle traffic able to enter the industrial property by adjacent roadways. Temporary storage for material is possible using existing parking lots and planting areas on the property. Heavy equipment traffic and onsite material delivery is available to all planting areas.

Nearby Opportunities:

DOR-NB-925, DOR-NB-926, DOR-NB-927, DOR-NB-F928, DOR-NB-F929, DOR-NB-F931, and DOR-NB-F943.

Proposed Project Credit	
Planting Acres:	7.3
Impervious Area Treated Credit (ac.):	2.76
Cost per Impervious Credit Acre:	$113,200.00

Costs	
Estimated Design Cost:	$10,000.00
Estimated Construction Cost:	$232,640.00
30% Contingency:	$69,792.00
Estimated Total Cost:	$312,432.00

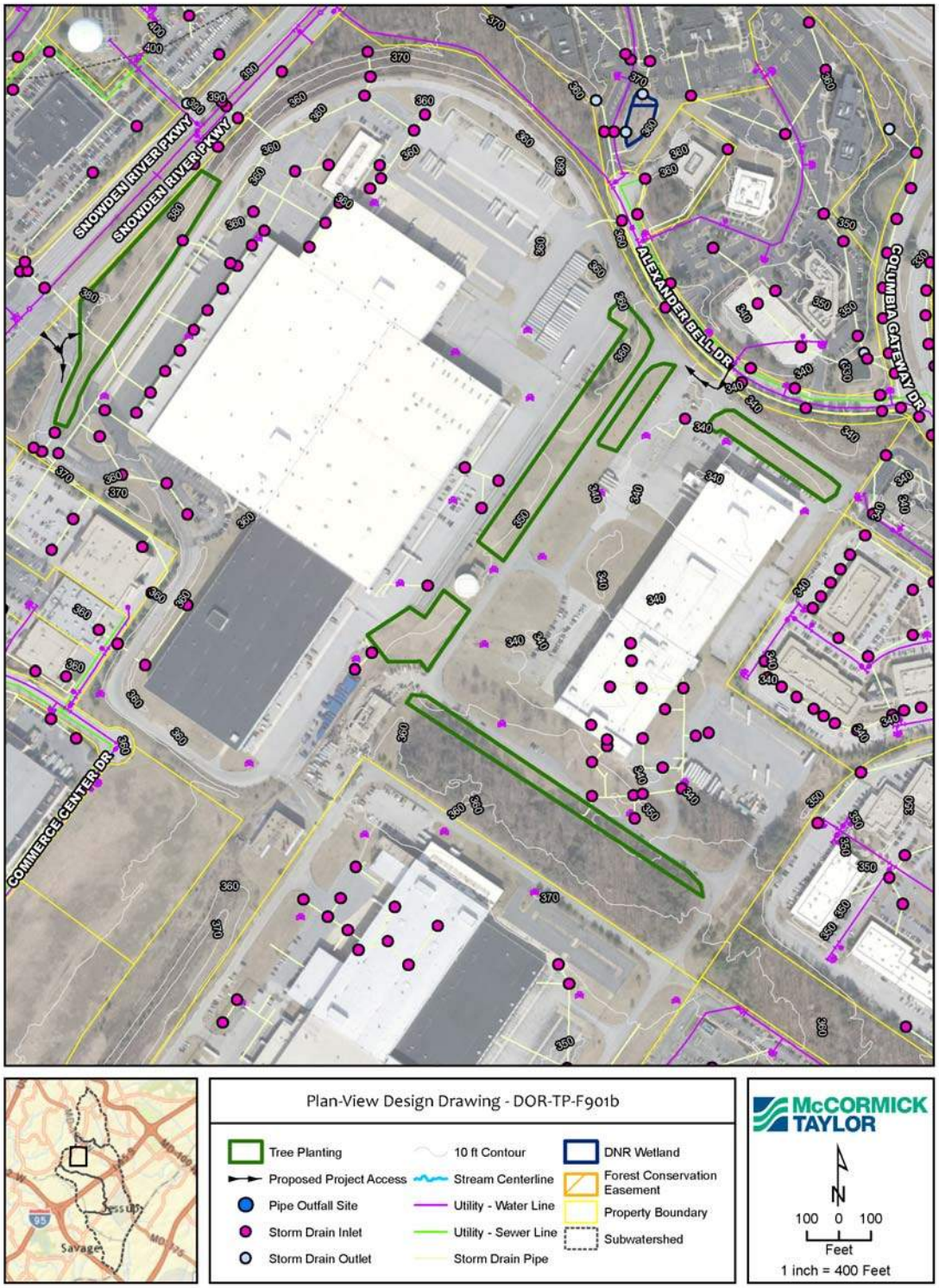
Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: DOR-TP-F901b

Site Name: Pepsi Delivery

Contractor: McCormick Taylor

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: DOR-TP-F905g
Site Name: Lee Deforest Drive
Contractor: McCormick Taylor
Watershed: Little Patuxent River

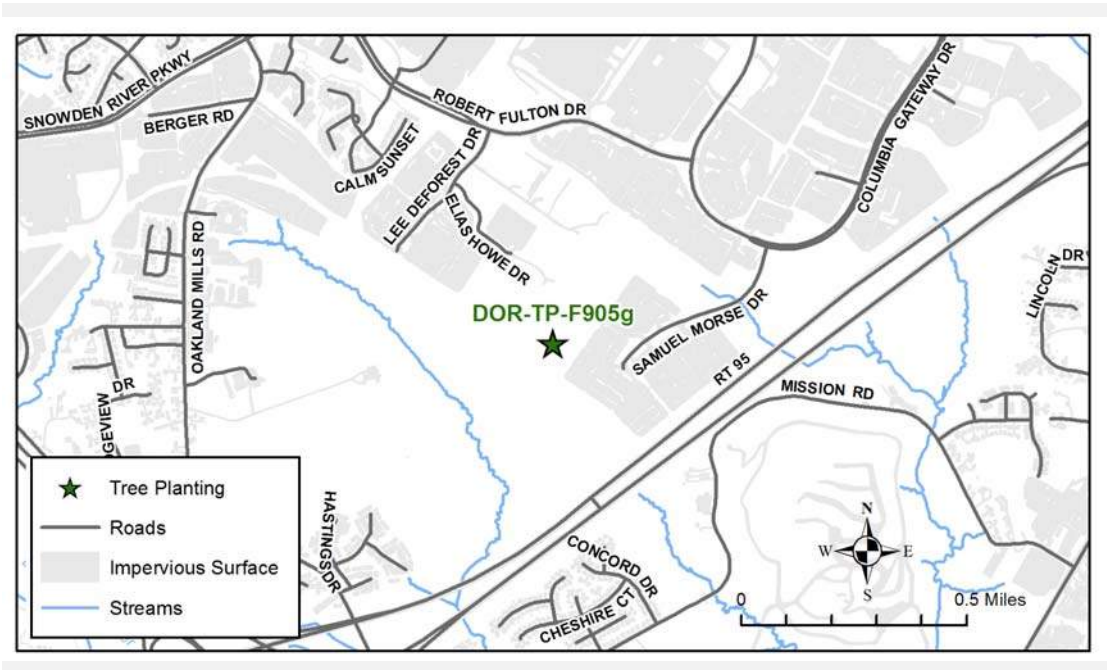
Project Type: Tree Planting

Ownership: Private- Commercial/Industrial
Multiple Owners

Existing Conditions:

The proposed tree planting project is a combination of five planting areas (DOR-TP-F905d, DOR-TP-F905e, DOR-TP-F905g, and DOR-TP-F905h) located south of the intersection of Robert Fulton Drive and Lee Deforest Drive in Columbia, MD. The property associated with the site is privately owned by two commercial titleholders. The project is generally made up of multiple upland areas adjacent to a commercial business park that receive full sun. Planting areas within the site are generally comprised of 90-95% herbaceous cover, 3-5% trees and shrubs, and 2-5% bare soil.

Dominant tree species observed in some planting areas and in adjacent forested areas include red maple (Acer rubrum), Virginia pine (Pinus virginiana), and tulip poplar (Liriodendron tulipifera). The majority of the planting areas have no invasive species present; however, Bradford pear (Pyrus calleryana) covers approximately 5% of the northwestern (DOR-TP-F905f) and southwestern (DOR-TP-F905d) planting areas. Soils within the project are primarily loam and are moderately compacted. Water sources other than rainfall include runoff from surrounding drainage areas, with a pervious flow length ranging from 5 to 50 ft. along a 10 to 30% slope. Greater than 15% slopes can be found within the southwestern planting area. There is no evidence of animal impacts or previous tree plantings.



Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: DOR-TP-F905g
Site Name: Lee Deforest Drive
Contractor: McCormick Taylor
Watershed: Little Patuxent River

Proposed tree planting site DOR-TP-F905g facing northwest at the southwestern parcel.

Proposed tree planting site DOR-TP-F905g facing north at the northwestern parcel.

Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: DOR-TP-F905g
Site Name: Lee Deforest Drive
Contractor: McCormick Taylor
Watershed: Little Patuxent River

Constraints/Utilities:

Constraints within the project include ownership, regular mowing in areas adjacent to the commercial park, and a potential wetland in the southwestern planting area.

Concept Description:

Approximately 4.74 ac. of commercial property will be planted with suitable tree species. No recent tree plantings have occurred within the project site. Selection of suitable tree species will be determined in a planting plan if the project is selected for planting.

Access to the site is generally easy, with foot, vehicle, and heavy equipment traffic able to enter the commercial property by roadways adjacent to the project parcels. The two eastern areas adjacent to the landfill would need to be accessed by entering the fence surrounding the capped landfill. Space for temporary storage and onsite material delivery is available.

Nearby Opportunities:

DOR-NB-F902, DOR-NB-F903, DOR-NB-F941, and DOR-NB-F942.

Proposed Project Credit	
Planting Acres:	4.7
Impervious Area Treated Credit (ac.):	1.8
Cost per Impervious Credit Acre:	$115,102.22

Costs	
Estimated Design Cost:	$10,000.00
Estimated Construction Cost:	$151,680.00
30% Contingency:	$45,504.00
Estimated Total Cost:	$207,184.00

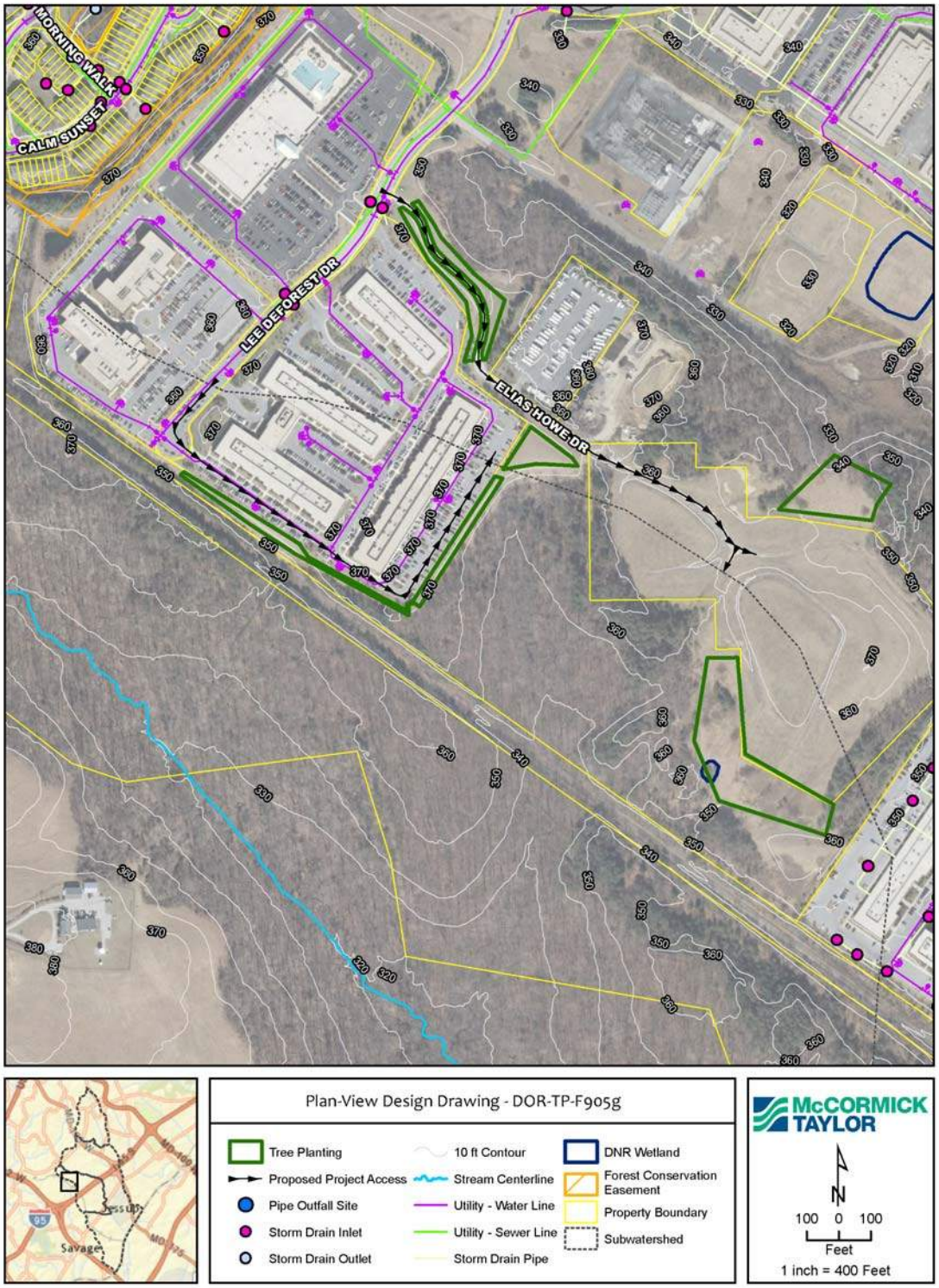
Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: DOR-TP-F905g

Site Name: Lee Deforest Drive

Contractor: McCormick Taylor

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: NLP-TP-D519

Site Name: Forest Hill

Contractor: KCI

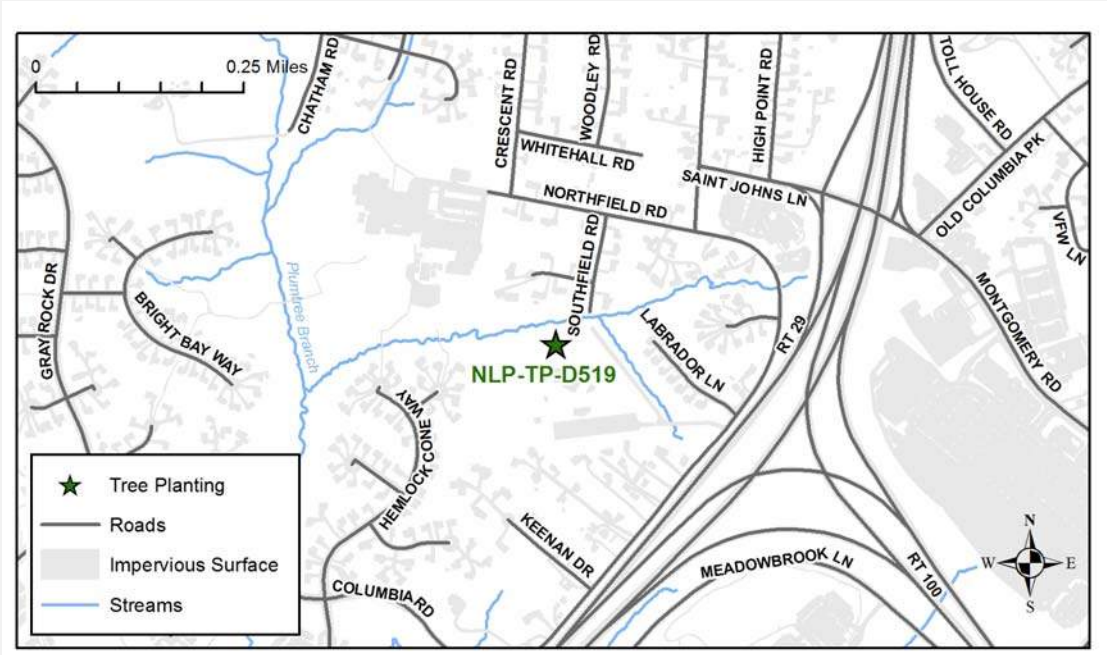
Watershed: Little Patuxent River

Project Type: Tree Planting

Ownership: Private- Commercial/Industrial
Single Owner

Existing Conditions:

The Forest Hill tree planting site consists of two separate areas around the perimeter of the Forest Hill Swim & Tennis Club property. Both areas are currently mowed grass and maintained by Forest Hill Swim & Tennis Club. The planting will occur around the existing large Norway spruce and white pine trees on the property. Majority of the site receives full sun.



Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: NLP-TP-D519

Site Name: Forest Hill

Contractor: KCI

Watershed: Little Patuxent River

View of open grass and existing trees facing west at southern portion of planting area.

View of open field facing west at northern portion of planting area.

Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: NLP-TP-D519
Site Name: Forest Hill
Contractor: KCI
Watershed: Little Patuxent River

Constraints/Utilities:

The open, mowed areas recommended for tree planting may be used by swim club members for various activities. The County will need to coordinate with Forest Hill Swim & Tennis Club for access. No utilities have been found to conflict with the planting of this site.

Concept Description:

Tree planting is proposed on 4.32 ac. This planting will extend the existing riparian buffer by approximately 150 ft. Very little site preparation will be required. A variety of native trees should be planted. Tree shelters should be installed to protect the trees from deer damage. Tree maintenance and inspections should be performed yearly, and should include the removal of invasive species and repair of tree shelters and stakes. Water access is close to the planting areas, however permission to use the water will need to be obtained from the Swim Club. The site can be accessed from the entrance to the Swim Club at the southern side of the property or from the gate at the northeastern side of the property.

Nearby Opportunities:

NLP-NB-D560, NLP-SR-F527

Proposed Project Credit	
Planting Acres:	4.3
Impervious Area Treated Credit (ac.):	1.64
Cost per Impervious Credit Acre:	$115,678.05

Costs	
Estimated Design Cost:	$10,000.00
Estimated Construction Cost:	$138,240.00
30% Contingency:	$41,472.00
Estimated Total Cost:	$189,712.00

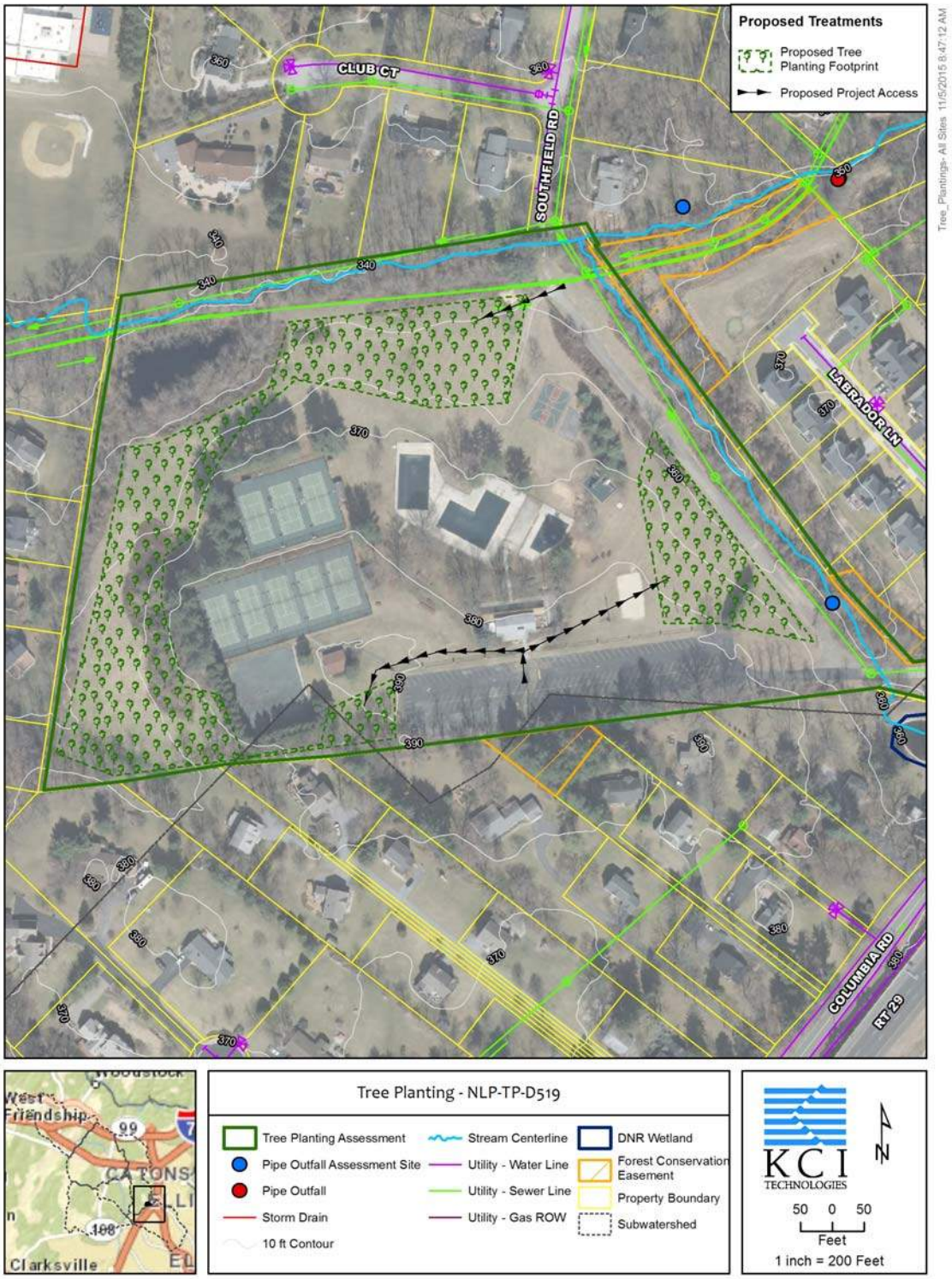
Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: NLP-TP-D519

Site Name: Forest Hill

Contractor: KCI

Watershed: Little Patuxent River



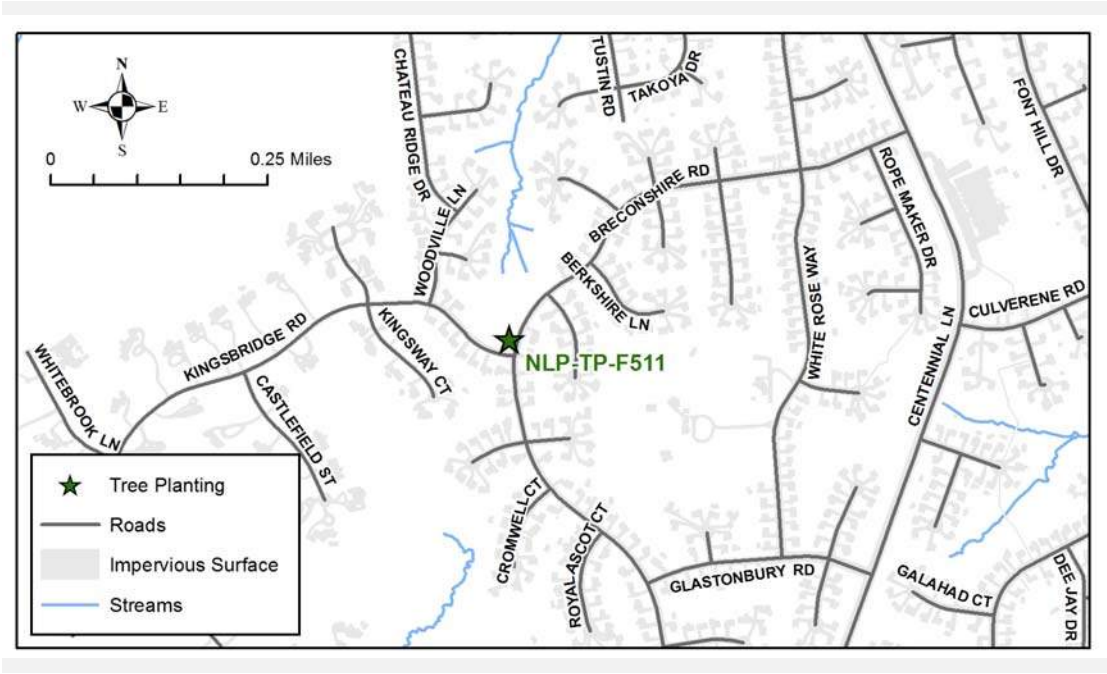
Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: NLP-TP-F511
Site Name: Breconshire
Contractor: KCI
Watershed: Little Patuxent River

Project Type: Tree Planting
Ownership: County Owned
Single Owner

Existing Conditions:

The Breconshire tree planting site consists of one planting area surrounding the stormwater management pond north of the intersection of Breconshire and Kingsbridge Roads. The planting areas are currently mowed and receive full sun. The planting should occur around the existing sycamore trees along Kingsbridge and Breconshire Roads without disturbing the existing trees. Majority of the site receives full sun.



Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: NLP-TP-F511

Site Name: Breconshire

Contractor: KCI

Watershed: Little Patuxent River

Site overview of open grass, existing sycamore trees, and stormwater management pond facing northwest from southern extent of planting area.

Site overview of open grass and existing sycamore trees facing northeast from southern extent of planting area.

Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: NLP-TP-F511
Site Name: Breconshire
Contractor: KCI
Watershed: Little Patuxent River

Constraints/Utilities:

Three storm drains connect road inlets to the pond inflow pipes and cross the proposed planting area. Trees should not be planted within a 20 ft. buffer over these storm drain pipes. No other utilities have been found to conflict with the planting of this site. Neighborhood use of the open space may be a constraint. Additionally, care must be taken when planting near the intersection of Kingsbridge and Breconshire Roads to avoid obstructing the view of drivers.

Concept Description:

Tree planting is proposed on 1.00 ac. surrounding the stormwater management pond on the southeastern and southwestern sides of the pond. The plantings will extend from the road to the edge of the water of the ponds. The ponds are excavated ponds, therefore no planting on the pond embankments on the northern side of the ponds should occur. Very little site preparation will be required. A variety of native trees should be planted. Tree shelters should be installed to protect the trees from deer damage. Tree maintenance and inspections should be performed yearly, and should include the removal of invasive species and repair of tree shelters and stakes. A fire hydrant on Breconshire Road may be used as a water source. The site can easily be accessed directly from Kingsbridge and Breconshire Roads.

Nearby Opportunities:

None recommended

Proposed Project Credit	
Planting Acres:	1
Impervious Area Treated Credit (ac.):	0.38
Cost per Impervious Credit Acre:	$135,789.47

Costs	
Estimated Design Cost:	$10,000.00
Estimated Construction Cost:	$32,000.00
30% Contingency:	$9,600.00
Estimated Total Cost:	$51,600.00

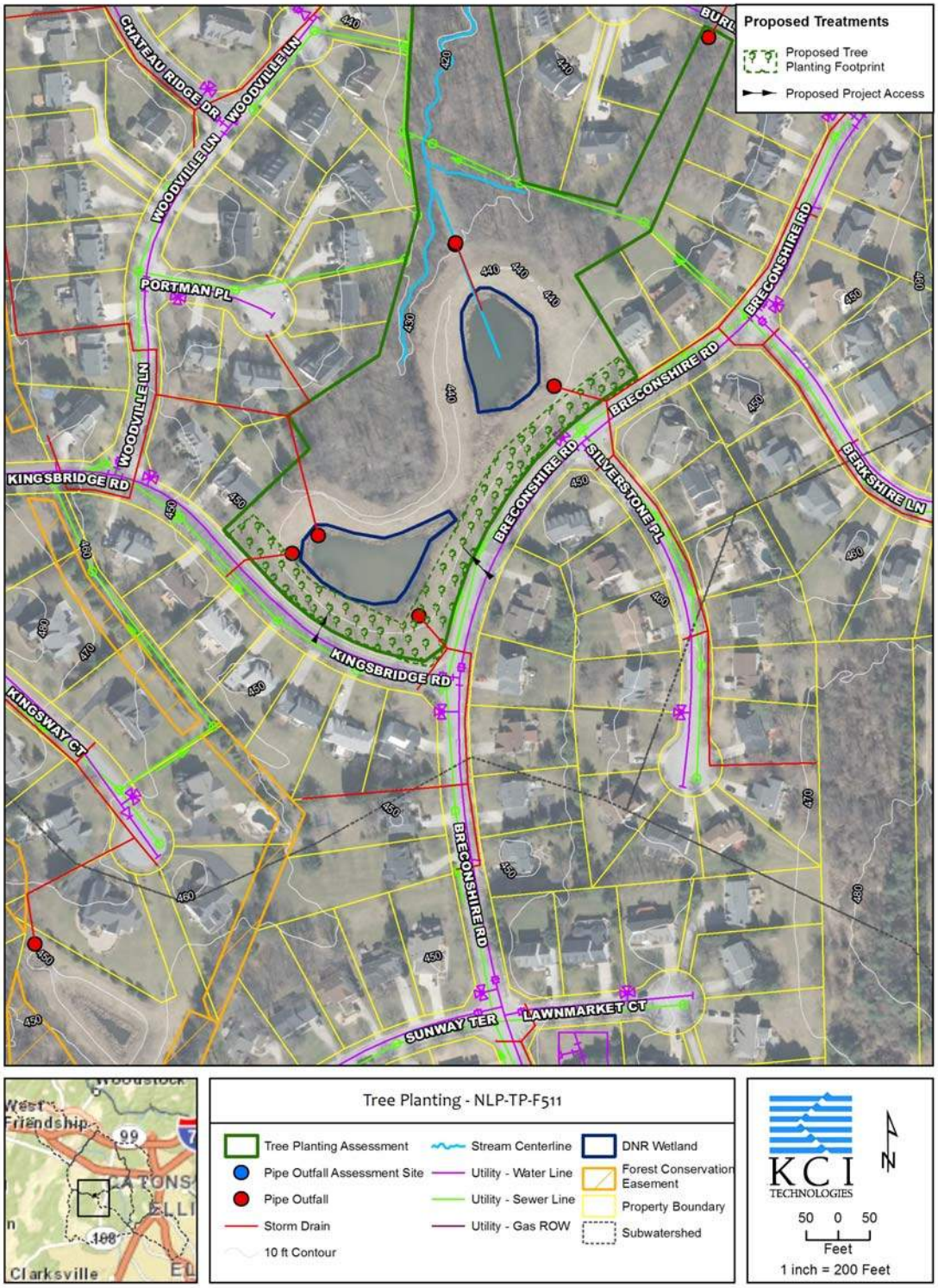
Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: NLP-TP-F511

Site Name: Breconshire

Contractor: KCI

Watershed: Little Patuxent River



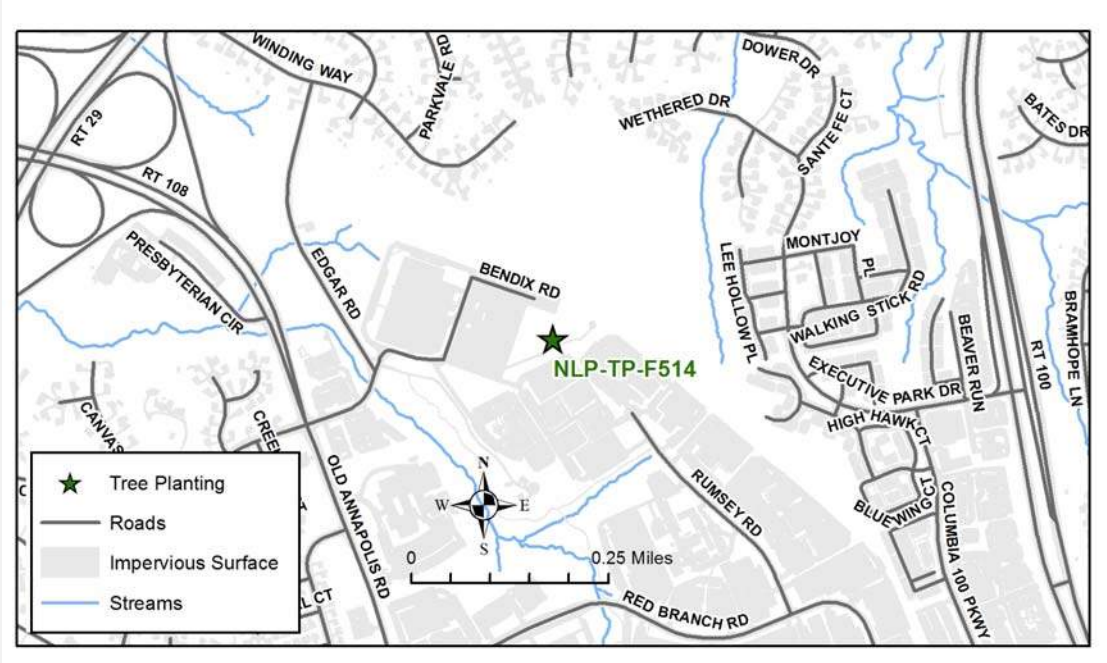
Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: NLP-TP-F514
Site Name: Thomas B. Dorsey Building
Contractor: KCI
Watershed: Little Patuxent River

Project Type: Tree Planting
Ownership: County Owned
Single Owner

Existing Conditions:

The Thomas B. Dorsey Building tree planting site consists of two areas. The southern portion of the site is currently an open mowed field. The northern portion of the site is an overgrown field with a stand of small Bradford pear trees. Other invasive species found include mile-a-minute and autumn olive. A stormwater management pond is present near the parking lot at the northern side of the site and the embankments of this pond should not be planted. Majority of the site receives full sun. Some areas appear to be used for storage.



Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: NLP-TP-F514

Site Name: Thomas B. Dorsey Building

Contractor: KCI

Watershed: Little Patuxent River

Site overview facing southwest at southern portion of planting area.

Site overview and view of Bradford pear tree stand facing east at northern portion of planting area.

Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: NLP-TP-F514
Site Name: Thomas B. Dorsey Building
Contractor: KCI
Watershed: Little Patuxent River

Constraints/Utilities:

A moderate amount of site preparation will be required and includes the removal of the Bradford pear trees and mowing of the site. The stormwater management pond basin should not be planted. A water line bisects the southern portion of the site; however, this would not likely greatly reduce the quantity of trees planted.

Concept Description:

Invasive species removal and tree planting is proposed on 5.58 ac. The stand of Bradford pear trees should be removed and the entire site will require mowing in preparation for the tree planting. A variety of native trees should be planted. Tree shelters should be installed to protect the trees from deer damage. Tree maintenance and inspections should be performed yearly, and should include the removal of invasive species and repair of tree shelters and stakes. Water will need to be transported to the site. The site can easily be accessed from the Thomas B. Dorsey building parking lot on Bendix Rd.

Nearby Opportunities:

NLP-NB-F548

Proposed Project Credit	
Planting Acres:	5.6
Impervious Area Treated Credit (ac.):	2.12
Cost per Impervious Credit Acre:	$114,211.32

Costs	
Estimated Design Cost:	$10,000.00
Estimated Construction Cost:	$178,560.00
30% Contingency:	$53,568.00
Estimated Total Cost:	$242,128.00

Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: NLP-TP-F514

Site Name: Thomas B. Dorsey Building

Contractor: KCI

Watershed: Little Patuxent River

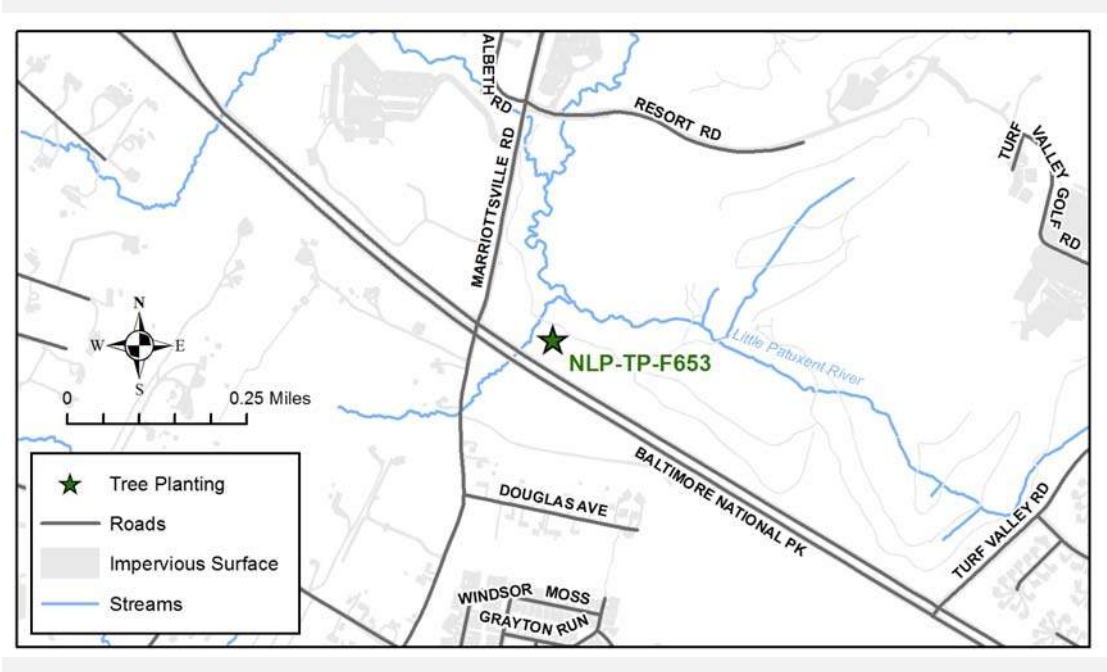
Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: NLP-TP-F653
Site Name: Turf Valley (e)
Contractor: KCI
Watershed: Little Patuxent River

Project Type: Tree Planting
Ownership: Private- Commercial/Industrial
Single Owner

Existing Conditions:

The Turf Valley tree planting site consists of one planting area on the Turf Valley property northeast of the intersection of Marriottsville Road and Baltimore National Pike. A stream bisects the planting area. The planting area is currently mowed and receives full sun. Multiflora rose was found throughout the planting area.



Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: NLP-TP-F653

Site Name: Turf Valley (e)

Contractor: KCI

Watershed: Little Patuxent River

Site overview of open field facing west from middle of planting area.

Site overview of open field facing east from middle of planting area.

Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: NLP-TP-F653
Site Name: Turf Valley (e)
Contractor: KCI
Watershed: Little Patuxent River

Constraints/Utilities:

No utilities have been found to conflict with the planting of this site. Site access directly from Marriottsville Road may be a constraint due to terrain and existing trees. Plans for future development of the property will need to be discussed with the owner prior to moving forward with this project.

Concept Description:

Invasive species removal and tree planting is proposed on 4.55 ac. The possibility for additional planting area exists east of the proposed tree planting area; however, this area needs to be investigated. A water line and gas right of way are known to be within the possible additional acreage to the east. The existing multiflora rose should be removed and the entire site will require mowing in preparation for the tree planting. A variety of native trees should be planted. Tree shelters should be installed to protect the trees from deer damage. Tree maintenance and inspections should be performed yearly, and should include the removal of invasive species and repair of tree shelters and stakes. Water will need to be transported to the site. The site may be able to be accessed from Marriottsville Road.

Nearby Opportunities:

NLP-SR-F504A, NLP-SR-F509A

Proposed Project Credit	
Planting Acres:	4.6
Impervious Area Treated Credit (ac.):	1.73
Cost per Impervious Credit Acre:	$115,190.75

Costs	
Estimated Design Cost:	$10,000.00
Estimated Construction Cost:	$145,600.00
30% Contingency:	$43,680.00
Estimated Total Cost:	$199,280.00

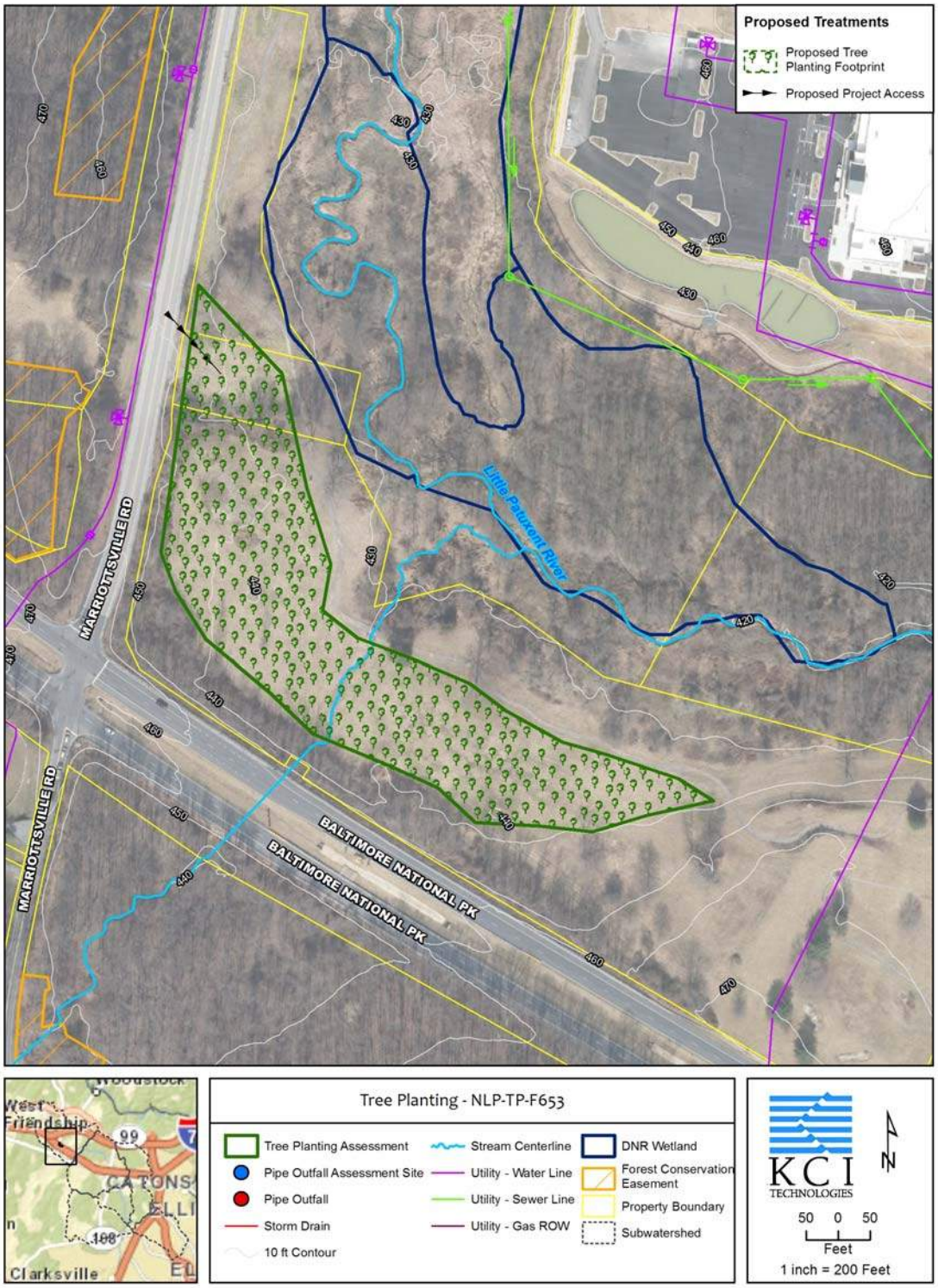
Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: NLP-TP-F653

Site Name: Turf Valley (e)

Contractor: KCI

Watershed: Little Patuxent River



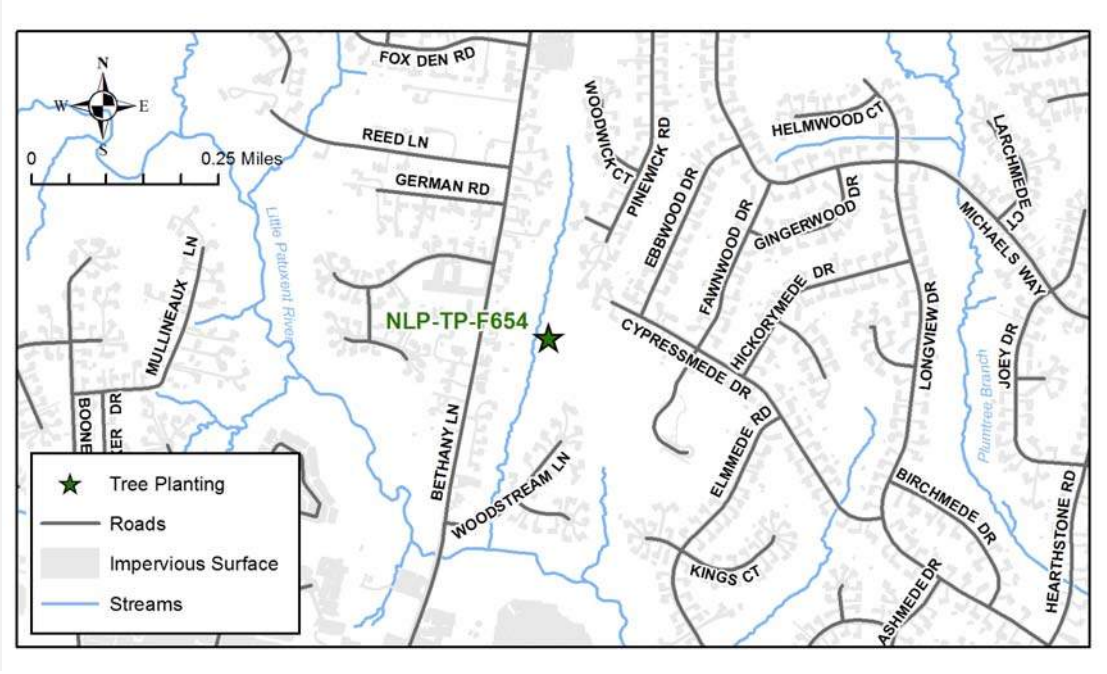
Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: NLP-TP-F654
Site Name: Bethany Lane
Contractor: KCI
Watershed: Little Patuxent River

Project Type: Tree Planting
Ownership: Private- Residential
Single Owner

Existing Conditions:

The Bethany Lane tree planting site consists of one planting area on a residential property on Bethany Lane. A stream bisects the planting area. A fenced pasture is on the western side of the stream and may be used by the homeowner. The planting area is currently mowed and receives full sun.



Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: NLP-TP-F654
Site Name: Bethany Lane
Contractor: KCI
Watershed: Little Patuxent River

View of proposed planting area within open field facing east from middle of planting area at stream.

View of proposed planting area within open field/pasture facing west from middle of planting area at stream.

Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: NLP-TP-F654
Site Name: Bethany Lane
Contractor: KCI
Watershed: Little Patuxent River

Constraints/Utilities:

Utility constraints include gas and sewer pipelines that bisect the planting area; however, these would not likely greatly reduce the quantity of trees planted. There is an outfall pipe on the western side of the stream in the center of the site. The storm drain infrastructure to this pipe will need to be investigated and if a storm drain pipe runs through the proposed planting area, a 20 ft. buffer should be placed over the storm drain pipe. Homeowner agreement will be required to plant this site. The fenced pasture may not be an option for planting. Access from the residential property at 3071 Bethany Lane may be limited by existing fences or buildings.

Concept Description:

Tree planting is proposed on 3.24 ac. Very little site preparation will be required. A variety of native trees should be planted. Tree shelters should be installed to protect the trees from deer damage. Tree maintenance and inspections should be performed yearly, and should include the removal of invasive species and repair of tree shelters and stakes. Water will need to be transported to the site. The site will need to be accessed from the residential property at 3071 Bethany Lane.

Nearby Opportunities:

NLP-SR-F551A

Proposed Project Credit	
Planting Acres:	3.2
Impervious Area Treated Credit (ac.):	1.23
Cost per Impervious Credit Acre:	$117,710.57

Costs	
Estimated Design Cost:	$10,000.00
Estimated Construction Cost:	$103,680.00
30% Contingency:	$31,104.00
Estimated Total Cost:	$144,784.00

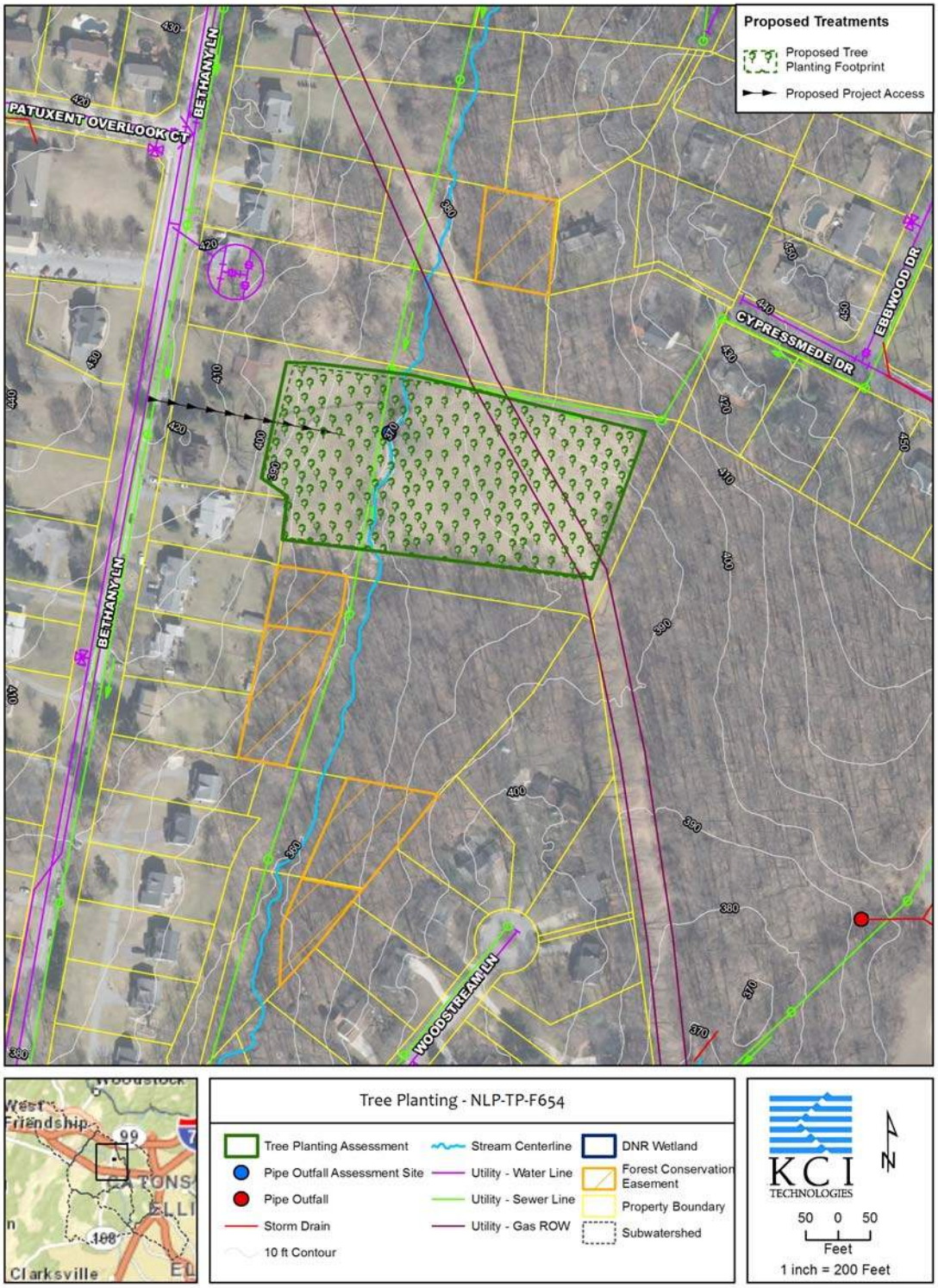
Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: NLP-TP-F654

Site Name: Bethany Lane

Contractor: KCI

Watershed: Little Patuxent River



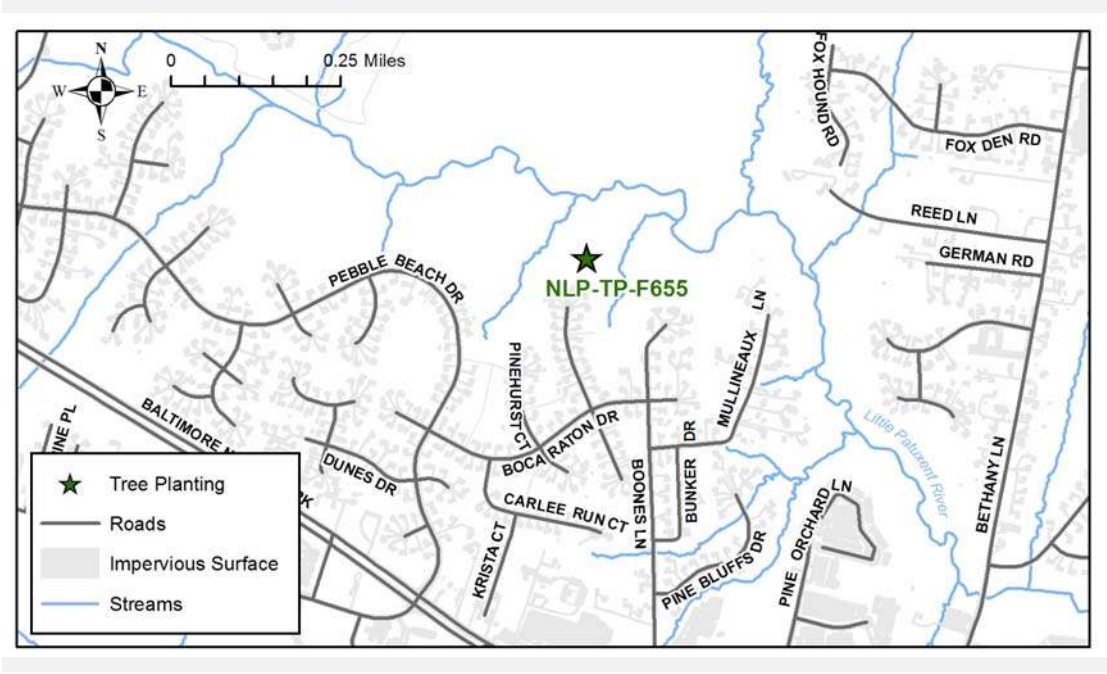
Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: NLP-TP-F655
Site Name: David W Force Park
Contractor: KCI
Watershed: Little Patuxent River

Project Type: Tree Planting
Ownership: County Owned
Single Owner

Existing Conditions:

The David W Force Park tree planting site consists of one planting area behind residential properties on the northern side of Congressional Court. The site is an overgrown field with scattered honey locust trees. Majority of the site receives full sun.



Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: NLP-TP-F655
Site Name: David W Force Park
Contractor: KCI
Watershed: Little Patuxent River

View of widespread invasive species facing north from middle of planting area.

View of existing trees and invasive species facing east from middle of planting area.

Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: NLP-TP-F655
Site Name: David W Force Park
Contractor: KCI
Watershed: Little Patuxent River

Constraints/Utilities:

A moderate amount of site preparation will be required and includes the removal of the honey locust trees and mowing of the site. No utilities have been found to conflict with the planting of this site.

Concept Description:

Invasive species removal and tree planting is proposed on 4.47 ac. This planting will extend the existing narrow riparian buffers of two tributaries to the Little Patuxent River. The existing honey locust trees should be removed and the entire site will require mowing in preparation for the tree planting. A variety of native trees should be planted. Tree shelters should be installed to protect the trees from deer damage. Tree maintenance and inspections should be performed yearly, and should include the removal of invasive species and repair of tree shelters and stakes. Water will need to be transported to the site. The site can be accessed from a walking path off Congressional Court.

Nearby Opportunities:

NLP-NB-D558, NLP-SR-F522A

Proposed Project Credit		Costs	
Planting Acres:	4.5	Estimated Design Cost:	$10,000.00
Impervious Area Treated Credit (ac.):	1.7	Estimated Construction Cost:	$143,040.00
Cost per Impervious Credit Acre:	$115,265.88	30% Contingency:	$42,912.00
		Estimated Total Cost:	$195,952.00

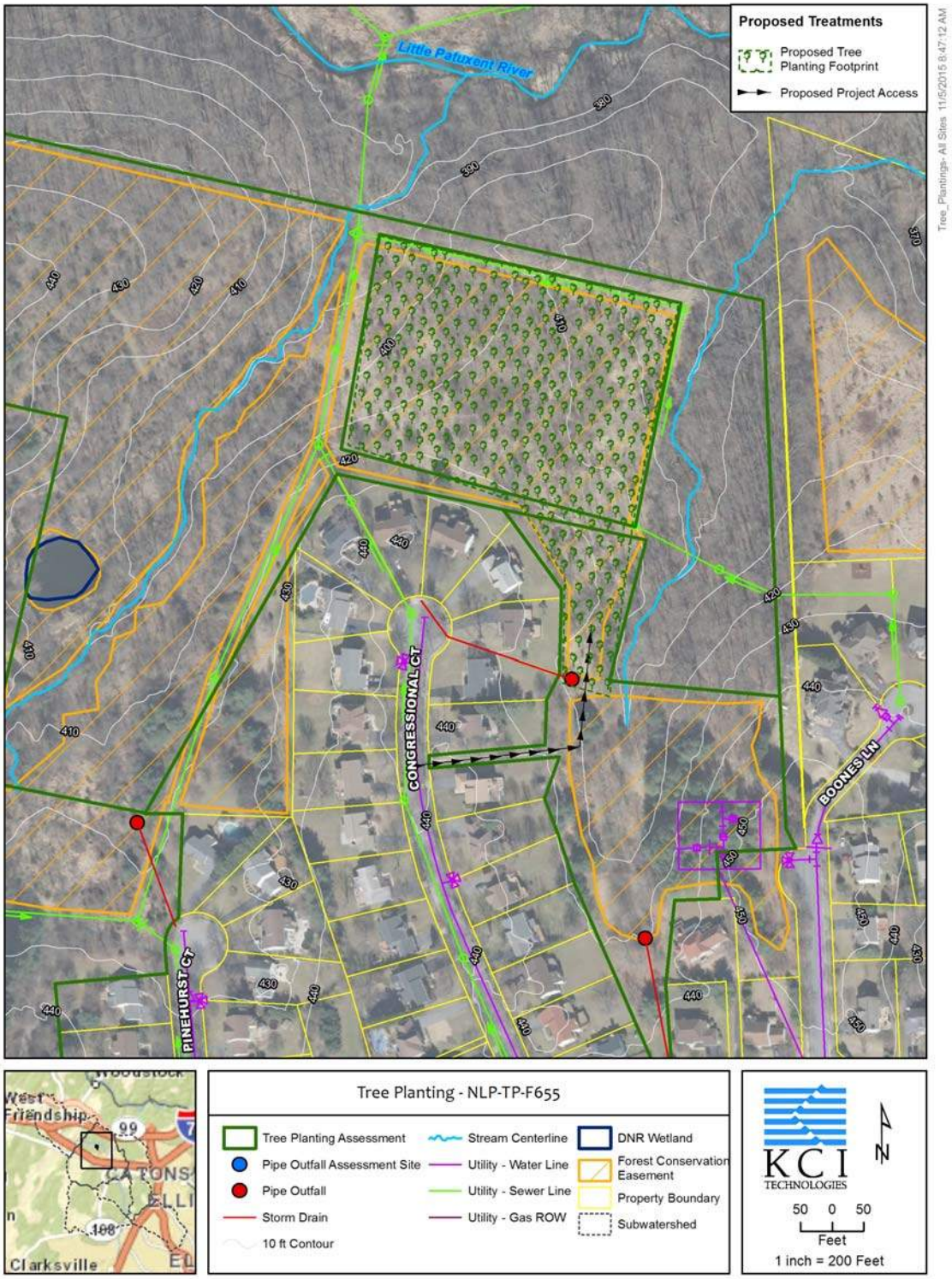
Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: NLP-TP-F655

Site Name: David W Force Park

Contractor: KCI

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SLP-TP-F701

Site Name: Forest Ridge Elementary School

Contractor: Versar

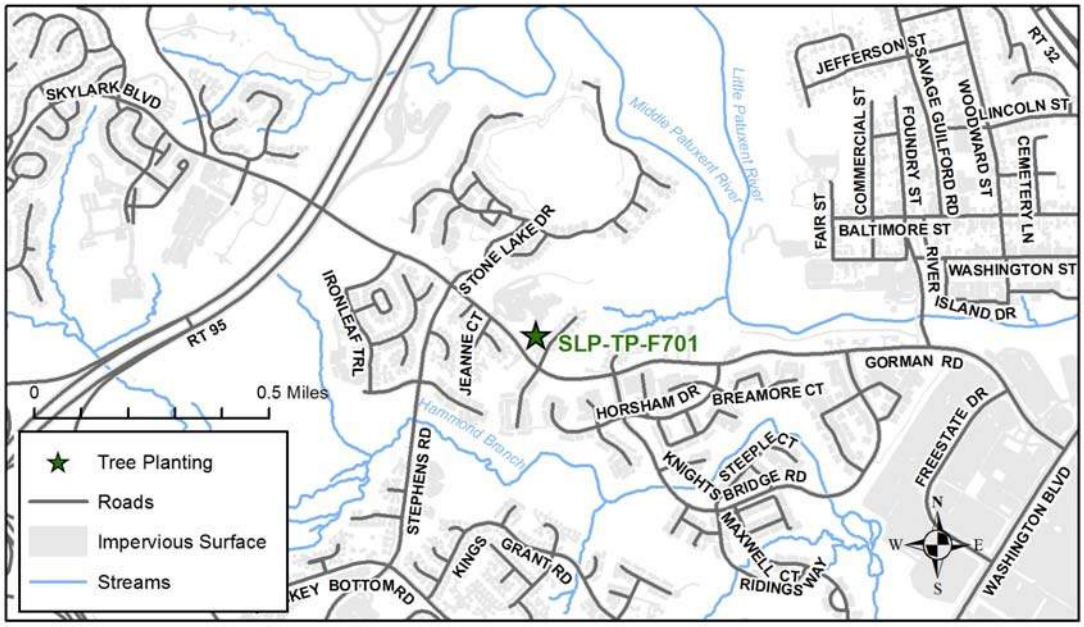
Watershed: Little Patuxent River

Project Type: Tree Planting

Ownership: Board of Education
Single Owner

Existing Conditions:

Howard County public school with a small existing wetland BMP stormwater pond on its southwest side, and baseball/playing fields on its north side.



Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SLP-TP-F701
Site Name: Forest Ridge Elementary School
Contractor: Versar
Watershed: Little Patuxent River

View looking southeast along Gorman Road, at the edge of the existing wetland BMP.

View looking northeast along the northeastern boundary of the site, at the narrow tree planting parcel.

Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SLP-TP-F701
Site Name: Forest Ridge Elementary School
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:

Plans for tree planting at the school need to be vetted with Howard County Schools, for safety issues, other potential intended land uses, etc.

Concept Description:

The concept here would be to plant trees along the southern and eastern sides of the existing wetland BMP, and then extending to the north along the eastern boundary of the school. The trees could be planted with very little, if any, site preparation. Access to the planting parcel is good, and no utilities appeared to be within the planting areas. Although somewhat compacted in some areas, the site soils appeared to be suitable for tree planting. Another potential tree planting parcel exists along the eastern edge of the ball fields on the northeastern side of the school.

Nearby Opportunities:

None recommended

Proposed Project Credit	
Planting Acres:	1.9
Impervious Area Treated Credit (ac.):	0.73
Cost per Impervious Credit Acre:	$122,542.47

Costs	
Estimated Design Cost:	$10,000.00
Estimated Construction Cost:	$61,120.00
30% Contingency:	$18,336.00
Estimated Total Cost:	$89,456.00

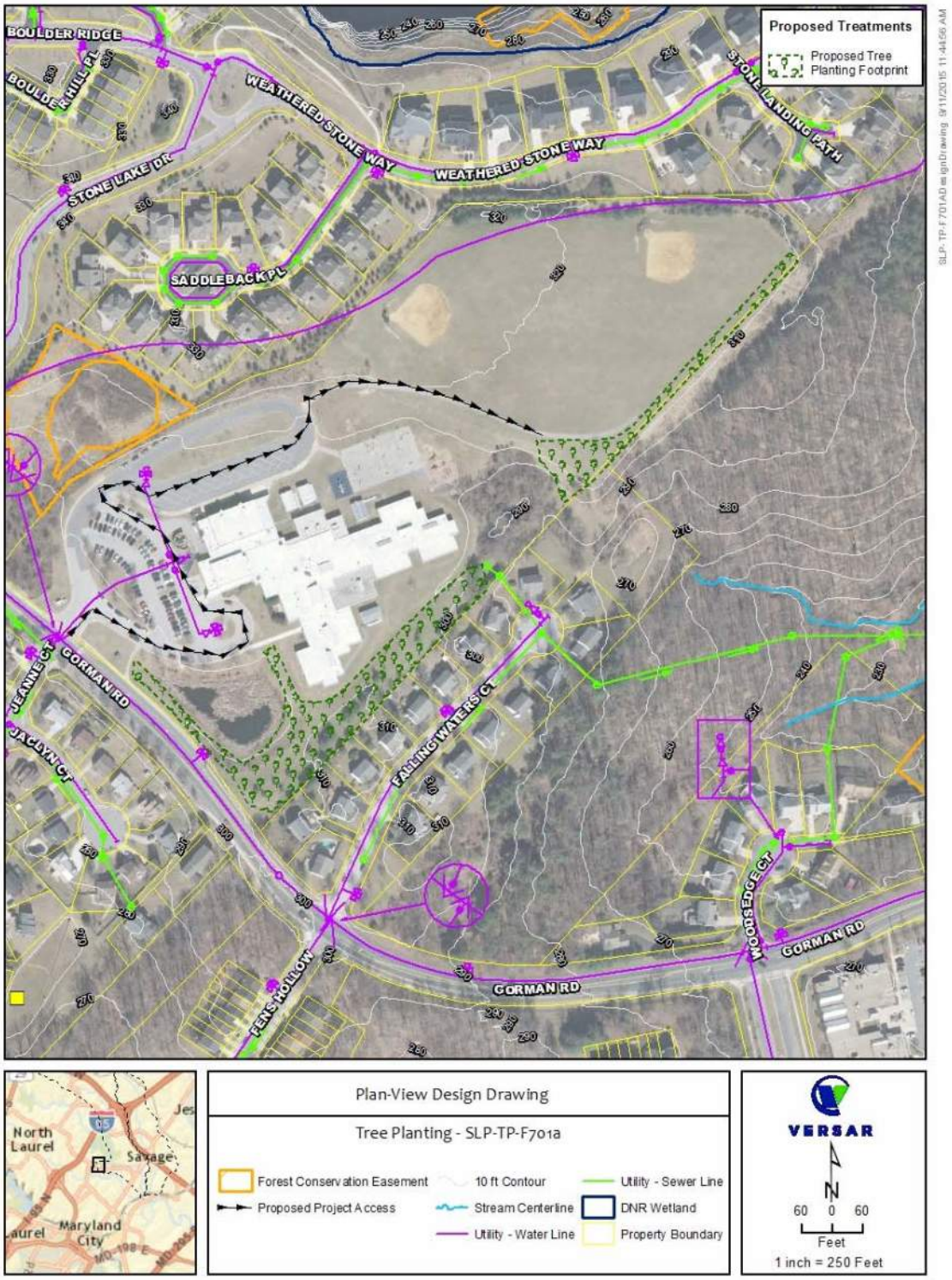
Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SLP-TP-F701

Site Name: Forest Ridge Elementary School

Contractor: Versar

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Tree Planting

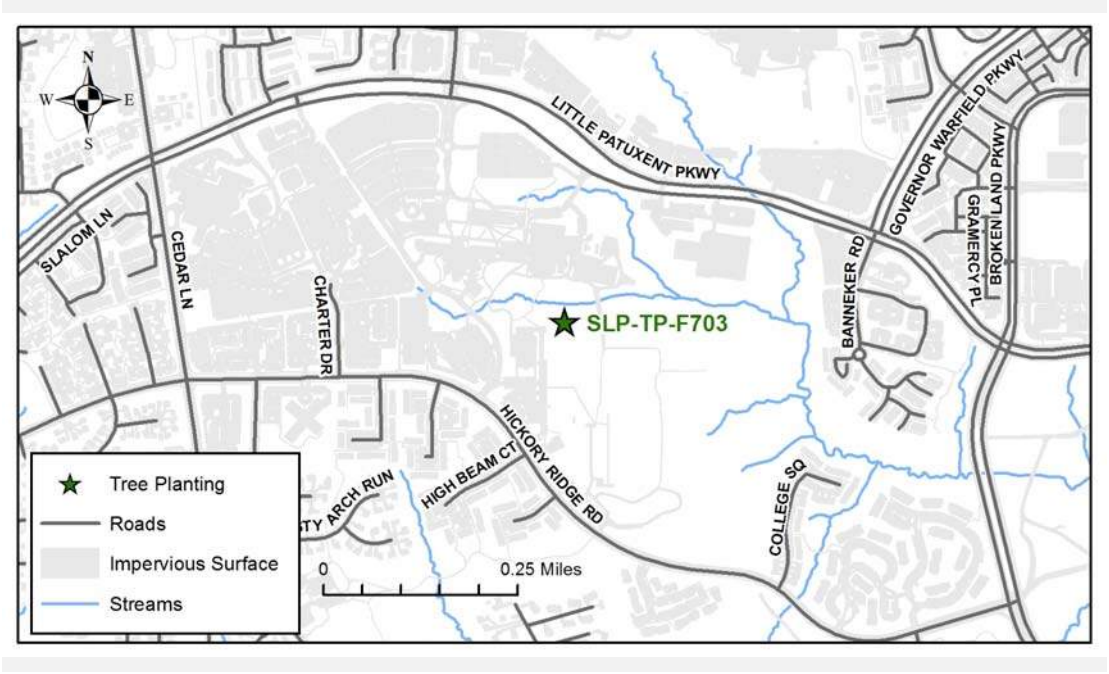
Site ID: SLP-TP-F703
Site Name: Howard Community College
Contractor: Versar
Watershed: Little Patuxent River

Project Type: Tree Planting

Ownership: Howard Community College
Single Owner

Existing Conditions:

Community college on a large property with three tree planting parcels on its north side, and another tree planting parcel on its south side. The existing wooded parcels are somewhat degraded, and contain large numbers of non-native invasive plant species.



Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SLP-TP-F703
Site Name: Howard Community College
Contractor: Versar
Watershed: Little Patuxent River

View looking northeast into existing wooded area along stream in northern part of the site.

View looking northwest into existing wooded area along stream in northern part of the site.

Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SLP-TP-F703
Site Name: Howard Community College
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:

Plans for tree planting at the college need to be vetted with Howard Community College, for safety issues, other potential intended land uses, etc. Some steep slopes exist along the existing wetland BMP; these should not be planted with trees. A sewer line passes through a portion of the northern proposed tree planting areas.

Concept Description:

The concept here would be to plant trees along the periphery of the existing wetland BMP, and then along the edges of two degraded wooded areas to its east. The third tree planting parcel exists to the immediate south of the track. The trees could be planted with very little, if any, site preparation. Access to the planting parcel is good. Although somewhat compacted in some areas, the site soils appeared to be suitable for tree planting. Some invasive species removal may be prudent in all three planting parcels.

Nearby Opportunities:

None recommended

Proposed Project Credit	
Planting Acres:	5.2
Impervious Area Treated Credit (ac.):	1.96
Cost per Impervious Credit Acre:	$114,408.16

Costs	
Estimated Design Cost:	$10,000.00
Estimated Construction Cost:	$164,800.00
30% Contingency:	$49,440.00
Estimated Total Cost:	$224,240.00

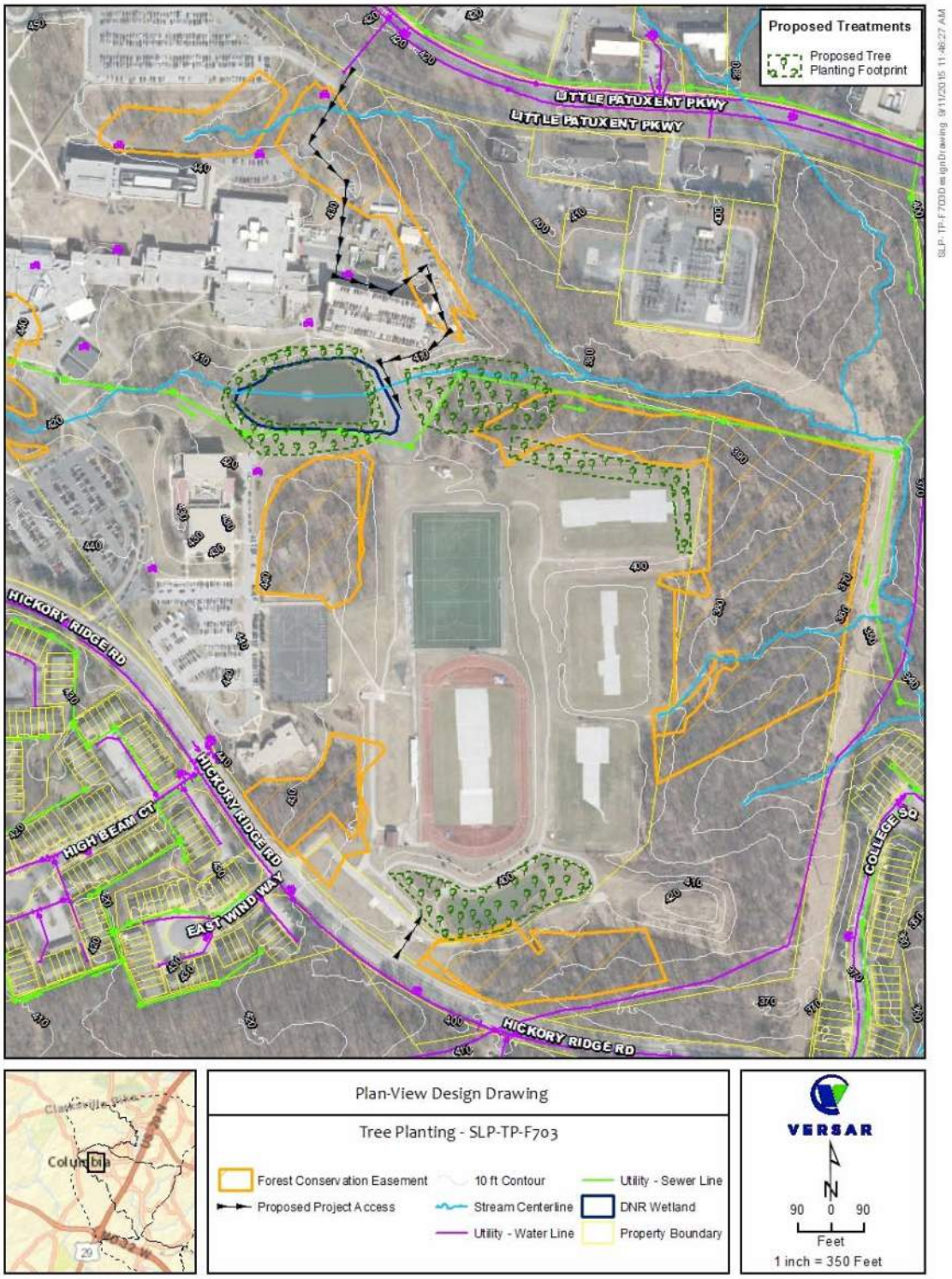
Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SLP-TP-F703

Site Name: Howard Community College

Contractor: Versar

Watershed: Little Patuxent River



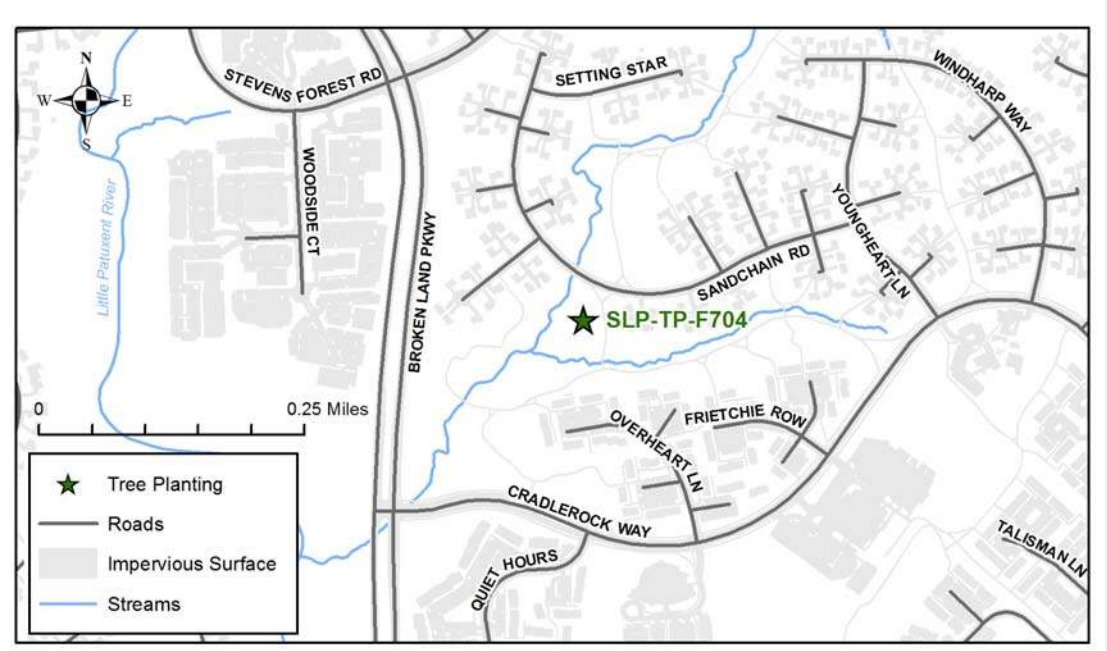
Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SLP-TP-F704
Site Name: Sand Chain Road
Contractor: Versar
Watershed: Little Patuxent River

Project Type: Tree Planting
Ownership: Columbia Association
Single Owner

Existing Conditions:

Two open, maintained lawn areas along the Columbia Association paths. Parts of the northern parcel likely contains nontidal wetlands.



Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SLP-TP-F704
Site Name: Sand Chain Road
Contractor: Versar
Watershed: Little Patuxent River

View looking southwest through southern-most tree planting parcel. Note broad, rather flat conditions over most of this site.

View looking north through northern-most planting parcel, toward Sandchain Road. Area with small trees along left site of photo likely contains nontidal wetlands.

Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SLP-TP-F704
Site Name: Sand Chain Road
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:

Plans for tree planting at this site need to be vetted with the Columbia Association, for access issues, other potential intended land uses, etc.

Concept Description:

The concept here would be to plant a mix of native trees in two lawn areas along the Columbia Association path that are currently regularly mowed. The trees could be planted with very little, if any, site preparation. Access to the planting parcel is good, and no utilities appeared to be within the planting areas. Although somewhat compacted in some areas, the site soils appeared to be suitable for tree planting.

Nearby Opportunities:

None recommended

Proposed Project Credit	
Planting Acres:	1.4
Impervious Area Treated Credit (ac.):	0.54
Cost per Impervious Credit Acre:	$128,681.48

Costs	
Estimated Design Cost:	$10,000.00
Estimated Construction Cost:	$45,760.00
30% Contingency:	$13,728.00
Estimated Total Cost:	$69,488.00

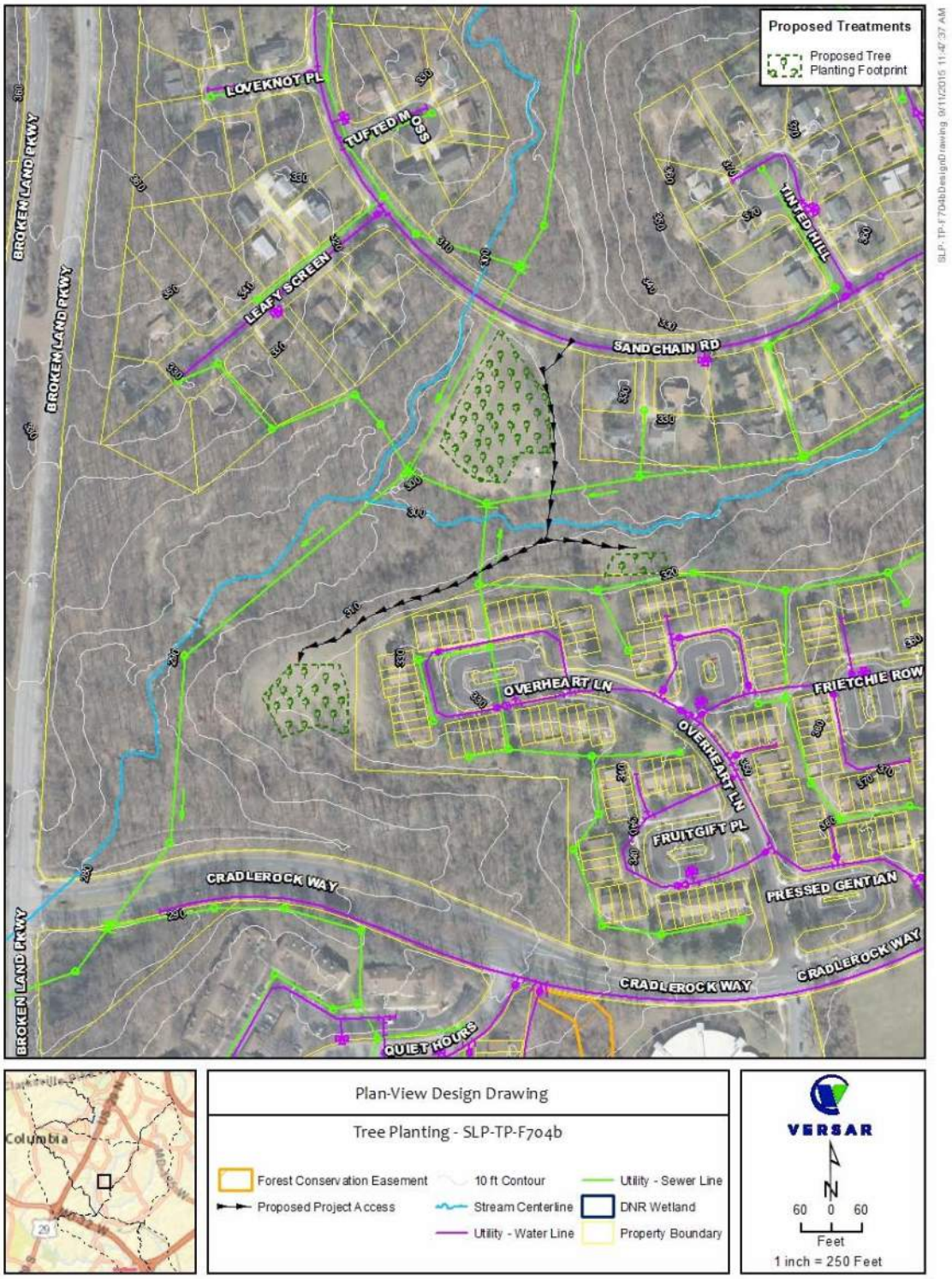
Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SLP-TP-F704

Site Name: Sand Chain Road

Contractor: Versar

Watershed: Little Patuxent River



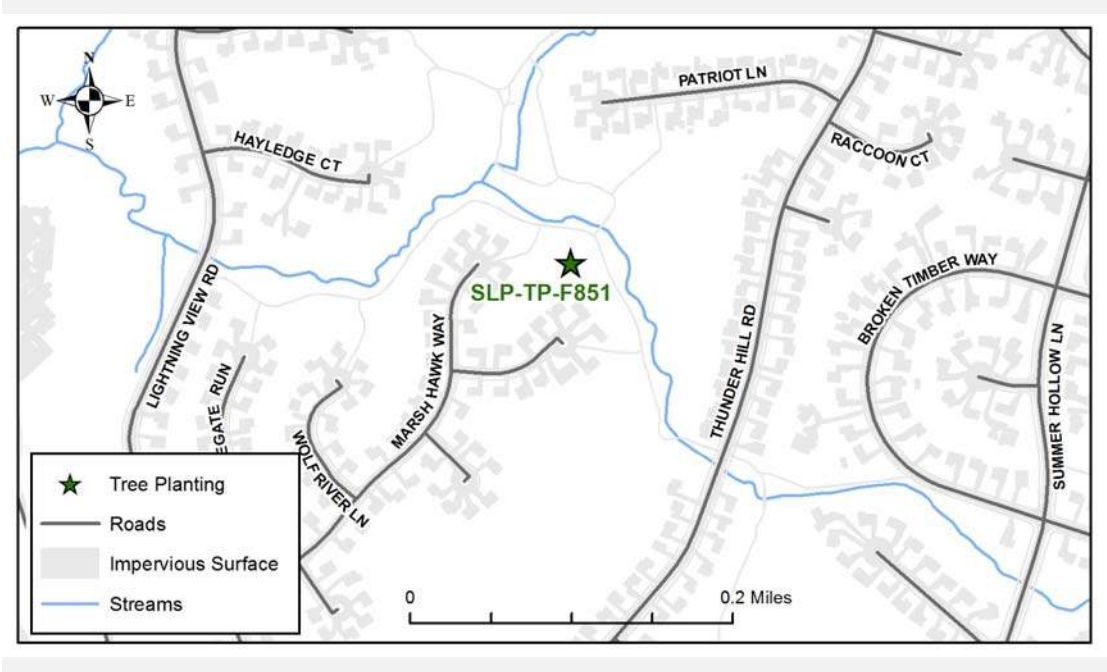
Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SLP-TP-F851
Site Name: Marsh Hawk Way
Contractor: Versar
Watershed: Little Patuxent River

Project Type: Tree Planting
Ownership: Columbia Association
Single Owner

Existing Conditions:

One open, maintained lawn area along the Columbia Association path at Marsh Hawk Way. The northern-most part of the parcel likely contains nontidal wetlands.



Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SLP-TP-F851

Site Name: Marsh Hawk Way

Contractor: Versar

Watershed: Little Patuxent River

View looking northeast through tree planting parcel. Note broad, rather flat open conditions over most of this site.

View looking south near the southern edge of the tree planting parcel. Note the proximity to the Columbia Association path and the existing houses.

Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SLP-TP-F851
Site Name: Marsh Hawk Way
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:

Plans for tree planting at this site need to be vetted with the Columbia Association, for access issues, other potential intended land uses, etc. A sewer line passes through the northeastern portion of the proposed planting area.

Concept Description:

The concept here would be to plant a mix of native trees in a large open lawn area along the Columbia Association path that is currently regularly mowed. The trees could be planted with very little, if any, site preparation. Access to the planting parcel is good. Although somewhat compacted in some areas, the site soils appeared to be suitable for tree planting.

Nearby Opportunities:

None recommended

Proposed Project Credit	
Planting Acres:	1
Impervious Area Treated Credit (ac.):	0.36
Cost per Impervious Credit Acre:	$137,555.56

Costs	
Estimated Design Cost:	$10,000.00
Estimated Construction Cost:	$30,400.00
30% Contingency:	$9,120.00
Estimated Total Cost:	$49,520.00

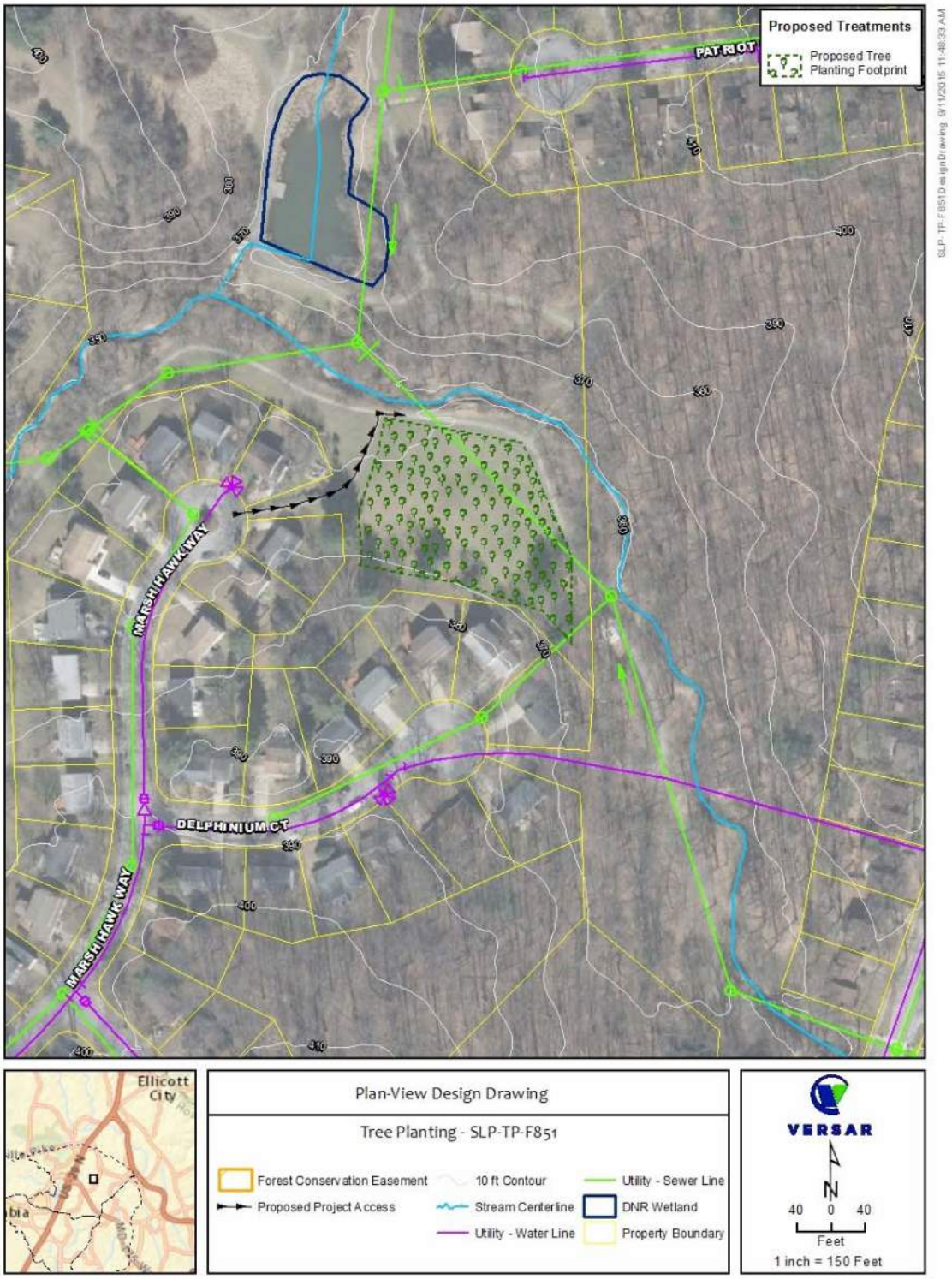
Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SLP-TP-F851

Site Name: Marsh Hawk Way

Contractor: Versar

Watershed: Little Patuxent River



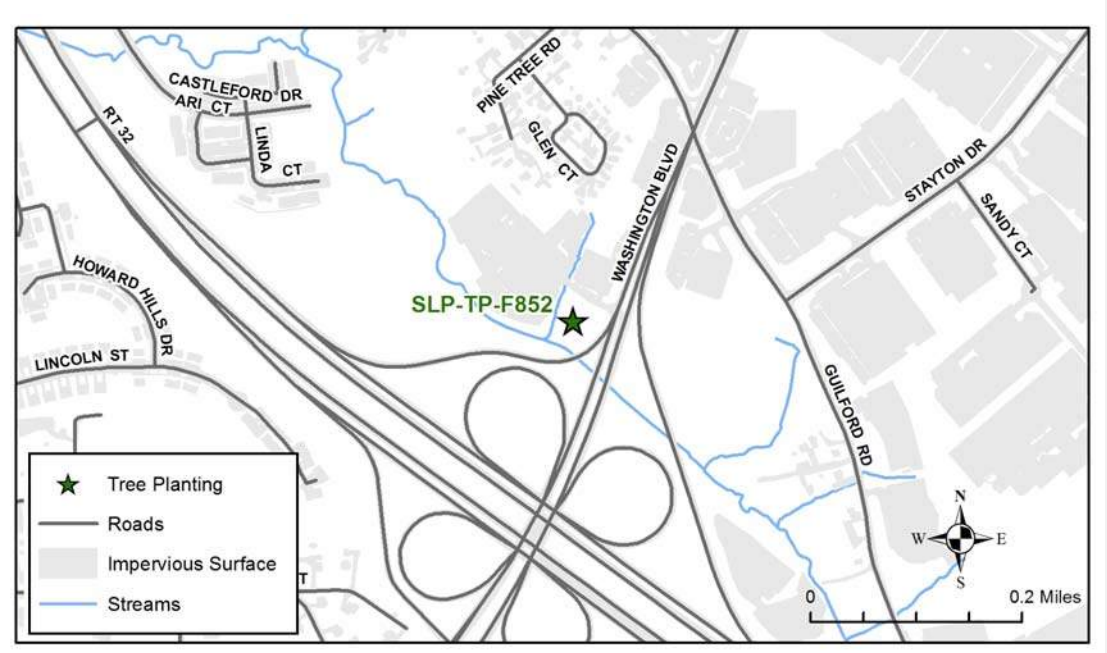
Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SLP-TP-F852
Site Name: Crossroads Business Park
Contractor: Versar
Watershed: Little Patuxent River

Project Type: Tree Planting
Ownership: Private- Commercial/Industrial
Single Owner

Existing Conditions:

One large open, regularly maintained lawn area on an industrial parcel, next to Route 1. Some recently planted tree saplings are located adjacent to the site and are associated with an existing stream restoration project.



Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SLP-TP-F852
Site Name: Crossroads Business Park
Contractor: Versar
Watershed: Little Patuxent River

View looking west through the tree planting parcel, at some of the existing buildings just off site.

View looking east through the tree planting parcel, toward Route 1, just off site.

Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SLP-TP-F852
Site Name: Crossroads Business Park
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:

Plans for tree planting at this site need to be vetted with the private land owner, for access issues, other potential intended land uses, etc. A sewer line passes through the western and southern portions of the proposed tree planting area.

Concept Description:

The concept here would be to plant a mix of native trees on a large open lawn area in this open site that is currently regularly mowed. The trees could be planted with very little, if any, site preparation. Access to the planting parcel is good. Although somewhat compacted in some areas, the site soils appeared to be suitable for tree planting.

Nearby Opportunities:

None recommended

Proposed Project Credit	
Planting Acres:	0.7
Impervious Area Treated Credit (ac.):	0.26
Cost per Impervious Credit Acre:	$145,661.54

Costs	
Estimated Design Cost:	$10,000.00
Estimated Construction Cost:	$21,440.00
30% Contingency:	$6,432.00
Estimated Total Cost:	$37,872.00

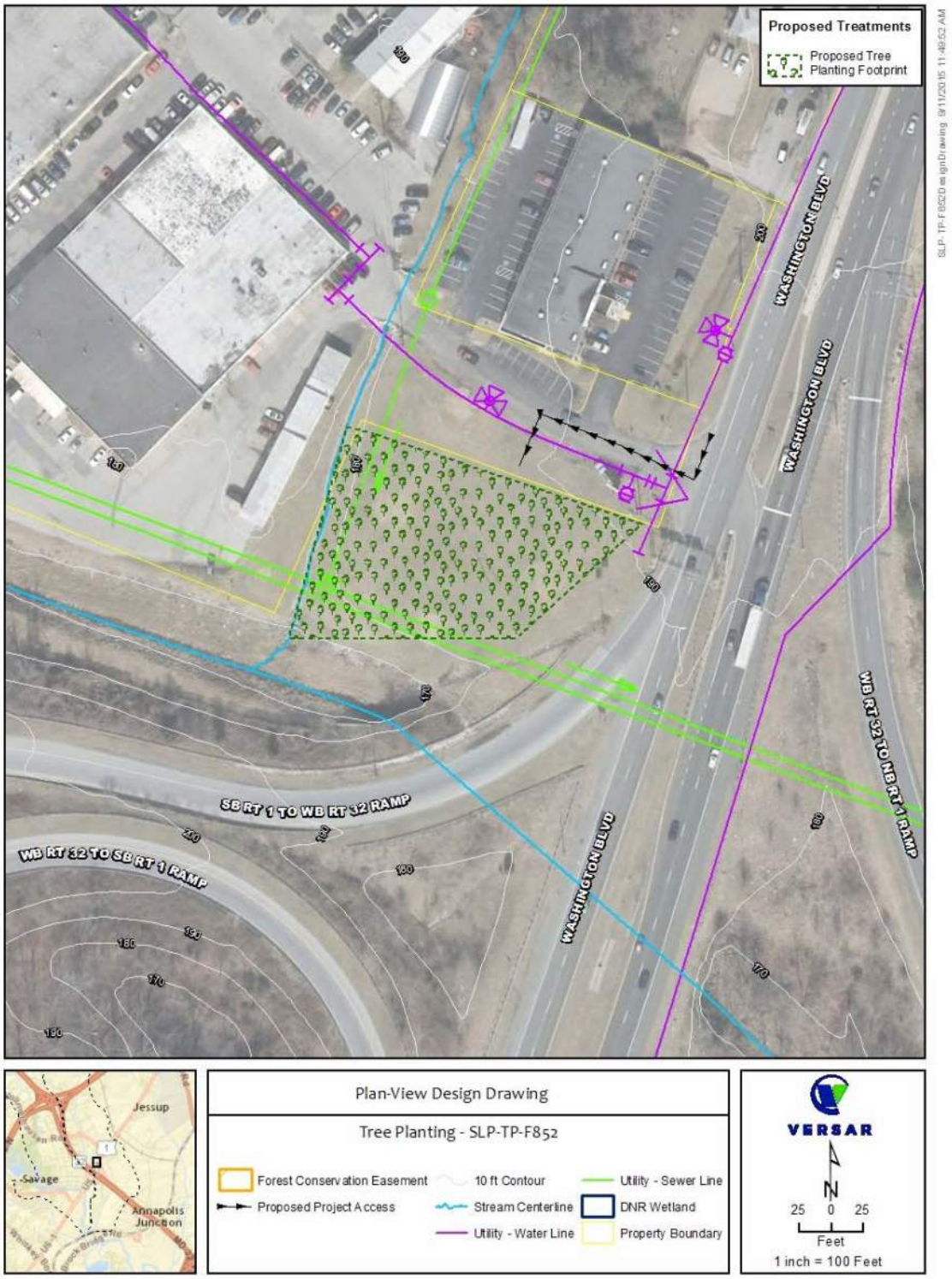
Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SLP-TP-F852

Site Name: Crossroads Business Park

Contractor: Versar

Watershed: Little Patuxent River



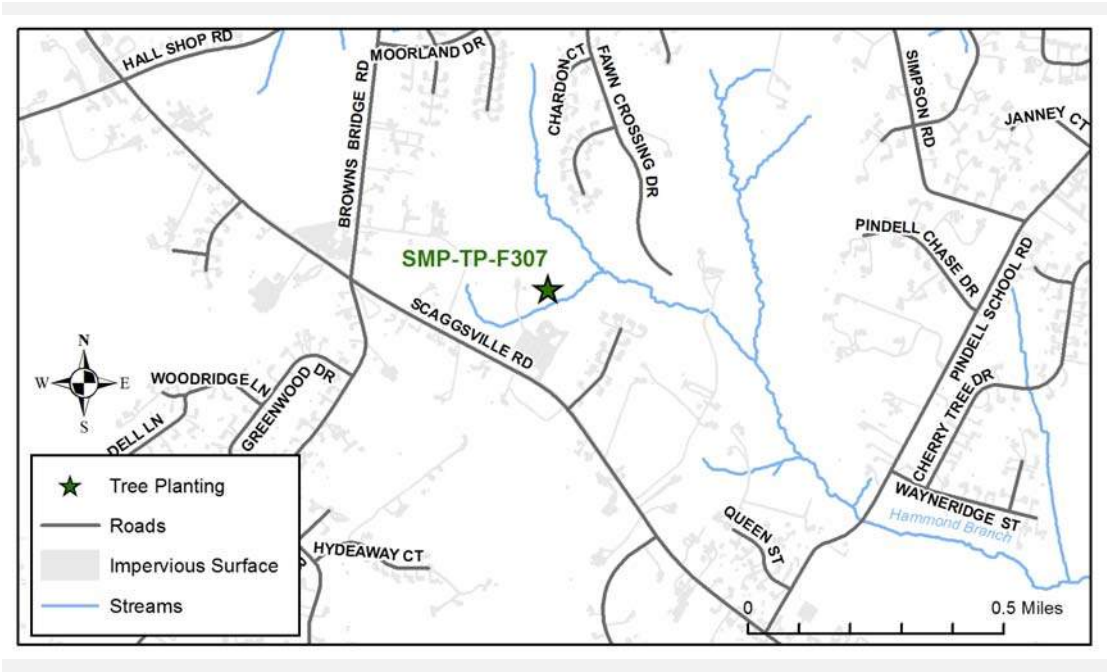
Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SMP-TP-F307
Site Name: Temple Isaiah
Contractor: Biohabitats
Watershed: Little Patuxent River

Project Type: Tree Planting
Ownership: Private- Mixed Use
Single Owner

Existing Conditions:

The site is the Temple Isaiah. Approximately a third of the property is occupied by the church, a house, and parking lots while the remainder of the property is open space and forest. The current vegetation cover is 50% trees, 25% turf, and 25% other herbaceous plants. Existing forest conservation easements are also present on the site. There is also evidence of recent tree plantings in the northern-most portion of the site. Forest consisting of southern red oak (Quercus falcata), white oak (Quercus alba), and maples (Acer sp.) is adjacent to the site to the north and east. Multiflora rose (Rosa multiflora) is also present in the adjacent forest covering roughly 5%. The site is located in an upland landscape with non-compacted and loamy textured soil. The regional forest association, which indicates the climax or dominant species for an area, is Appalachian Oak.



Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SMP-TP-F307
Site Name: Temple Isaiah
Contractor: Biohabitats
Watershed: Little Patuxent River

Western portion of tree planting area wrapping around the main parking lot and building looking north.

Eastern portion of tree planting area wrapping around the main parking lot and building looking south towards Scaggsville Road.

Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SMP-TP-F307
Site Name: Temple Isaiah
Contractor: Biohabitats
Watershed: Little Patuxent River

Constraints/Utilities:

Constraints at the site include current mowing practices and wildlife (i.e. deer). In addition, space for proposed planting areas at the site is limited by existing forest conservation easements and other previous tree plantings.

Concept Description:

The proposed project consists of two tree planting areas totaling 6.57 ac. One 2.91 ac. planting area is located on the southern portion of the site wrapping around three sides of a large parking lot and around the side of the main temple facility. This area is currently maintained as mowed turf. A second 3.66 ac. planting area is located on the northern portion of the site surrounding a house associated with the temple. The second planting areas is currently maintained as mowed turf with a few groupings of trees.

The proposed planting areas receive full sun. There is also no evidence at the proposed tree planting areas of erosion, contamination or debris. While some stormwater from the parking lot bypasses the southern planting area site via piping, there is sheet flow to the southern planting area from the adjacent parking lot. No stormwater runoff was observed to be directed toward the northern tree planting area.

The site provides access for delivery, temporary storage, as well as foot, vehicle, and heavy equipment traffic. The project has possible educational potential due to its location on a temple property.

Potential water sources for the proposed tree planting project include rainfall, stormwater runoff, nearby hose hook up, and tanker water delivery. Medium site preparation would be required, primarily consisting of invasives removal of multiflora rose which covers approximately 5% of the planting areas.

The concept proposes planting a mix of native tree species saplings. Deer are active in the area; therefore, newly planted trees would need to be protected from potential wildlife impacts using appropriate fencing, tree protectors, repellents, etc. The existing trees within the planting areas could be preserved as long as trees are healthy and not an invasive species. A few existing trees noted for preservation surrounding the house included pin oak (Quercus palustris), white pine (Pinus strobus), cedar (Cedrus sp.) and hickory (Carya sp.).

Nearby Opportunities:

None recommended

Proposed Project Credit	
Planting Acres:	6.6
Impervious Area Treated Credit (ac.):	2.5
Cost per Impervious Credit Acre:	$113,324.80

Costs	
Estimated Design Cost:	$10,000.00
Estimated Construction Cost:	$210,240.00
30% Contingency:	$63,072.00
Estimated Total Cost:	$283,312.00

Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SMP-TP-F307

Site Name: Temple Isaiah

Contractor: Biohabitats

Watershed: Little Patuxent River

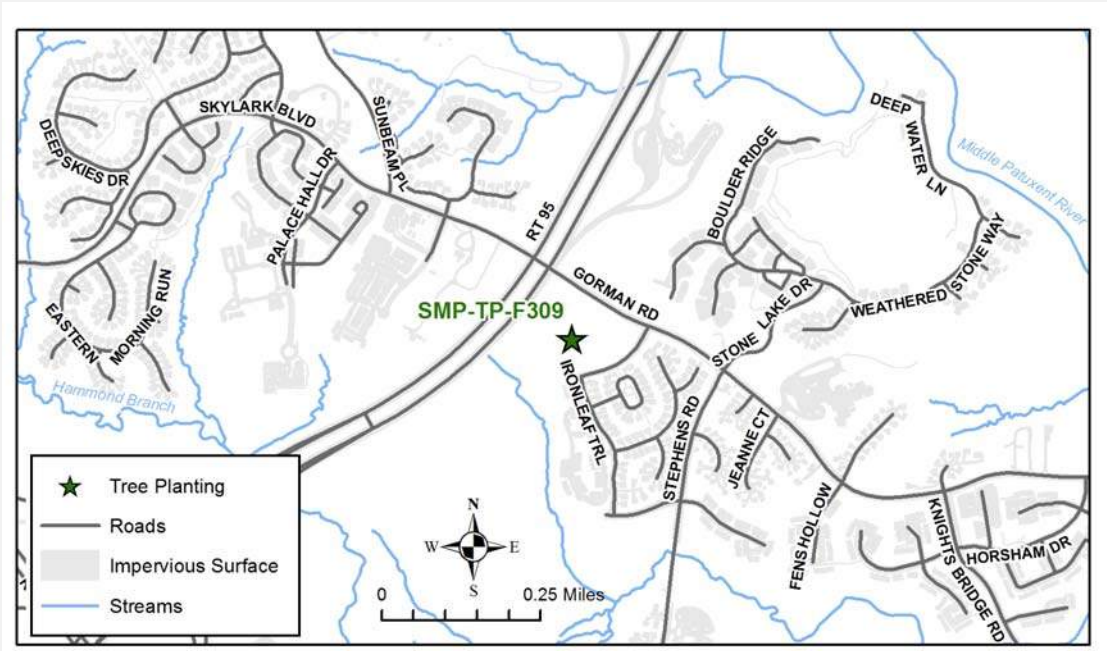
Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SMP-TP-F309
Site Name: Eternal Rings Road
Contractor: Biohabitats
Watershed: Little Patuxent River

Project Type: Tree Planting
Ownership: Private- Commercial/Industrial
Single Owner

Existing Conditions:

The site is a privately owned vacant lot. At the time of assessment a sign for leasing commercial space was present. The current vegetative cover is 20% trees and 80% other herbaceous plants. Existing forest conservation easements are present at the site. Forest consisting of red maple (Acer rubrum) is adjacent to the site to the west and southwest. The adjacent forest is 75% covered with invasive species including mile-a-minute (Persicaria perfoliata), Japanese honeysuckle (Lonicera japonica), multiflora rose (Rosa multiflora), and Japanese stiltgrass (Microstegium vimineum). The site is located in an upland landscape with non-compacted and loamy textured soil. The regional forest association, which indicates the climax or dominant species for an area, is Appalachian Oak.



Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SMP-TP-F309

Site Name: Eternal Rings Road

Contractor: Biohabitats

Watershed: Little Patuxent River

Tree planting area adjacent to Eternal Rings Road looking northeast. Eternal Rings Road is on the right.

Tree planting area looking north towards Gorman Road.

Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SMP-TP-F309
Site Name: Eternal Rings Road
Contractor: Biohabitats
Watershed: Little Patuxent River

Constraints/Utilities:

Constraints at the site include current mowing practices and wildlife (i.e. deer). In addition, the site is a privately owned, commercial vacant land that could have plans for development.

Concept Description:

The proposed project consists of one tree planting area that is 11.1 ac. The planting area is currently a vacant lot that is mowed periodically.

The proposed planting area receives full sun and high wind exposure is present. There are no steep slopes (greater the 15%) or low lying areas within the planting area. There is also no evidence of erosion, contamination or debris within the proposed planting area. Stormwater runoff is directed across the planting area via an open channel or drainage swale located in the southern portion of the site.

The site provides access for delivery, temporary storage, as well as foot, vehicle, and heavy equipment traffic. The project has possible educational potential due to its location near the entrance of and adjacent to a residential community.

Potential water sources for the proposed tree planting project include rainfall, nearby hydrant hook up, and tanker water delivery. No site preparation would be required because the tree planting area is periodically mowed with no invasives present.

The concept proposes planting a mix of native tree species saplings. Deer are active in the area; therefore, newly planted trees would need to be protected from potential wildlife impacts using appropriate fencing, tree protectors, repellents, etc.

Nearby Opportunities:

None recommended

Proposed Project Credit	
Planting Acres:	11
Impervious Area Treated Credit (ac.):	4.22
Cost per Impervious Credit Acre:	$111,890.05

Costs	
Estimated Design Cost:	$10,000.00
Estimated Construction Cost:	$355,520.00
30% Contingency:	$106,656.00
Estimated Total Cost:	$472,176.00

Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SMP-TP-F309

Site Name: Eternal Rings Road

Contractor: Biohabitats

Watershed: Little Patuxent River

Howard County Watershed Assessment Concept Plan: Tree Planting

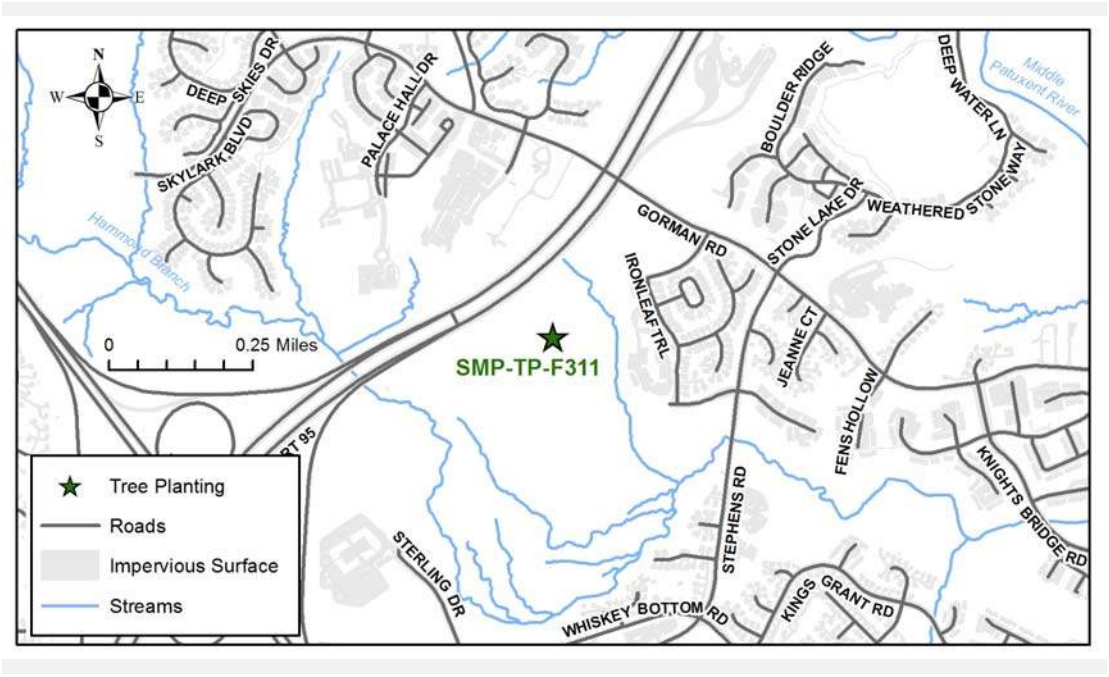
Site ID: SMP-TP-F311
Site Name: Northern Lakes
Contractor: Biohabitats
Watershed: Little Patuxent River

Project Type: Tree Planting

Ownership: Private- Commercial/Industrial
Single Owner

Existing Conditions:

The site is a privately owned vacant lot. The current vegetative type is 25% trees and 75% other herbaceous plants. Forest consisting of red maple (Acer rubrum), black walnut (Juglans nigra), and tulip poplar (Liriodendron tulipifera) is adjacent to the site. The adjacent forest is 75% covered with invasive species including Japanese honeysuckle (Lonicera japonica) and Japanese stilt grass (Microstegium vimineum). The site is located in an upland landscape with non-compacted and loamy textured soil. The regional forest association, which indicates the climax or dominant species for an area, is Appalachian Oak.



Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SMP-TP-F311
Site Name: Northern Lakes
Contractor: Biohabitats
Watershed: Little Patuxent River

Northern tree planting area looking east towards Northern Lakes Lane.

Southern tree planting area looking south toward power lines.

Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SMP-TP-F311
Site Name: Northern Lakes
Contractor: Biohabitats
Watershed: Little Patuxent River

Constraints/Utilities:

Constraints at the site include current mowing practices and wildlife (i.e. deer). In addition, the property is privately owned with limited access due to existing utilities and distance from a main road.

Concept Description:

The proposed project consists of two tree planting areas totaling 20.12 ac. One 16.27 ac. planting area is located on the northern portion of the site and another 3.85 ac. planting areas is located on the southern portion of the site. The two areas are mostly separated by existing forest. The proposed planting areas appear to be periodically mowed. Existing forest conservation areas are also present along various portions of the proposed planting areas. The proposed project includes tree planting in portions of existing forest conservation areas that are not currently planted.

The proposed planting area receives full sun and a high wind exposure is present. There are no steep slopes (greater the 15%) or low lying areas. There is no evidence at the site of erosion, contamination, or debris within the planting area. Stormwater is directed to the planting areas through shallow concentrated overland flow such as rills.

A BGE electric transmission line and right-of-way borders the southern planting area and could provide access to the planting site. The BGE right of way can be accessed 0.4 miles east of the site at Stephens Road. This access would allow for delivery, temporary storage, as well as vehicle and heavy equipment traffic. Foot traffic would be limited due to the distance from Stephens Road to the site. The project doesn't have educational potential due to its more remote location. Alternate site access from Northern Lakes Lane would require crossing a stream and from I-95 would likely require a traffic control plan.

Potential water sources for the proposed tree planting project is limited to rainfall and tanker water delivery. No site preparation would be required because tree planting areas are periodically mowed with no invasives present.

The concept proposes planting a mix of native tree species saplings. Deer are active in the area; therefore, newly planted trees would need to be protected from potential wildlife impacts using appropriate fencing, tree protectors, repellents, etc. Existing trees within the planting areas could be preserved as long as trees are healthy and not an invasive species.

Nearby Opportunities:

None recommended

Proposed Project Credit	
Planting Acres:	20
Impervious Area Treated Credit (ac.):	7.65
Cost per Impervious Credit Acre:	$110,717.91

Costs	
Estimated Design Cost:	$10,000.00
Estimated Construction Cost:	$643,840.00
30% Contingency:	$193,152.00
Estimated Total Cost:	$846,992.00

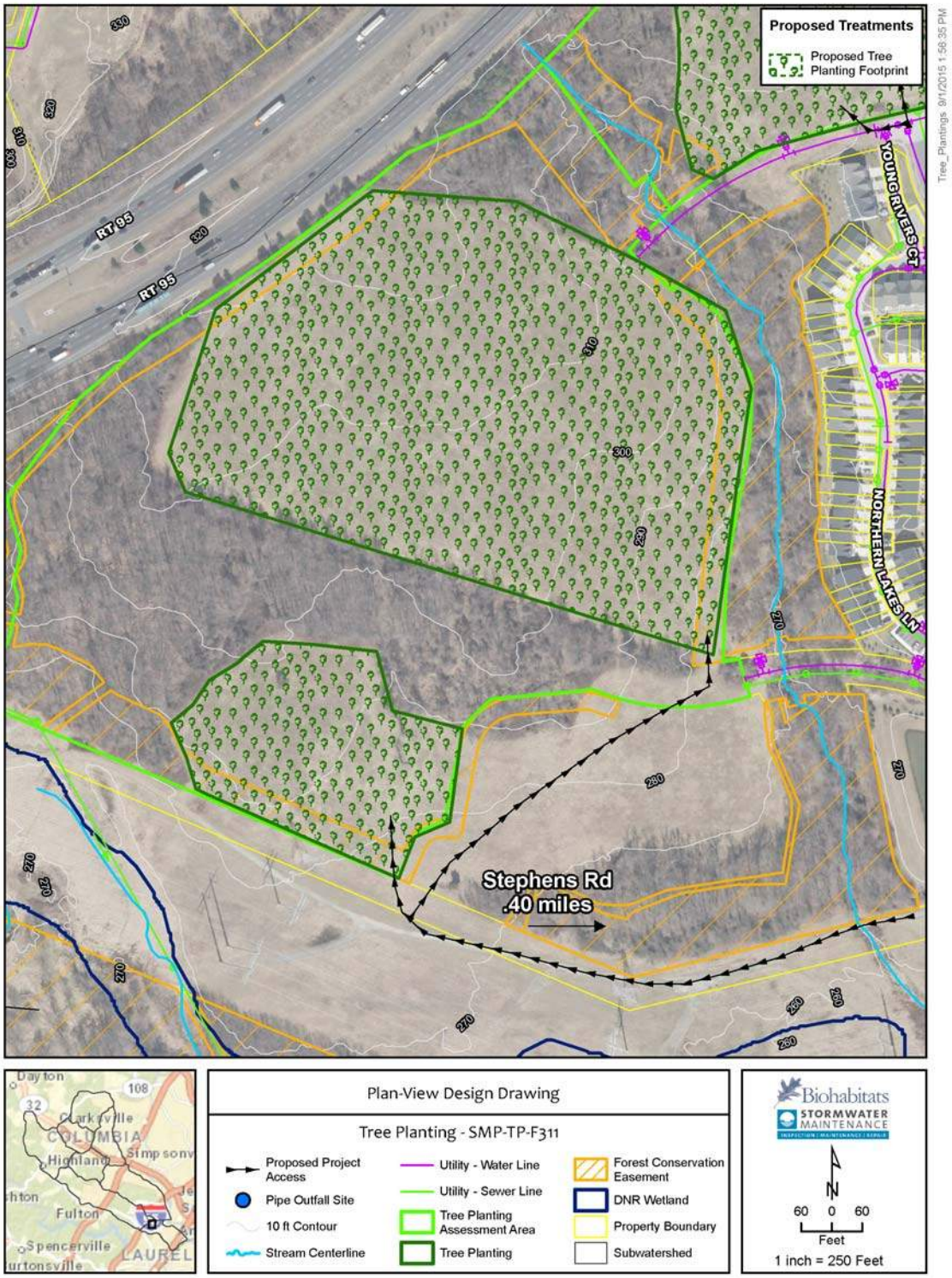
Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SMP-TP-F311

Site Name: Northern Lakes

Contractor: Biohabitats

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SMP-TP-F405

Site Name: Hammond Branch at Hammond Drive

Contractor: Biohabitats

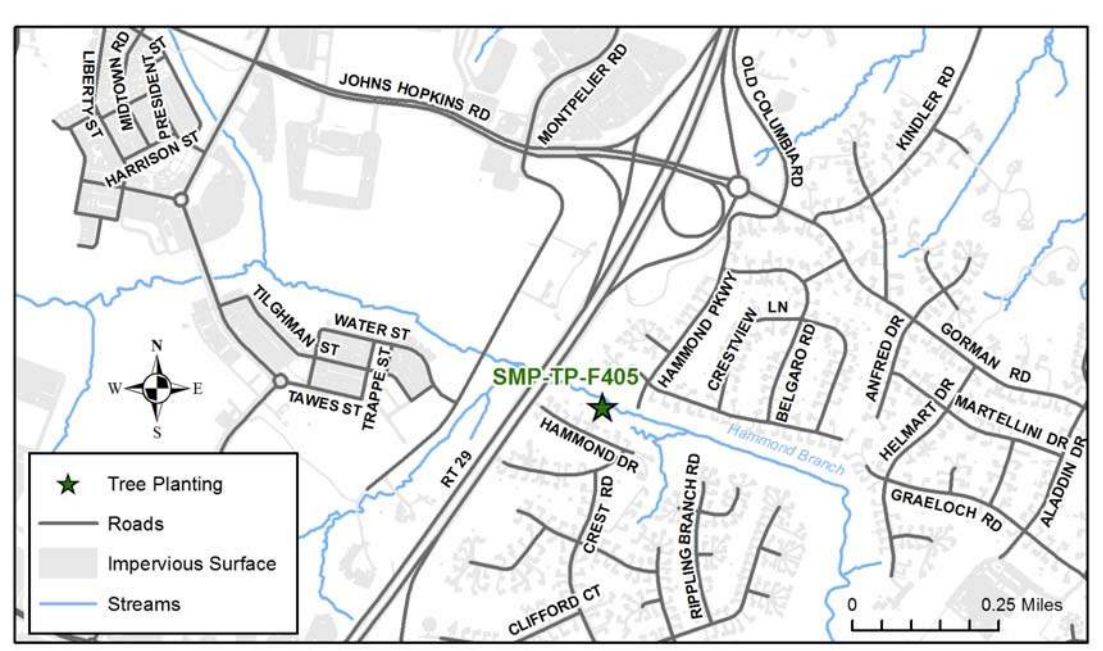
Watershed: Little Patuxent River

Project Type: Tree Planting

Ownership: County Owned
Single Owner

Existing Conditions:

The site is a county owned right-of-way adjacent to Hammond Branch. Portions of the site are being managed by adjacent homeowners while the remaining portion of the site is an unmaintained riparian buffer. The current vegetative cover is 60% trees, 30% other herbaceous plants, and 10% turf. Forest consisting of red maple (Acer rubrum), tulip poplar (Liriodendron tulipifera), sycamore (Platanus occidentalis), and silver maple (Acer saccharinum) is present adjacent to the site. The adjacent forest is roughly 45% covered with invasive species including multiflora rose (Rosa multiflora), Japanese honeysuckle (Lonicera japonica), English ivy (Hedera helix), and garlic mustard (Alliaria petiolata). The site is located within the riparian buffer of Hammond Branch with non-compacted and loamy textured soil. The average bank height along the stream is currently 4 ft. with limited floodplain connection. The regional forest association, which indicates the climax or dominant species for an area, is Appalachian Oak.



Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SMP-TP-F405

Site Name: Hammond Branch at Hammond Drive

Contractor: Biohabitats

Watershed: Little Patuxent River

Tree planting area bounded by Hammond Branch on the left with residences to the right looking southeast.

Tree planting area looking northwest with residences to the left and Hammond Branch to the right.

Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SMP-TP-F405
Site Name: Hammond Branch at Hammond Drive
Contractor: Biohabitats
Watershed: Little Patuxent River

Constraints/Utilities:

Constraints at the site include encroachment from adjacent homeowners, wildlife (i.e. deer), underground utilities such as sanitary sewer and fiber optics and access only available via private property.

Concept Description:

The proposed project consists of one tree planting area that is 1.07 ac. The planting area is confined within the riparian buffer between Hammond Branch and the adjacent residential properties. A restoration project is recommended for the segment of Hammond Branch flowing through the site, and concurrent implementation of the tree planting and stream restoration projects should be explored. The proposed planting project would also serve to enhance the riparian buffer of the stream.

The site receives partial sun due to existing tree cover. There are low lying areas consisting of floodplain depressions throughout the planting area. There is no evidence at the planting area of erosion, contamination, or debris. Approximately 30% of the planting area is covered with invasive species including multiflora rose (Rosa multiflora), English ivy (Hedera helix), garlic mustard (Alliaria petiolata), and Japanese honeysuckle (Lonicera japonica). Stormwater runoff from the upslope drainage area is directed to the planting area via a 14 in. outfall pipe. In addition, the site also receives stormwater runoff via sheet flow over the pervious, turf surfaces as a result of sloping topography within the planting area.

The site provides access for delivery, temporary storage, as well as foot and vehicle traffic. However, heavy equipment access is not possible and all access would require crossing private residential properties. The project has minimal educational potential due to the site being adjacent to private properties, thus limiting exposure and access to the public. Potential water sources for the proposed tree planting project are limited to rainfall. Some site preparation would be required including minor invasives removal. The concept proposes planting a mix of native tree species saplings. Deer are active in the area; therefore, newly planted trees would need to be protected from potential wildlife impacts using appropriate fencing, tree protectors, repellents, etc. The existing trees within the planting area could be preserved as long as trees are healthy and not an invasive species.

Nearby Opportunities:

SMP-SR-F335

Proposed Project Credit		Costs	
Planting Acres:	1.1	Estimated Design Cost:	$10,000.00
Impervious Area Treated Credit (ac.):	0.41	Estimated Construction Cost:	$34,240.00
		30% Contingency:	$10,272.00
Cost per Impervious Credit Acre:	$132,956.10	Estimated Total Cost:	$54,512.00

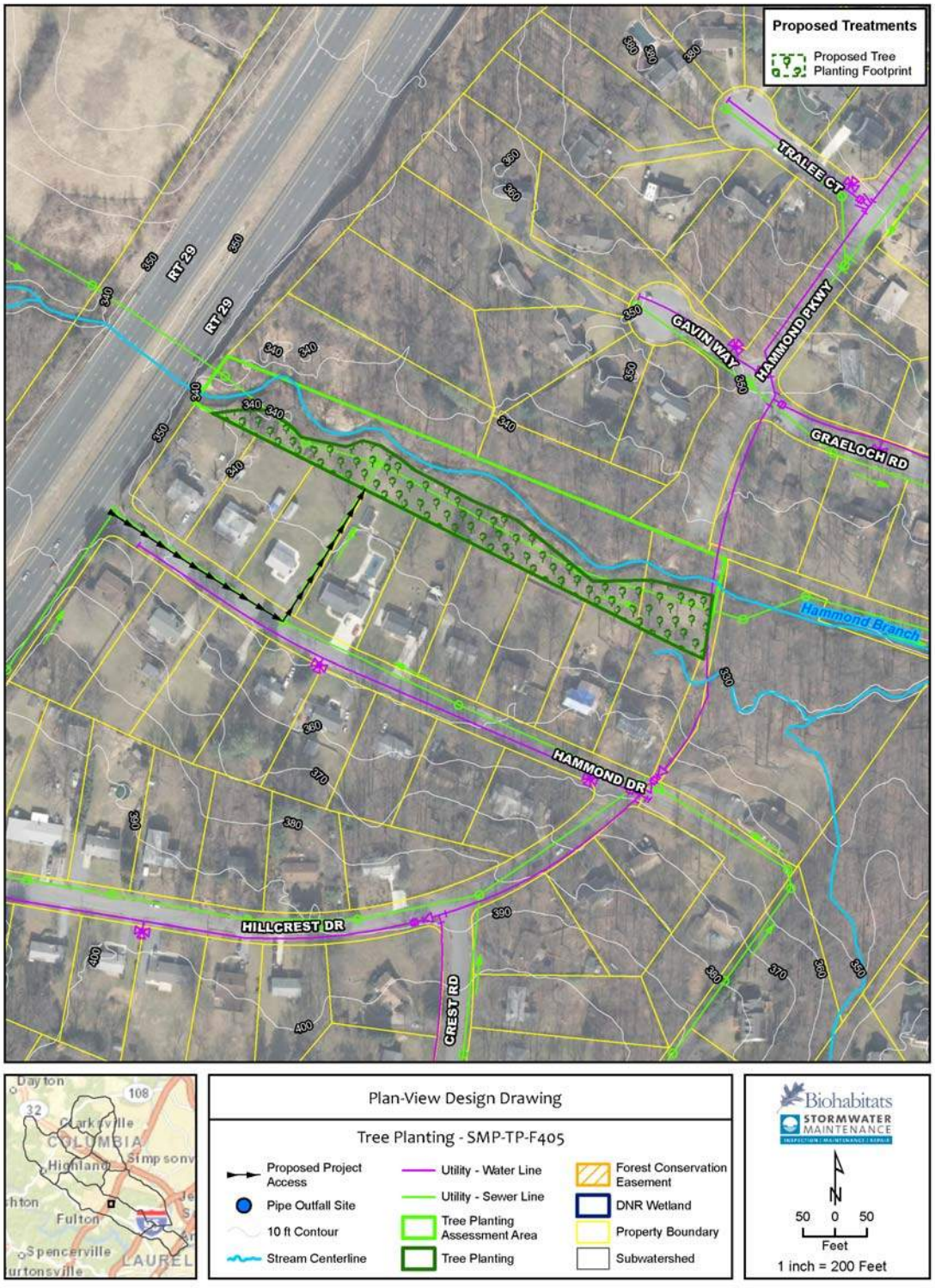
Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SMP-TP-F405

Site Name: Hammond Branch at Hammond Drive

Contractor: Biohabitats

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SMP-TP-F406

Site Name: Hammond Branch at Maple Lawn

Contractor: Biohabitats

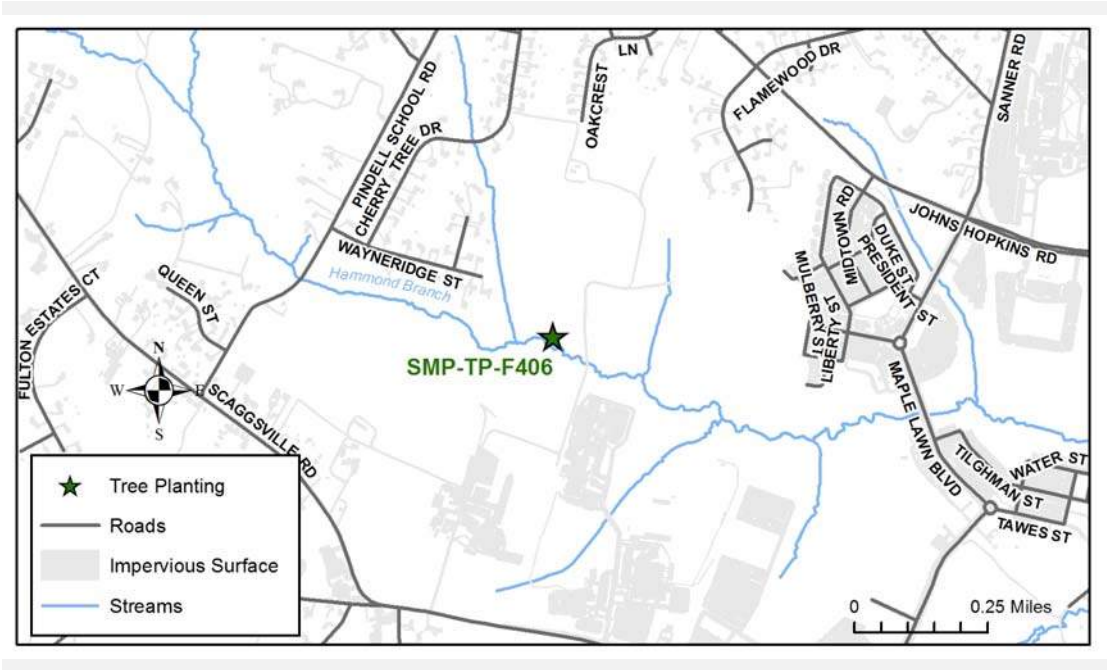
Watershed: Little Patuxent River

Project Type: Tree Planting

Ownership: Private- Residential
Single Owner

Existing Conditions:

The site is a vacant area located between Hammond Branch and a stormwater management pond. While there is no Maryland State Department of Assessments and Taxation (SDAT) account ID associated with the parcel, the parcel appears to be contained within a larger tract of land owned by Maple Lawn Farms, Inc. The current vegetative cover is 90% other herbaceous plants and 5% trees, and 5% bare ground. Forest consisting of tulip poplar (Liriodendron tulipifera) and red maple (Acer rubrum) is present adjacent to the site. The adjacent forest is roughly 10% covered with the invasive species including multiflora rose (Rosa multiflora). The site is located within the riparian buffer of Hammond Branch with moderately compacted and loamy textured soil. The average bank height along the stream is currently 2 ft. with frequent floodplain connection. The regional forest association, which indicates the climax or dominant species for an area, is Appalachian Oak.



Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SMP-TP-F406

Site Name: Hammond Branch at Maple Lawn

Contractor: Biohabitats

Watershed: Little Patuxent River

Tree planting area looking east. Riprap lined outfall from stormwater pond to the left visible in foreground.

Tree planting area looking east adjacent to Hammonds Branch. Power lines visible to the right.

Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SMP-TP-F406
Site Name: Hammond Branch at Maple Lawn
Contractor: Biohabitats
Watershed: Little Patuxent River

Constraints/Utilities:

Constraints at the site include 100 ft. overhead wires, wildlife (i.e. deer), presence of wetlands, and close proximity of a stormwater management pond with a silt fence. Private ownership of the site could also result in a constraint.

Concept Description:

The proposed project consists of one tree planting area that is 3.84 ac. The planting area encompasses Hammond Branch and is confined to the north by a stormwater management pond. The proposed planting area does not appear to be maintained. Existing forest conservation areas, associated with the nearby Maple Lawn residential development, are present covering portions of the proposed planting areas. The proposed project includes planting trees in portions of existing forest conservation areas that are not currently planted. A restoration project is recommended for Hammond Branch within the vicinity of the planting area, and concurrent implementation of the tree planting and stream restoration projects should be explored. The proposed planting project would also serve to enhance the riparian buffer of the stream.

The planting area receives full sun and low lying areas consisting of floodplain depressions are present. There is no evidence of erosion, contamination, or debris within the proposed planting area. However, there is recent and on-going construction nearby which appears to be associated with residential development. Approximately 5% of the planting area is covered with invasive species including multiflora rose (Rosa multiflora). Stormwater runoff from a stormwater management pond is directed to the planting area via a 36 in. outfall pipe. In addition, the site also receives stormwater runoff via sheet flow over pervious, herbaceous surfaces as a result of sloping topography within the planting area. The site provides access for delivery, temporary storage, as well as foot, vehicle, and heavy equipment traffic. The project has minimal educational potential due to the site being adjacent to a residential development, thus limiting exposure and access to the public. Potential water sources for the proposed tree planting project include rainfall, stormwater runoff, overbank flows during storm events from the adjacent stream and tanker water delivery. Minimal site preparation would be required including minor invasives removal. The concept proposes planting a mix of native tree species saplings. Deer are active in the area; therefore, newly planted trees would need to be protected from potential wildlife impacts using appropriate fencing, tree protectors, repellents, etc. The existing trees within the planting area could be preserved as long as trees are healthy and not an invasive species.

Nearby Opportunities:

SMP-SR-F338

Proposed Project Credit	
Planting Acres:	3.8
Impervious Area Treated Credit (ac.):	1.46
Cost per Impervious Credit Acre:	$116,263.01

Costs	
Estimated Design Cost:	$10,000.00
Estimated Construction Cost:	$122,880.00
30% Contingency:	$36,864.00
Estimated Total Cost:	$169,744.00

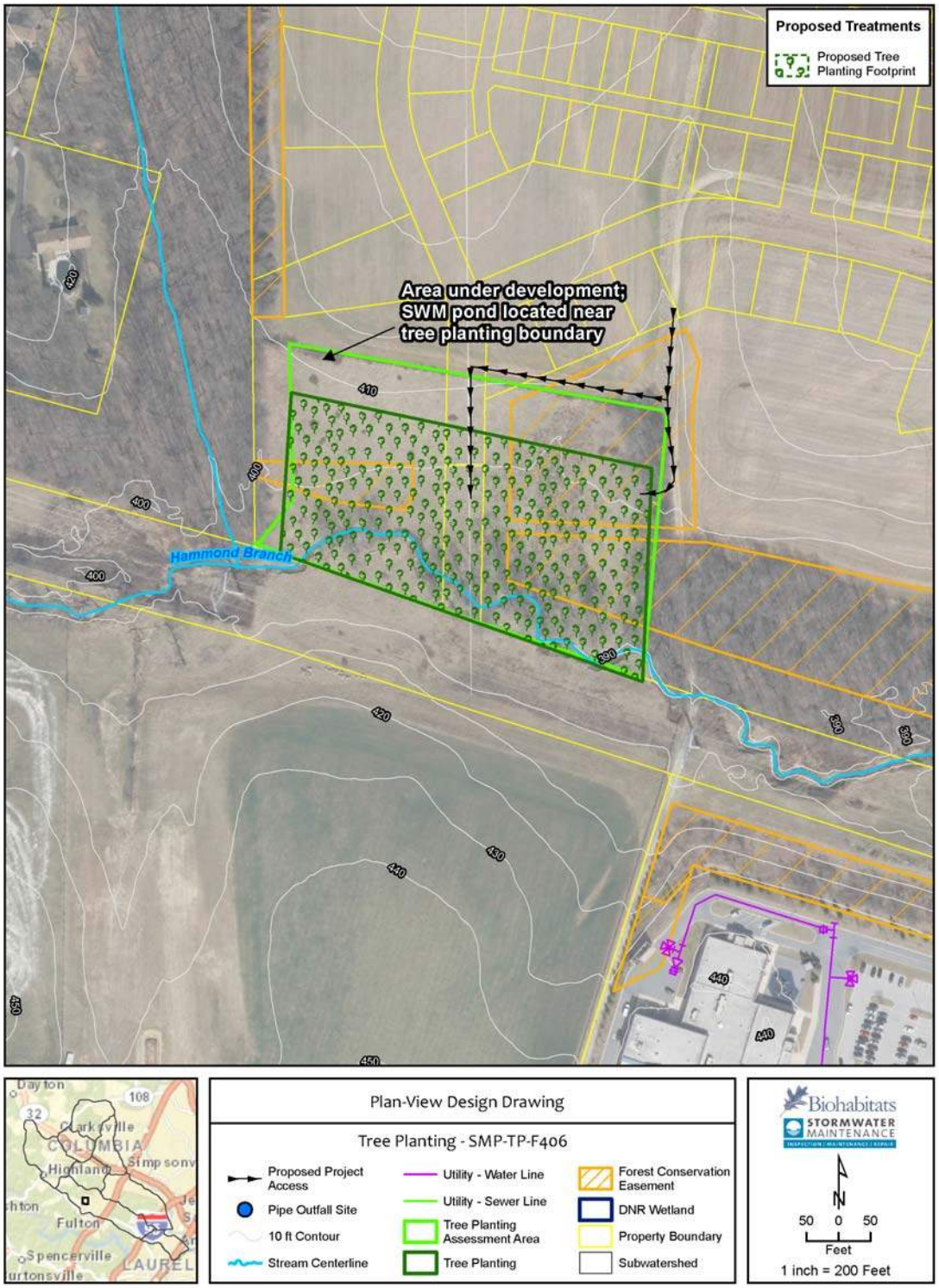
Howard County Watershed Assessment Concept Plan: Tree Planting

Site ID: SMP-TP-F406

Site Name: Hammond Branch at Maple Lawn

Contractor: Biohabitats

Watershed: Little Patuxent River



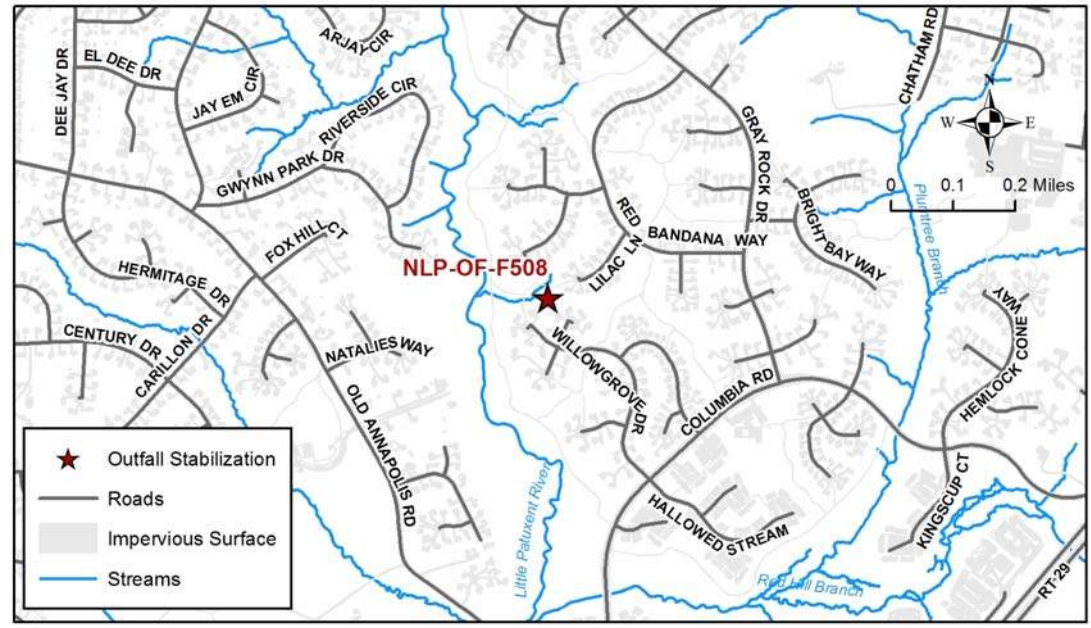
Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: NLP-OF-F508
Site Name: Lilac Ln
Contractor: KCI
Watershed: Little Patuxent River

Proposed BMP Type: Outfall Stabilization
Stabilization Type: Step Pool Storm Conveyance
Ownership: Columbia Association
Single Owner

Existing Conditions:

The proposed outfall stabilization begins at a stormwater outfall from Lilac Lane with no existing stormwater treatment. The reach is situated south of the walking trail. The reach is approximately 650 lf. from the outfall to the confluence with the Little Patuxent River. Several headcuts, up to 3 ft. in height, were observed immediately downstream of the outfall, with failing riprap displaced along the channel. Banks are approximately 6.5 ft. high and are composed of very fine silty material that is easily erodible. Approximately 20 lf. along the left bank is severely eroded downstream of the headcuts. Near bank stress appears to be moderate; however, no bankfull indicators occur along the channel. This outfall is located within Columbia Association property, where the sewer easement and walking trail may provide good access.



Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: NLP-OF-F508
Site Name: Lilac Ln
Contractor: KCI
Watershed: Little Patuxent River

Facing upstream towards outfall, displaced riprap and eroded banks.

Facing upstream towards headcuts and debris jams.

Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: NLP-OF-F508
Site Name: Lilac Ln
Contractor: KCI
Watershed: Little Patuxent River

Constraints/Utilities:
There is one utility pipe present across the outfall channel. The proposed construction should avoid impacting it. There are specimen tree impacts anticipated.

Concept Description:
A Step Pool Storm Conveyance (SPSC) is proposed for this reach due to the steep elevation gradient over a short distance of approximately 100 ft. The proposed SPSC begins at the outfall and continues for approximately 100 ft. downstream. The SPSC includes four riffle weirs with 30 ft. width and 8 ft. length, and four pools with 30 ft. width, 3 ft. depth, and 17 ft. length. The SPSC will treat more than 1 in. of rainfall and safely convey the 100 yr. flow. However, because of the diminishing credit returns on treatment over 1 in. of rainfall, it may be feasible to cut costs by reworking the SPSC design to bring the rainfall depth treated closer to the targeted 1 in. depth.

Nearby Opportunities:
None recommended

Proposed Project Credit	
Drainage Area (ac.):	15.11
Impervious Area within Drainage (ac.):	2.78
Impervious Area Treated (ac.):	3.89
Impervious Area Treated Credit (ac.):	3.89

Water Quality Volume	
WQVolume Target (cf.):	11,825
Max Treated (cf.):	43,838
Percent Treated:	370%
Rainfall Depth Treated (in.):	2.6

Costs

Estimated Design Cost:	$100,000.00
Estimated Construction Cost:	$100,000.00
30 % Contingency:	$30,000.00
Estimated Total Cost:	$230,000.00
Cost per Impervious Credit Acre:	$59,125.96

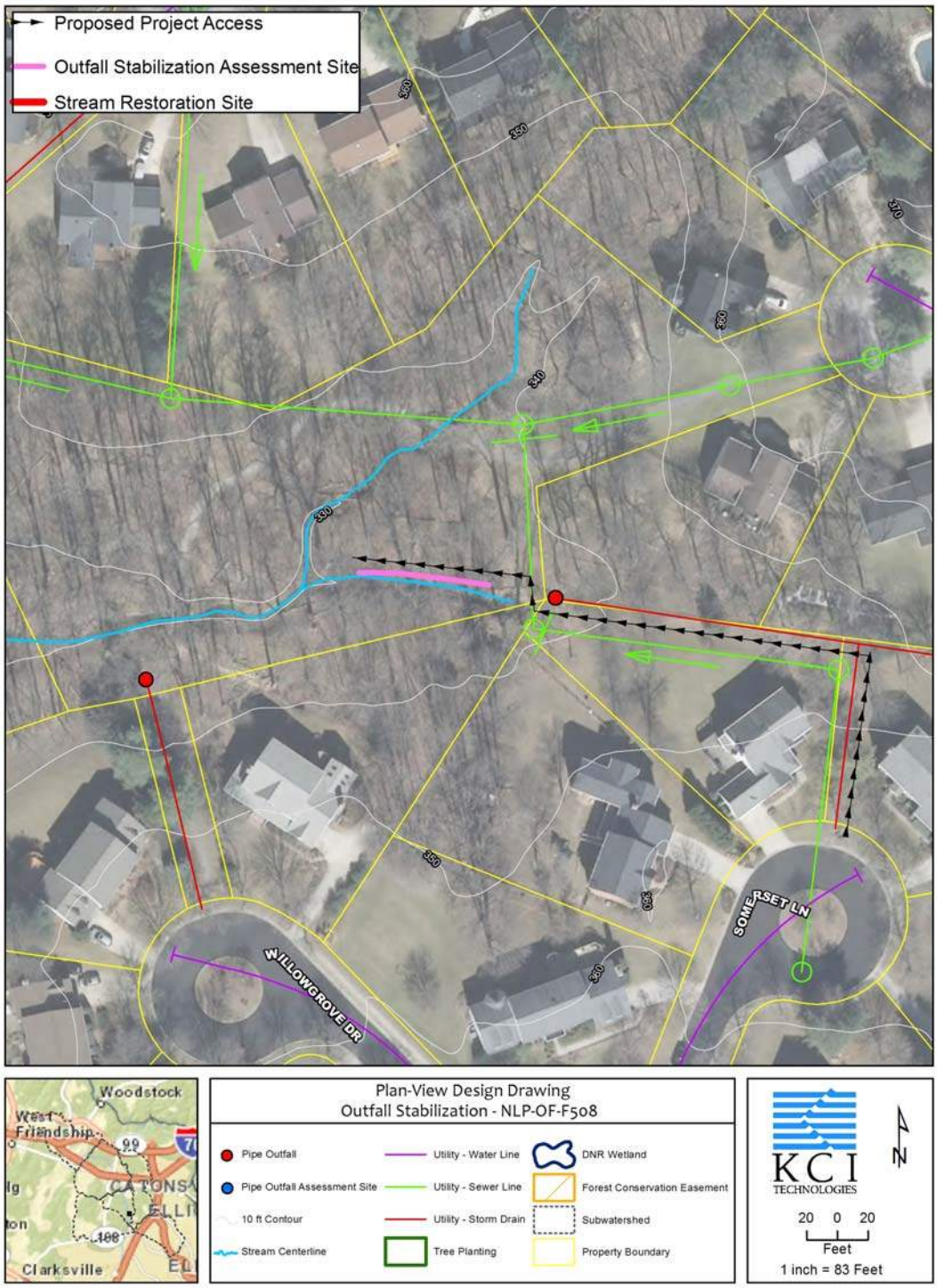
Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: NLP-OF-F508

Site Name: Lilac Ln

Contractor: KCI

Watershed: Little Patuxent River



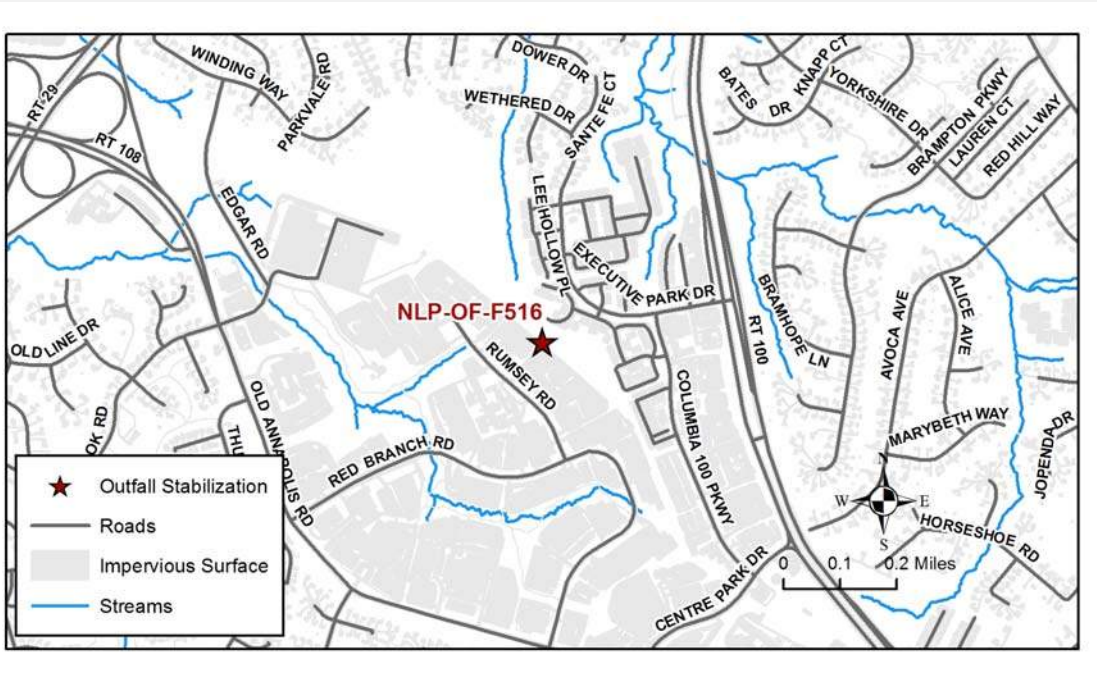
Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: NLP-OF-F516
Site Name: Rumsey Rd
Contractor: KCI
Watershed: Little Patuxent River

Proposed BMP Type: Outfall Stabilization
Stabilization Type: Step Pool Storm Conveyance
Ownership: Private- Commercial/Industrial Single Owner

Existing Conditions:

The proposed restoration reach begins at an outfall that drains multiple commercial buildings and parking lots on Rumsey Road to the southwest and residential use on Teal Wing Court to the northeast. The outfall conveys water into an unnamed tributary that leads to Red Hill Branch. This reach has several headcuts of 1 ft., 2 ft., and 5 ft. in height. There is also another significant headcut 100 ft. downstream near the next outfall. This next outfall pipe appears to be in good condition, but has moderate sediment deposition. Both outfalls are proposed to be stabilized at the same time during construction.



Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: NLP-OF-F516
Site Name: Rumsey Rd
Contractor: KCI
Watershed: Little Patuxent River

Facing upstream towards large headcut.

Facing upstream towards second outfall pipe with sediment deposition.

Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: NLP-OF-F516
Site Name: Rumsey Rd
Contractor: KCI
Watershed: Little Patuxent River

Constraints/Utilities:
The reach runs through multiple private commercial properties therefore good property owner coordination and approval will be needed; however both outfalls are situated close to parking areas with minimal disturbance to trees and utilities.

Concept Description:
A Step Pool Storm Conveyance (SPSC) is proposed for this reach due to the steep elevation gradient over 120 ft. The proposed SPSC begins at the outfall and continues approximately 150 ft. downstream. The SPSC includes five riffle weirs with 20 ft. width and 8 ft. length, five pools with 20 ft. width, 3 ft. depth, and 16 ft. length, and a cascade structure with 20 ft. width, 30 ft. length and 0.5 ft. depth. The SPSC will treat more than 1 in. of rainfall and safely convey the 100 yr. flow. However, because of the diminishing credit returns on treatment over 1 in. of rainfall, it may be feasible to cut costs by reworking the SPSC design to bring the rainfall depth treated closer to the targeted 1 in. depth.

Nearby Opportunities:
None recommended

Proposed Project Credit

Drainage Area (ac.):	5.08
Impervious Area within Drainage (ac.):	3.8
Impervious Area Treated (ac.):	5.32
Impervious Area Treated Credit (ac.):	5.32

Water Quality Volume

WQVolume Target (cf.):	13,337
Max Treated (cf.):	43,838
Percent Treated:	330%
Rainfall Depth Treated (in.):	2.6

Costs

Estimated Design Cost:	$100,000.00
Estimated Construction Cost:	$100,000.00
30 % Contingency:	$30,000.00
Estimated Total Cost:	$230,000.00
Cost per Impervious Credit Acre:	$43,233.08

Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: NLP-OF-F516

Site Name: Rumsey Rd

Contractor: KCI

Watershed: Little Patuxent River

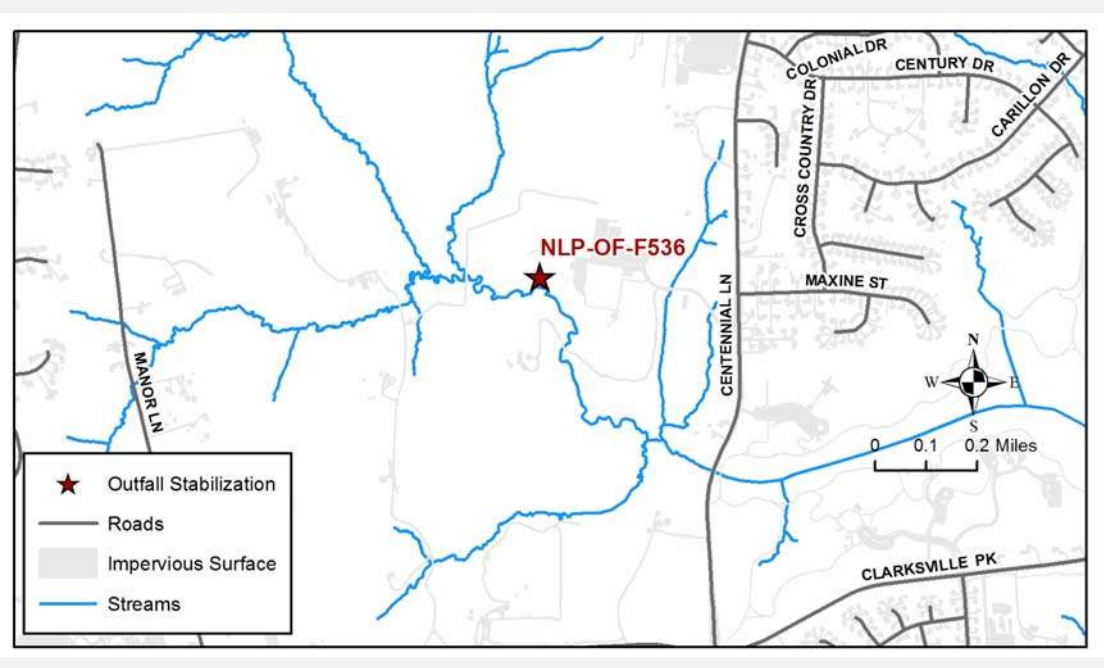
Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: NLP-OF-F536
Site Name: Soccer Association of Columbia
Contractor: KCI
Watershed: Little Patuxent River

Proposed BMP Type: Outfall Stabilization
Stabilization Type: Step Pool Storm Conveyance
Ownership: Private- Commercial/Industrial
Multiple Owners

Existing Conditions:

The proposed outfall stabilization site originates at an outfall from a stormwater management pond that collects water from the Soccer Association of Columbia property located to the west of Centennial Lane. The site is located in the woods along the southern edge of the Soccer Association property. The outfall channel conveys water to an unnamed tributary that leads to Centennial Lake.
The proposed restoration reach is approximately 100 lf. from the outfall to the confluence with the unnamed tributary. This channel is narrow and severely incised due to headcuts that have migrated towards the outfall. The banks are vertical and raw, with minimal surface protection, exposing the highly erodible silt soil to confined stormwater flows with little protection.



Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: NLP-OF-F536

Site Name: Soccer Association of Columbia

Contractor: KCI

Watershed: Little Patuxent River

Facing upstream towards outfall.

Facing downstream , above headcuts.

Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: NLP-OF-F536
Site Name: Soccer Association of Columbia
Contractor: KCI
Watershed: Little Patuxent River

Constraints/Utilities:
At the outfall, a steep embankment around the stormwater management pond may make access difficult for heavy machinery. The reach flows onto a private commercial property, making property owner coordination and approval an important aspect of the project success.

Concept Description:
A Step Pool Storm Conveyance (SPSC) is proposed for this reach due to the steep elevation gradient over a short distance of 111 ft. The proposed SPSC will begin at the outfall and continue approximately 130 ft. downstream. The SPSC includes four riffle weirs with 20 ft. width and 8 ft. length, four pools with 20 ft. width, 3 ft. depth, and 16 ft. length, and a cascade structure with 20 ft. width, 34 ft. length and 0.8 ft. depth. The SPSC will treat more than 1 in. of rainfall and safely convey the 100 yr. flow. There is an existing wet pond upstream of this outfall. The wet pond should already provide some water quality treatment. However, because of the diminishing credit returns on treatment over 1 in. of rainfall, it may be feasible to cut costs by reworking the SPSC design to bring the rainfall depth treated closer to the targeted 1 in. depth. This outfall stabilization project may be reclassified as a stream restoration project if the length of channel restored exceeds 200 lf.

Nearby Opportunities:
None recommended

Proposed Project Credit

Drainage Area (ac.):	24.96
Impervious Area within Drainage (ac.):	2.88
Impervious Area Treated (ac.):	4.03
Impervious Area Treated Credit (ac.):	4.03

Water Quality Volume

WQVolume Target (cf.):	13,939
Max Treated (cf.):	37,993
Percent Treated:	270%
Rainfall Depth Treated (in.):	2.6

Costs

Estimated Design Cost:	$100,000.00
Estimated Construction Cost:	$100,000.00
30 % Contingency:	$30,000.00
Estimated Total Cost:	$230,000.00
Cost per Impervious Credit Acre:	$57,071.96

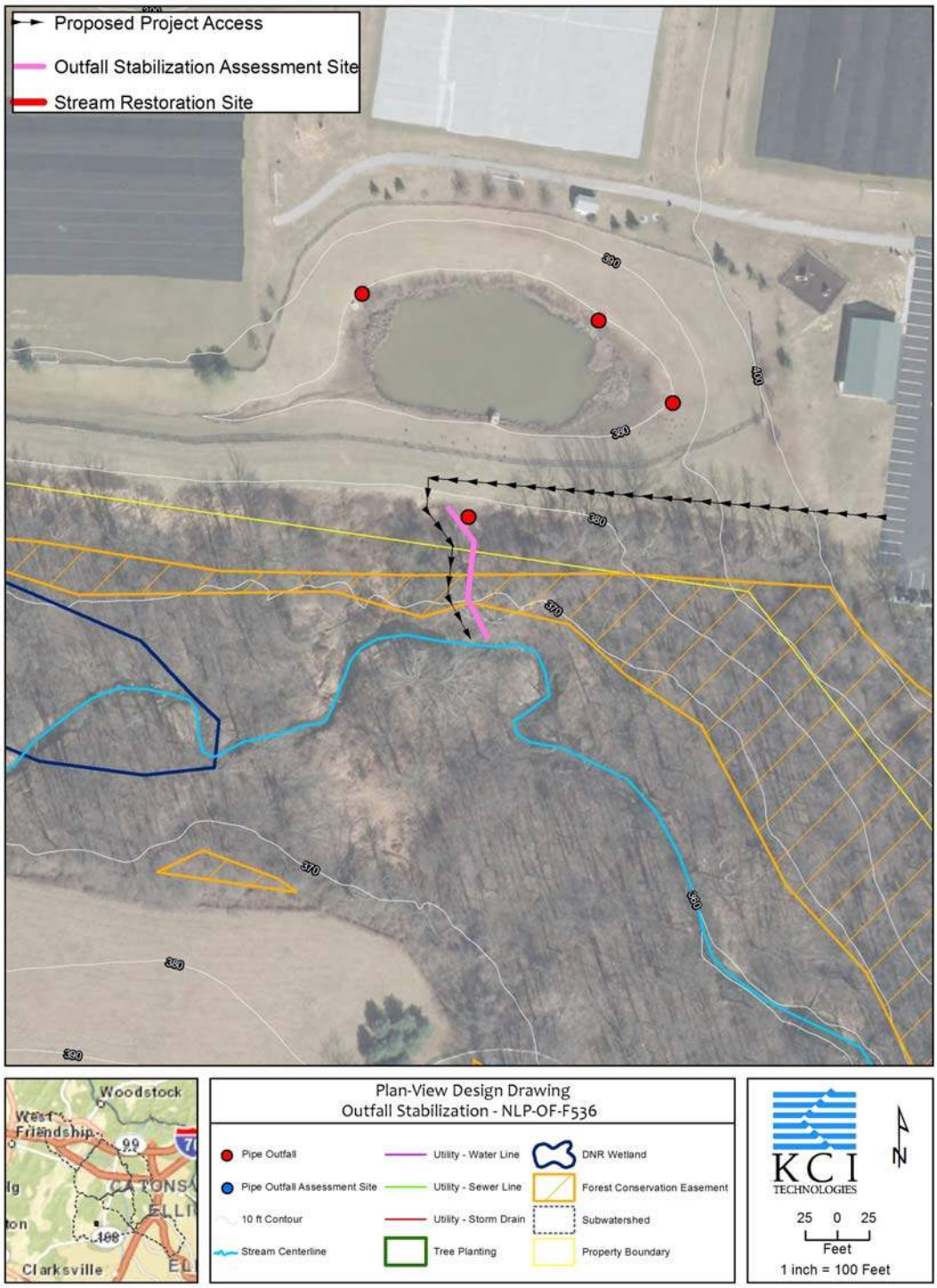
Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: NLP-OF-F536

Site Name: Soccer Association of Columbia

Contractor: KCI

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Outfall Stabilization

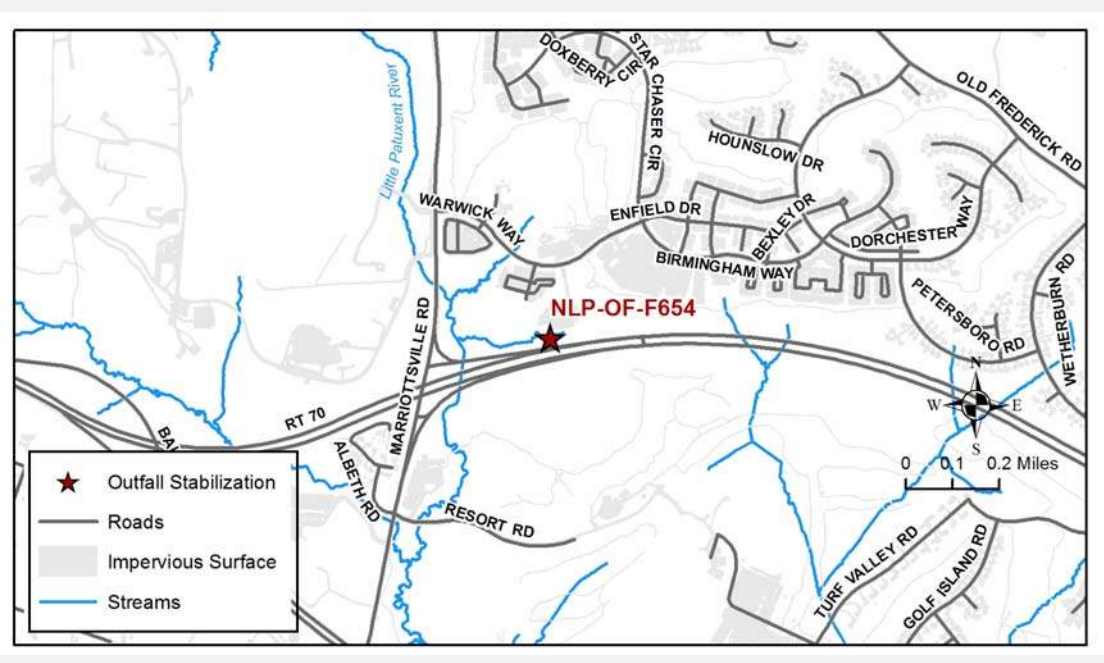
Site ID: NLP-OF-F654
Site Name: Waverly Woods
Contractor: KCI
Watershed: Little Patuxent River

Proposed BMP Type: Outfall Stabilization
Stabilization Type: Riffle-Pool Channel
Ownership: Private- Residential Single Owner

Existing Conditions:

The outfall stabilization and restoration reach begins downstream of an outfall from I-70 that contributes flows to an unnamed tributary to the Little Patuxent River. The storm drain outlets onto a concrete channel that conveys flow to the edge of the property line demarcated by a fence. Approximately 1.5 ft. has eroded at the downstream edge of the concrete, with erosion continuing approximately 275 lf. downstream. Erosion is greatest along the outer meander bends.

The reach is located within a narrow, undeveloped parcel of Waverly Woods which separates I-70 from the Waverly Woods Condominiums. The site is wholly contained within an existing County Forest Conservation Easement. This segment of channel is highly sinuous with very steep bank angles, shallow root depths, and minimal surface protection. Banks are currently 3 ft. in height with high near bank stresses, as determined by the bankfull depth (1.5 ft.).



Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: NLP-OF-F654
Site Name: Waverly Woods
Contractor: KCI
Watershed: Little Patuxent River

Facing upstream towards the outfall, severe erosion at the bottom of the concrete channel.

Facing downstream from outfall, bank erosion along outer meander bends.

Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: NLP-OF-F654
Site Name: Waverly Woods
Contractor: KCI
Watershed: Little Patuxent River

Constraints/Utilities:

A water line runs parallel to the channel, crossing twice within a very tight meander bend. The elevation of the water line may require some design considerations. Construction entrance access might be feasible from the Waverly Woods parking lot from Warwick Way.

Concept Description:

The restoration approach for this segment of channel includes a full cross section design and realignment to the planform. The goal of this approach is to reduce bed and bank stress by creating a stable channel cross section, adding bank protection, and reducing stress caused by the highly sinuous planform. Bank treatments might include bioengineering treatments, such as coir fiber rolls, alternating roughness, as well as planting of trees, shrubs, and live stakes. The stream restoration cost per linear foot was used for this outfall stabilization project due to the restoration approach being closer to a stream restoration concept than to a typical outfall stabilization, despite its shorter length. This outfall stabilization project may be reclassified as a stream restoration project if the length of channel restored exceeds 200 lf.

Nearby Opportunities:

None recommended

Proposed Project Credit	
Length Restored (ft):	272
Impervious Area Treated Credit (ac.):	2.72
Cost Per Impervious Credit Acre:	$95,264.71

Costs	
Estimated Design Cost:	$100,000.00
Estimated Construction Cost:	$122,400.00
30% Contingency:	$36,720.00
Estimated Total Cost:	$259,120.00

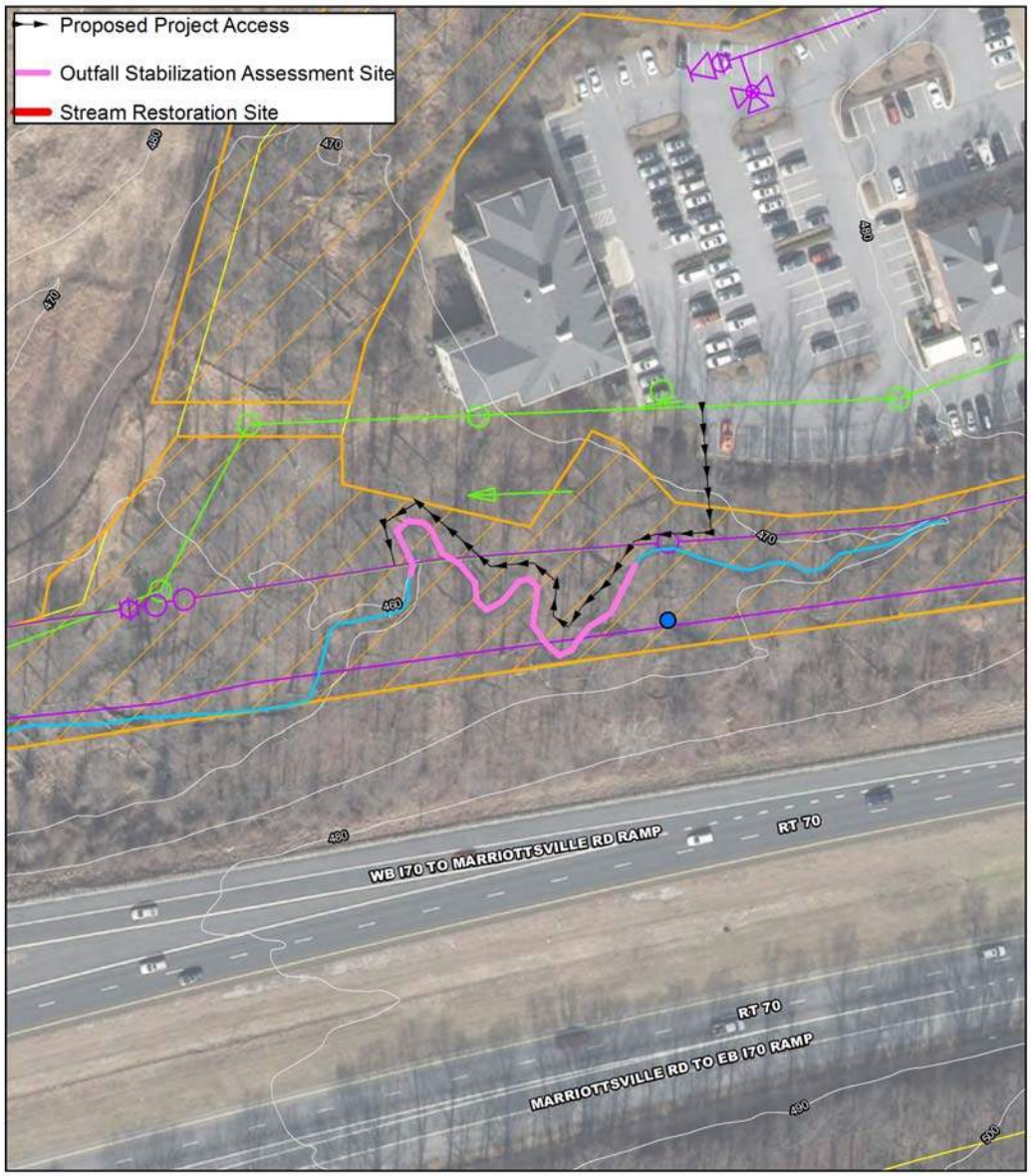
Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: NLP-OF-F654

Site Name: Waverly Woods

Contractor: KCI

Watershed: Little Patuxent River



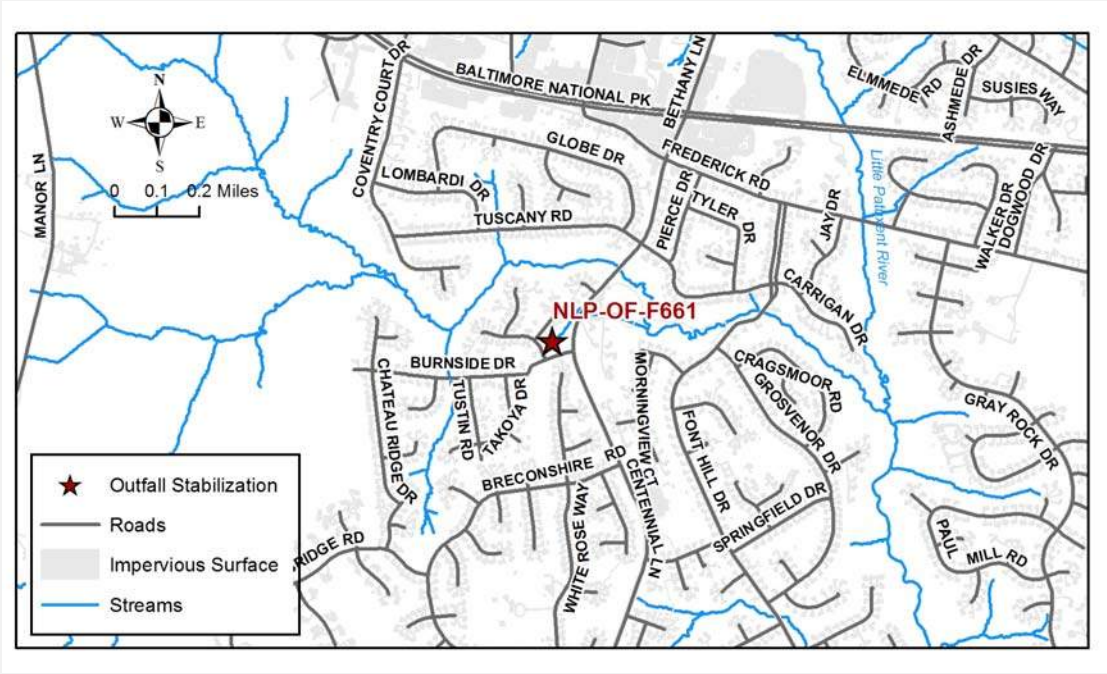
Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: NLP-OF-F661
Site Name: Little Brick House Ct.
Contractor: KCI
Watershed: Little Patuxent River

Proposed BMP Type: Outfall Stabilization
Stabilization Type: Riffle-Pool Channel
Ownership: Private- Residential
Multiple Owners

Existing Conditions:

The proposed outfall stabilization site is located on a channel running along the back of private property lots along Feaga Farm Ct and parallel to Centennial Lane. A sewer line runs parallel to the channel, with two crossings in the proposed reach. The channel is incised following several headcuts that begin approximately 100 lf. downstream of the outfall. A series of headcuts have produced a 3-4 ft. elevation drop within the channel over a 20 lf. distance. Banks are approximately 3 ft. high with shallow root depths, steep bank angles, and minimal surface protection. The bankfull depth is approximately 1.5 ft. high, as determined by the low bank height immediately upstream of the headcuts.



Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: NLP-OF-F661
Site Name: Little Brick House Ct.
Contractor: KCI
Watershed: Little Patuxent River

Facing upstream at headcut.

Facing downstream, erosion along outer bends.

Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: NLP-OF-F661
Site Name: Little Brick House Ct.
Contractor: KCI
Watershed: Little Patuxent River

Constraints/Utilities:

The channel is located on three private properties through which a sewer also runs parallel. Construction access can be obtained through the sewer and storm drain easements on Little Brick House Ct and/or from the sewer easement from Feaga Farm Ct.

Concept Description:

Although considered an outfall stabilization project, this restoration site contains enough length that a riffle-pool sequence similar to the standard approach for a stream restoration project is proposed. The restoration approach for this segment of channel includes full cross section design to achieve riffle-pool morphology. The goal of this approach is to reduce bed and bank stress by creating a stable channel cross section, then adding bank protection to resist the bank stresses that occur. Bank treatments might include bioengineering treatments, such as coir fiber rolls, and alternating roughness. Tree, shrub, and live stake planting is proposed throughout the site; however, tree planting will be restricted to areas outside of the sewer easement. The stream restoration cost per linear foot was used for this outfall stabilization project due to the restoration approach being more similar to a stream restoration concept, despite its shorter length. This outfall stabilization project may be reclassified as a stream restoration project if the length of channel restored exceeds 200 lf.

Nearby Opportunities:

None recommended

Proposed Project Credit	
Length Restored (ft):	209
Impervious Area Treated Credit (ac.):	2.09
Cost Per Impervious Credit Acre:	$110,047.85

Costs	
Estimated Design Cost:	$100,000.00
Estimated Construction Cost:	$100,000.00
30% Contingency:	$30,000.00
Estimated Total Cost:	$230,000.00

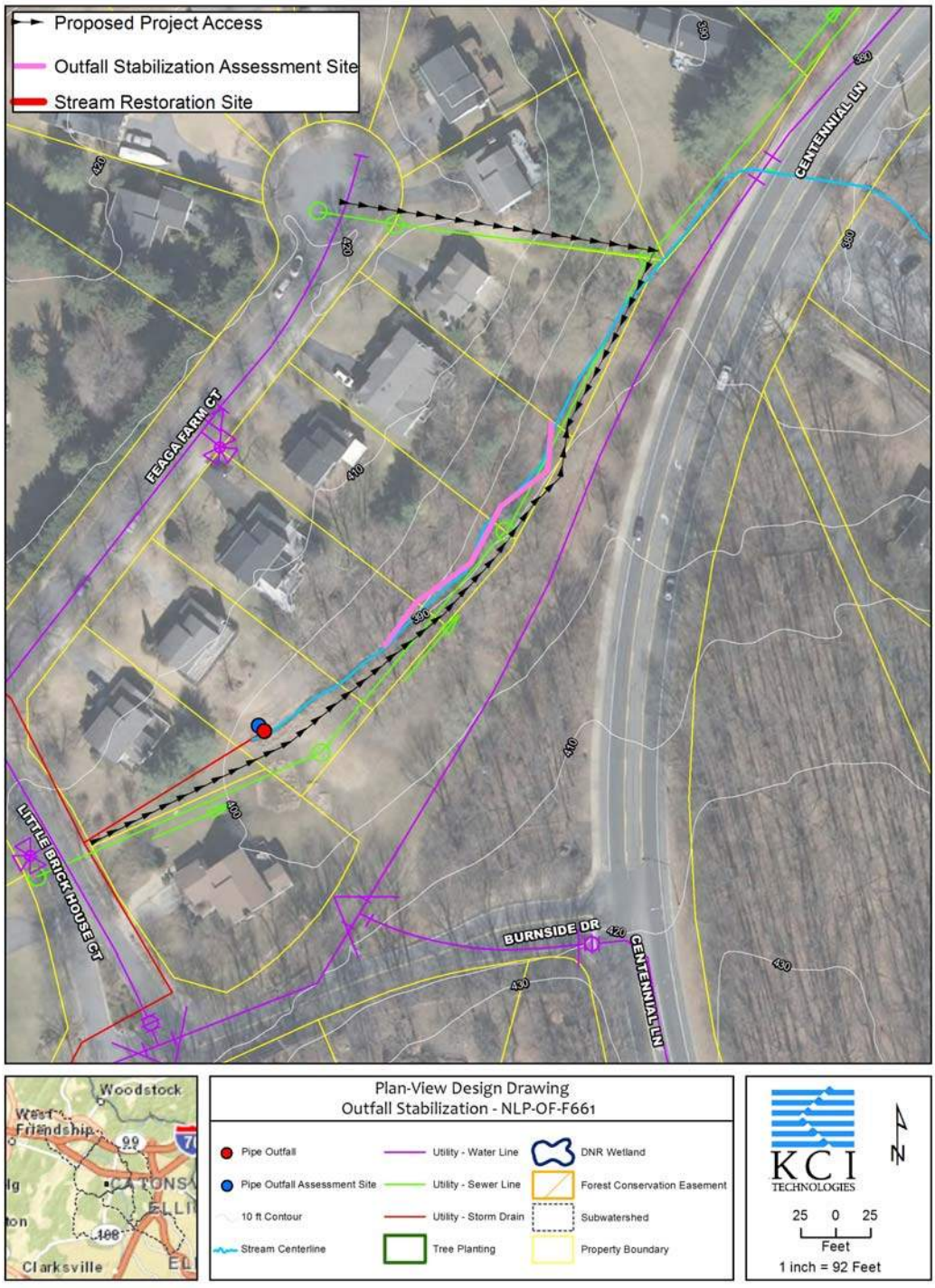
Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: NLP-OF-F661

Site Name: Little Brick House Ct.

Contractor: KCI

Watershed: Little Patuxent River



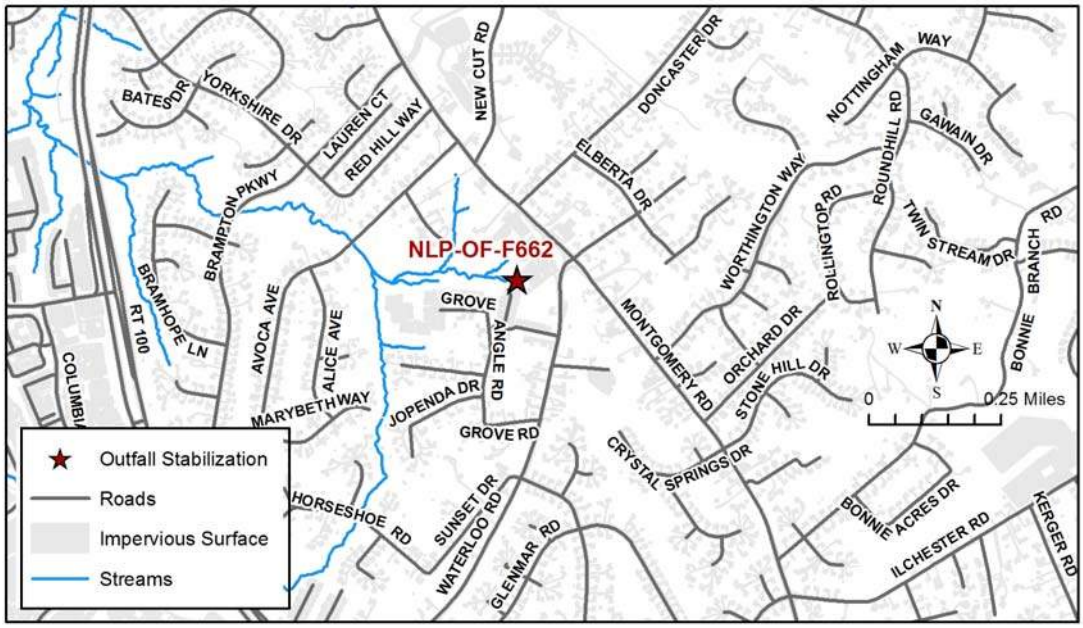
Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: NLP-OF-F662
Site Name: Waterloo Rd
Contractor: KCI
Watershed: Little Patuxent River

Proposed BMP Type: Outfall Stabilization
Stabilization Type: Step Pool Storm Conveyance
Ownership: Private- Mixed Use
Multiple Owners

Existing Conditions:

The outfall stabilization site originates from an outfall that drains multiple parking lots and restaurants at the corner of Montgomery Rd and Waterloo Rd. The outfall pipe is in a rusted condition, and trash below the embankment from the parking lots is abundant. The total length of erosion is approximately 200 lf., through which trees and limbs have fallen. Bank erosion heights were observed on the right and left banks at a height of 5.5 and 10 ft. respectively. The banks are a silty material that is easily erodible due to its composition, the vertical bank angle, moderate root depths and moderate surface protection. Near bank stresses were found to be very high due to the large bank heights and severe incision. No bankfull indicators were observed. A severe erosion rating is given to this outfall reach as the height of erosion is greater than 5 ft.



Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: NLP-OF-F662
Site Name: Waterloo Rd
Contractor: KCI
Watershed: Little Patuxent River

Facing downstream: channel erosion and debris.

Facing upstream: steep bed slope, fallen trees, and eroded banks.

Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: NLP-OF-F662
Site Name: Waterloo Rd
Contractor: KCI
Watershed: Little Patuxent River

Constraints/Utilities:

No utility impacts are anticipated. Minimal impacts to the trees. The valley slope is very steep, making access more difficult. The sewer easement from Evening Sky Court appears to be the most feasible point of access due to the embankment of the outfall pipe.

Concept Description:

A Step Pool Storm Conveyance (SPSC) is proposed for this reach due to the steep elevation gradient over a relatively short distance of 200 ft. The proposed SPSC begins at the outfall and continues approximately 266 ft. downstream. The SPSC includes seven riffle weirs with 30 ft. width and 8 ft. length, seven pools with 30 ft. width, 3 ft. depth, and 22 ft. length, and a cascade with 30 ft. width following by three pools with 30 ft. length. The proposed design will treat more than 1 in. of rainfall and safely convey the 100 yr. flow. However, because of the diminishing credit returns on treatment over 1 in. of rainfall, it may be feasible to cut costs by reworking the SPSC design to bring the rainfall depth treated closer to the targeted 1 in. depth.

Nearby Opportunities:

None recommended

Proposed Project Credit

Drainage Area (ac.):	16.36
Impervious Area within Drainage (ac.):	5.65
Impervious Area Treated (ac.):	7.91
Impervious Area Treated Credit (ac.):	7.91

Water Quality Volume

WQVolume Target (cf.):	21,428
Max Treated (cf.):	105,210
Percent Treated:	490%
Rainfall Depth Treated (in.):	2.6

Costs

Estimated Design Cost:	$100,000.00
Estimated Construction Cost:	$100,000.00
30 % Contingency:	$30,000.00
Estimated Total Cost:	$230,000.00
Cost per Impervious Credit Acre:	$29,077.12

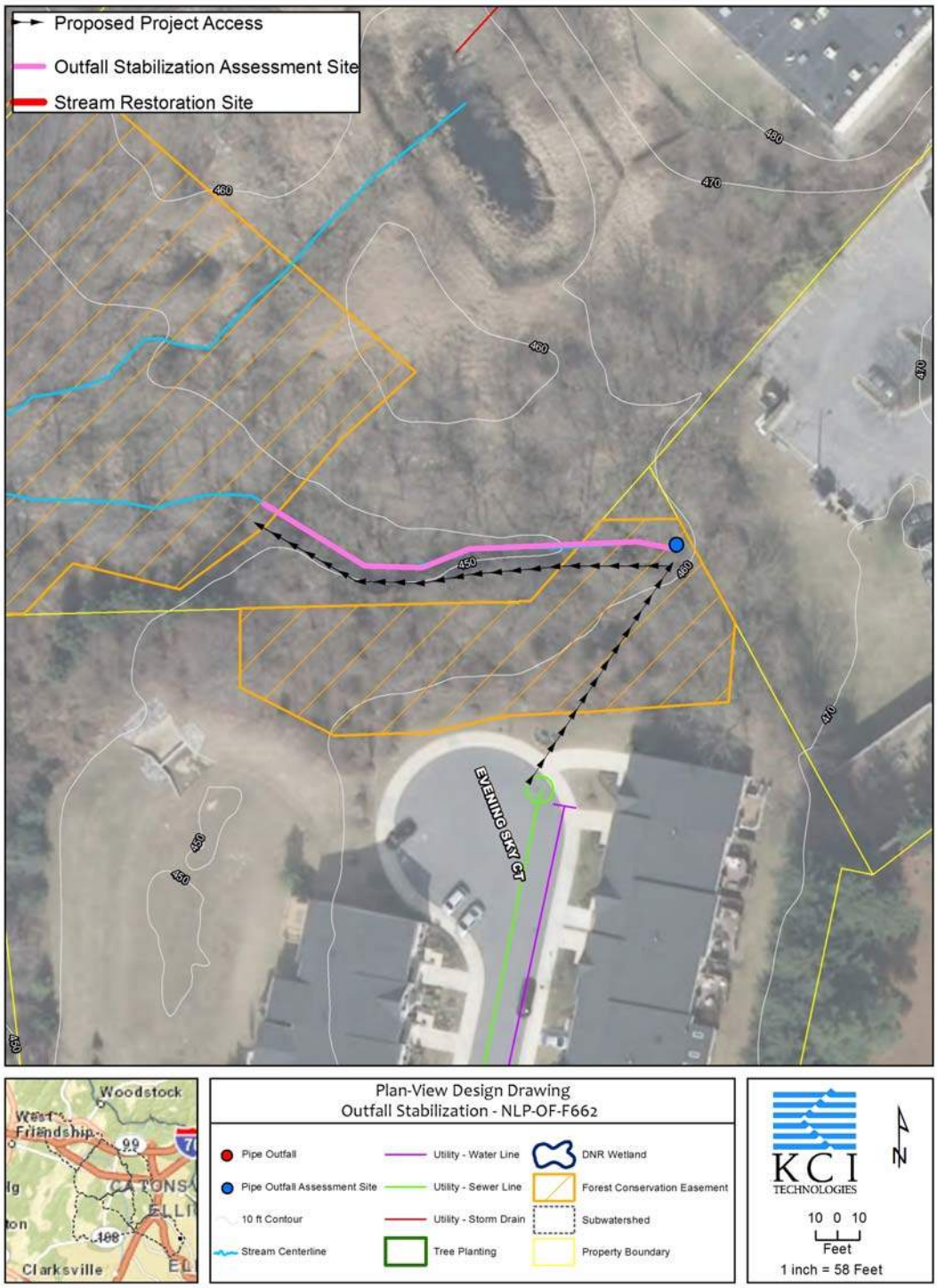
Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: NLP-OF-F662

Site Name: Waterloo Rd

Contractor: KCI

Watershed: Little Patuxent River



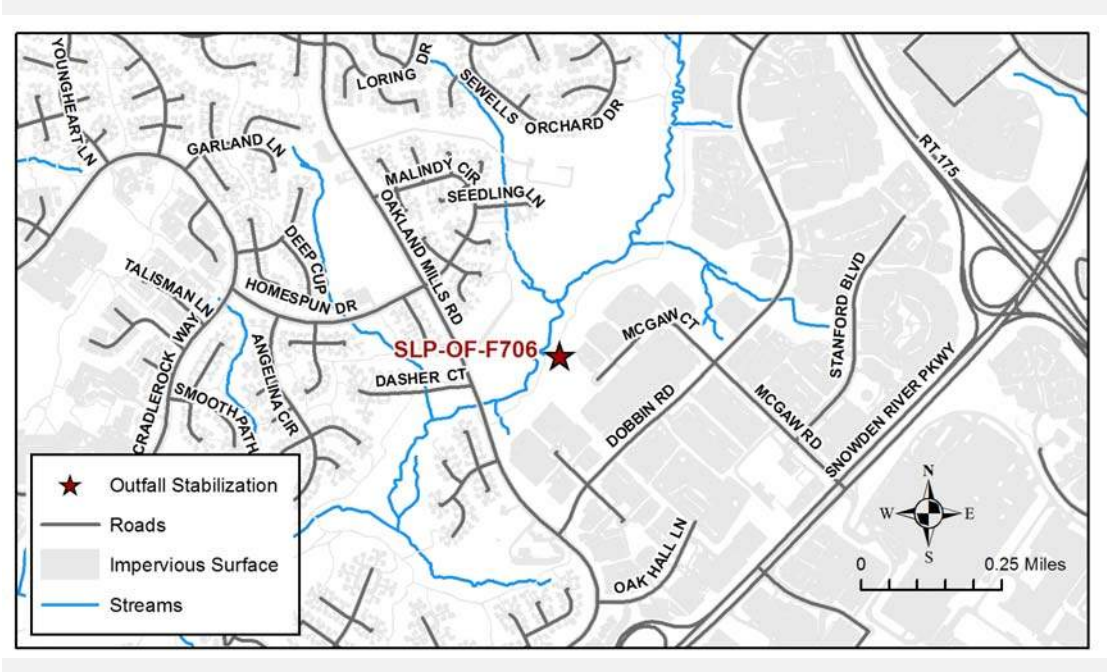
Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F706
Site Name: 8928 McGaw Court
Contractor: Versar
Watershed: Little Patuxent River

Proposed BMP Type: Outfall Stabilization
Stabilization Type: Riprap
Ownership: Columbia Association
Single Owner

Existing Conditions:

SLP-OF-F706 is located behind 8928 McGaw Court, approximately 365 ft. northwest from the end of McGaw Court. The surrounding development that drains into the outfall is designated as Industrial under 2010 Maryland Department of Planning Land Use/Land Cover. The outfall is a concrete endwall with 30 ft. long rock apron made up of boulders and large riprap. A 2.5 ft. cascade is located about 10 ft. from the endwall. Geotextile fabric has been exposed from under the riprap. Below the rock, an approximately 3 ft. 8 in. deep gully has formed into a hard clay layer. The outfall goes under the Patuxent Branch Trail (a paved, mixed-use path) in a 48 in. corrugated metal pipe about 140 ft. downstream of the endwall. The outfall enters an unnamed tributary of the Little Patuxent River another 55 ft. below the trail.



Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F706
Site Name: 8928 McGaw Court
Contractor: Versar
Watershed: Little Patuxent River

At outfall pipe looking downstream.

Area of erosion upstream of Patuxent Branch Trail.

Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F706
Site Name: 8928 McGaw Court
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:
The primary constraint is the trees along the outfall. Great care should be taken in planning and constructing the outfall stabilization to minimize the impact on the tree roots. Also, the cascade is split by a paved, mixed-use trail with a sanitary sewer underneath.

Two private stormwater management ponds are upstream of outfall SLP-OF-F706. One is located on the property of 6656 Dobbin Road Investors LLC, at 6656 Dobbin Road, Columbia, Maryland. The other is owned by Arcus Data Security Inc. at 8928 McGaw Court, Columbia, Maryland.

Concept Description:
A 140 ft. long, rock cascade outfall stabilization is recommended for SLP-OF-706 because the channel is too steep (average slope is 10%) and the length does not allow enough pools for full credit using a step pool storm conveyance credit.

The outfall can be accessed either from the Patuxent Branch Trail, or from the end of McGaw Court. Access from McGaw Court requires creating a 380 ft. long access road through the forest. Both accesses are on land owned by the Columbia Association.

Nearby Opportunities:
None recommended

Proposed Project Credit	
Length Restored (ft):	140
Impervious Area Treated Credit (ac.):	1.4
Cost Per Impervious Credit Acre:	$178,571.43

Costs	
Estimated Design Cost:	$120,000.00
Estimated Construction Cost:	$100,000.00
30% Contingency:	$30,000.00
Estimated Total Cost:	$250,000.00

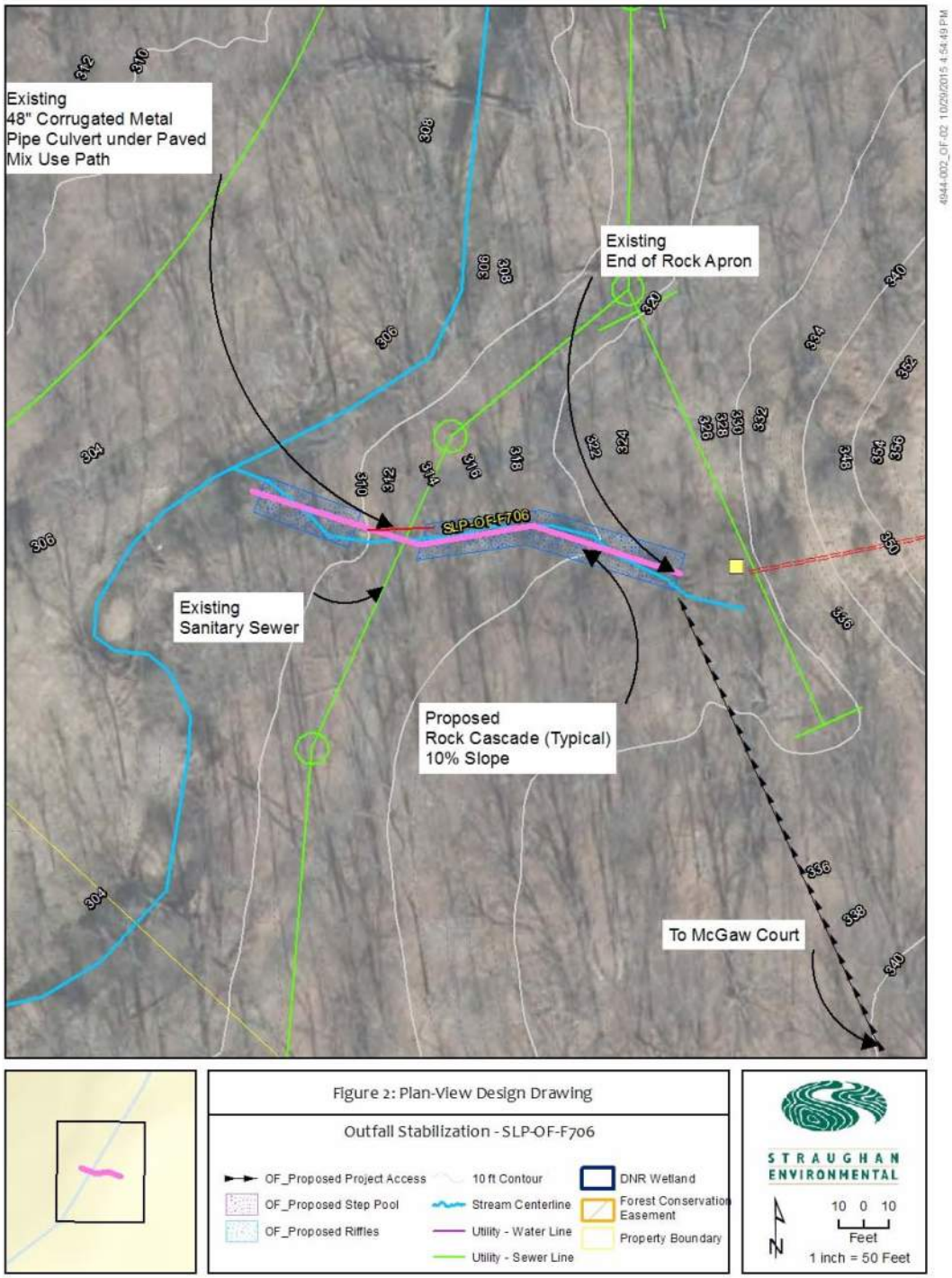
Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F706

Site Name: 8928 McGaw Court

Contractor: Versar

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F710

Site Name: South of Phelps Luck and Tamar Drives Intersection

Contractor: Versar

Watershed: Little Patuxent River

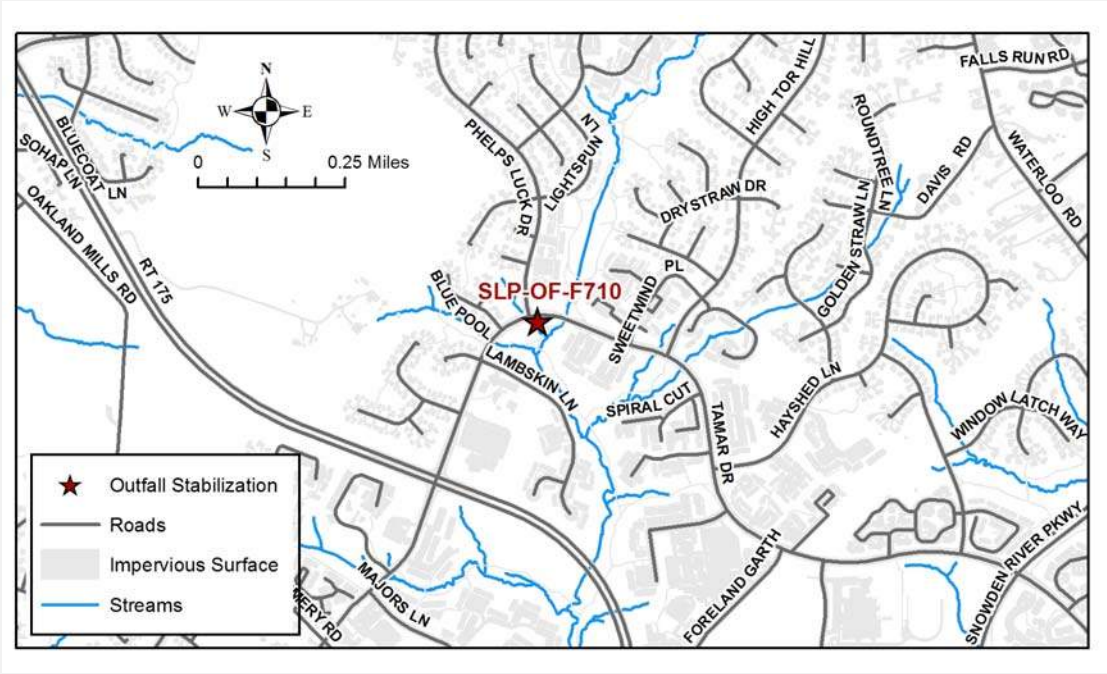
Proposed BMP Type: Outfall Stabilization

Stabilization Type: Riprap

Ownership: Columbia Association
Single Owner

Existing Conditions:

SLP-OF-F710 is located south of the intersection of Phelps Luck and Tamar Drives. The surrounding development that drains into the outfall is designated as Medium and High Density Residential under 2010 Maryland Department of Planning Land Use/Land Cover. The outfall has a concrete endwall with a 42 in. reinforced concrete pipe. The pipe discharges to a 15 ft. long trapezoidal concrete apron, and 1 ft.-10 in. drop off the end into a naturally eroded plunge pool. Downstream of the plunge is a 3 ft.-7 in. deep natural channel with vertical side slopes flowing for 160 ft. to an unnamed to a tributary of the Little Patuxent River. A paved, mixed-use trail crosses the channel via a wooden bridge about 100 ft. downstream of the concrete apron.



Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F710

Site Name: South of Phelps Luck and Tamar Drives Intersection

Contractor: Versar

Watershed: Little Patuxent River

At outfall pipe looking downstream.

Eroded area downstream of outfall pipe.

Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F710

Site Name: South of Phelps Luck and Tamar Drives Intersection

Contractor: Versar

Watershed: Little Patuxent River

Constraints/Utilities:

The primary constraint is the trees along the outfall. The tree roots are helping reduce the erosion, and removing them to construct the rock cascade may destabilize the slope. Great care should be taken in planning and constructing the outfall stabilization to minimize the impact on the tree roots.

An upstream pond is located on land owned by the Howard County Department of Recreation.

Concept Description:

A 168 ft. rock cascade outfall stabilization is recommended for SLP-OF-710 although this outfall has a slope of less than 5%. The primary reason for choosing this option is because it offers greater impervious credit treatment than the step pool storm conveyance. The outfall can be accessed directly from Tamar Drive, across land owned by the Columbia Association.

Nearby Opportunities:

None recommended

Proposed Project Credit	
Length Restored (ft):	168
Impervious Area Treated Credit (ac.):	1.68
Cost Per Impervious Credit Acre:	$148,809.52

Costs	
Estimated Design Cost:	$120,000.00
Estimated Construction Cost:	$100,000.00
30% Contingency:	$30,000.00
Estimated Total Cost:	$250,000.00

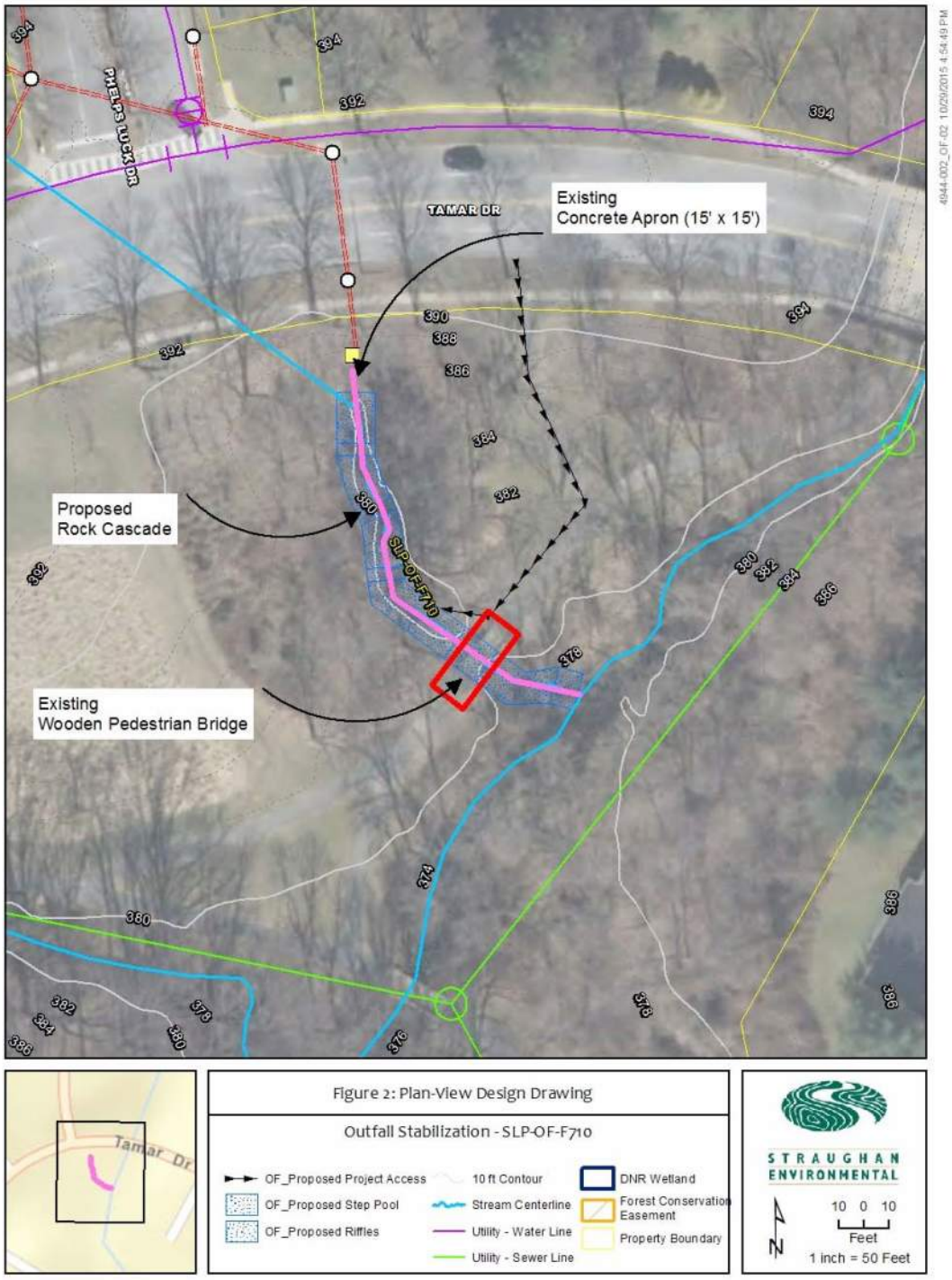
Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F710

Site Name: South of Phelps Luck and Tamar Drives Intersection

Contractor: Versar

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F711

Site Name: Cradlerock Way and Homespun Drive

Contractor: Versar

Watershed: Little Patuxent River

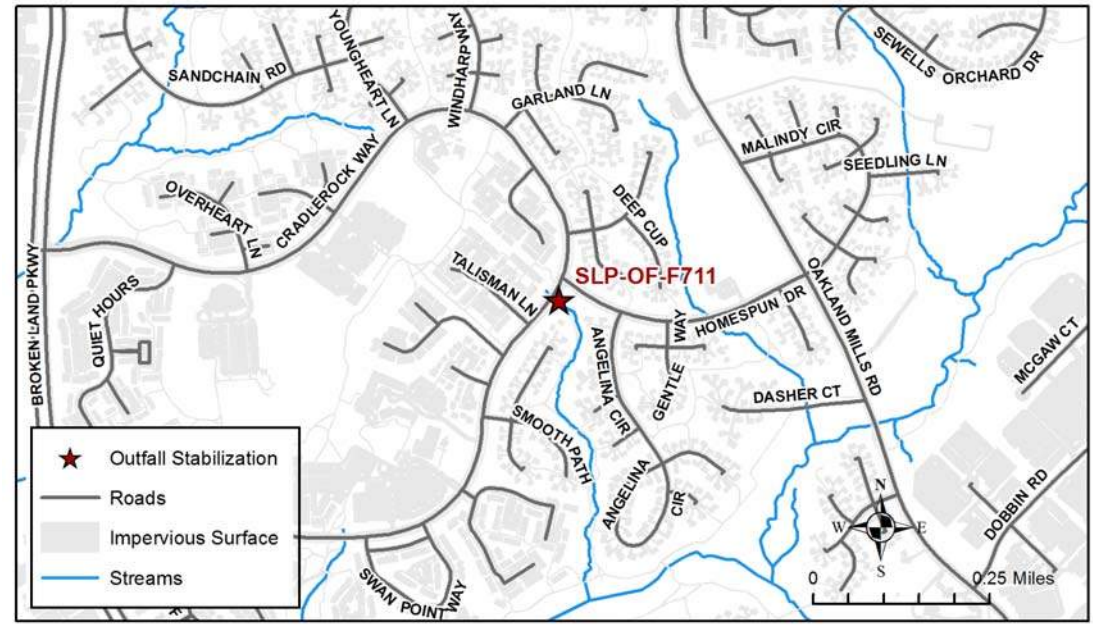
Proposed BMP Type: Outfall Stabilization

Stabilization Type: Step Pool Storm Conveyance.

Ownership: Columbia Association
Single Owner

Existing Conditions:

SLP-OF-F711 is located 130 ft. south of the traffic circle at Homespun Drive and Cradlerock Way. Lake Elkhorn is downstream of the outfall and the surrounding development that drains into the outfall is designated as Medium and High Density Residential under 2010 Maryland Department of Planning Land Use/Land Cover. The outfall has a concrete endwall with 4 ft. and 3 ft. diameter reinforced concrete pipes. Below the outfall is 29 ft. of riprap. Erosion has exposed a hard clay layer downstream of the riprap. The channel continues in a series of long pools interrupted by two sections of riprap. A third section riprap starts about 300 ft. from the outfall, the limit of this study. The stream continues in a similar fashion downstream.



Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F711

Site Name: Cradlerock Way and Homespun Drive

Contractor: Versar

Watershed: Little Patuxent River

Downstream of outfall looking upstream.

Eroded area in channel downstream of outfall pipe.

Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F711
Site Name: Cradlerock Way and Homespun Drive
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:
The primary constraint is the trees along the outfall. The tree roots are helping reduce the erosion, and removing them to construct the rock cascade may destabilize the slope. Great care should be taken in planning and constructing the outfall stabilization to minimize the impact on the tree roots.

Concept Description:
A 226 ft. long step pool storm conveyance with eight pool and riffle segments is recommended for SLP-OF-F711. A paved trail follows the channel for the entire length, providing site access. A paved trail follows the channel for the entire length, providing site access. This outfall stabilization project may be reclassified as a stream restoration project if the length of channel restored exceeds 200 lf.

Nearby Opportunities:
None recommended

Proposed Project Credit	
Drainage Area (ac.):	41.92
Impervious Area within Drainage (ac.):	14.41
Impervious Area Treated (ac.):	14.4
Impervious Area Treated Credit (ac.):	7.2

Water Quality Volume	
WQVolume Target (cf.):	54,798
Max Treated (cf.):	43,815
Percent Treated:	46%
Rainfall Depth Treated (in.):	0.46

Costs

Estimated Design Cost:	$120,000.00
Estimated Construction Cost:	$106,160.00
30 % Contingency:	$31,848.00
Estimated Total Cost:	$258,008.00
Cost per Impervious Credit Acre:	$35,834.44

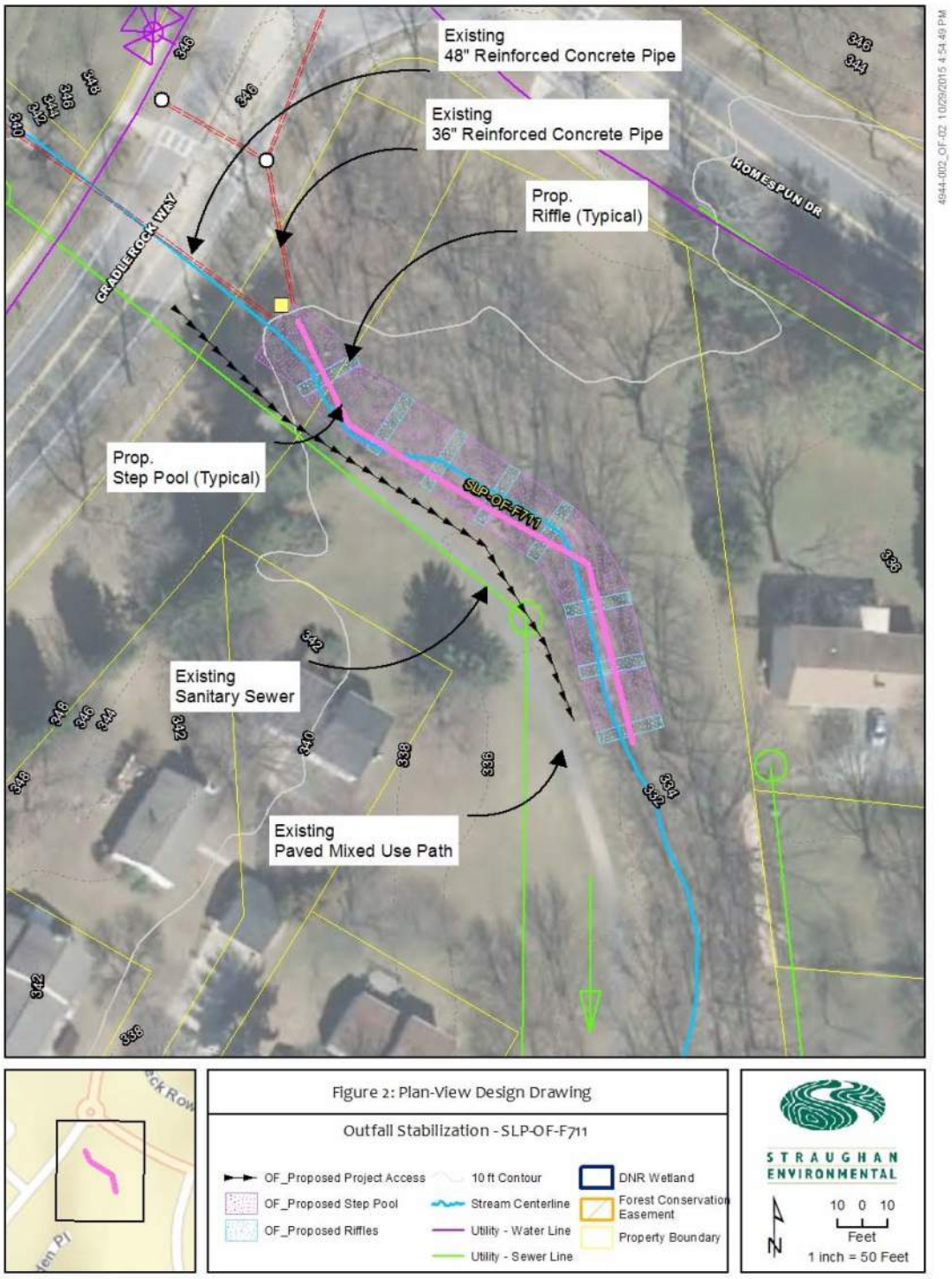
Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F711

Site Name: Cradlerock Way and Homespun Drive

Contractor: Versar

Watershed: Little Patuxent River



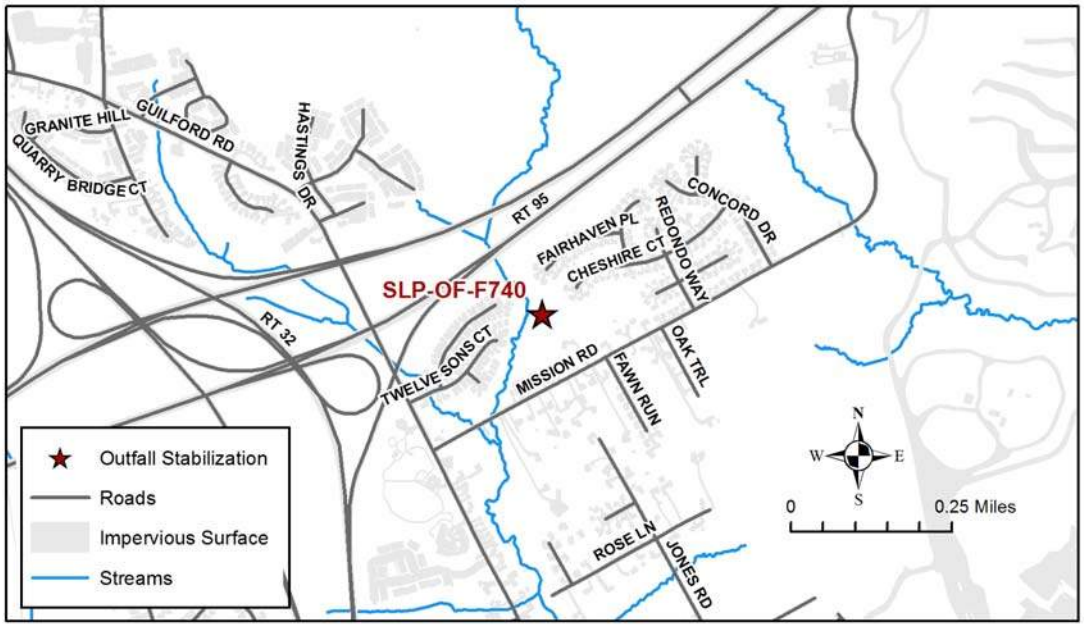
Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F740
Site Name: Cheshire Court
Contractor: Versar
Watershed: Little Patuxent River

Proposed BMP Type: Outfall Stabilization
Stabilization Type: Riprap
Ownership: Private- Residential
Multiple Owners

Existing Conditions:

The targeted outfall is located on the property line between the Heritage Woods Homeowner's Association and the Signal Hill Neighborhood Homeowner's Association. The dry pond that the outfall drains is located on Heritage Woods HOA property, while the outfall channel is located on Signal Hill Neighborhood HOA property. The corrugated metal 30 in. diameter outfall that drains the dry pond has a rusted-out, flared end apron. The outfall channel is fairly stable, except along one meander bend where minor to moderate erosion exists. The receiving stream appears to be very stable and providing good instream habitat. It was also observed that the dry pond's low flow orifice was clogged with debris.



Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F740
Site Name: Cheshire Court
Contractor: Versar
Watershed: Little Patuxent River

A 30 in. diameter corrugated metal outfall pipe with a rusted-out flared metal apron. The outfall drains a dry pond.

Minor to moderate erosion occurring around a meander bend in the outfall channel.

Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F740
Site Name: Cheshire Court
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:
The proposed project will require coordination with two separate Homeowner's Associations and will likely result in the removal of a few moderate sized trees.

Concept Description:
The proposed stabilization project will focus on replacing the rusting metal pipe and apron with a new concrete pipe, and using some riprap and minor grading to stabilize the eroding outfall channel banks. Debris should also be removed from the dry pond's low flow orifice. The site can be accessed from the end of Cheshire Court.

Nearby Opportunities:
None recommended

Proposed Project Credit	
Length Restored (ft):	127
Impervious Area Treated Credit (ac.):	1.27
Cost Per Impervious Credit Acre:	$181,102.36

Costs	
Estimated Design Cost:	$100,000.00
Estimated Construction Cost:	$100,000.00
30% Contingency:	$30,000.00
Estimated Total Cost:	$230,000.00

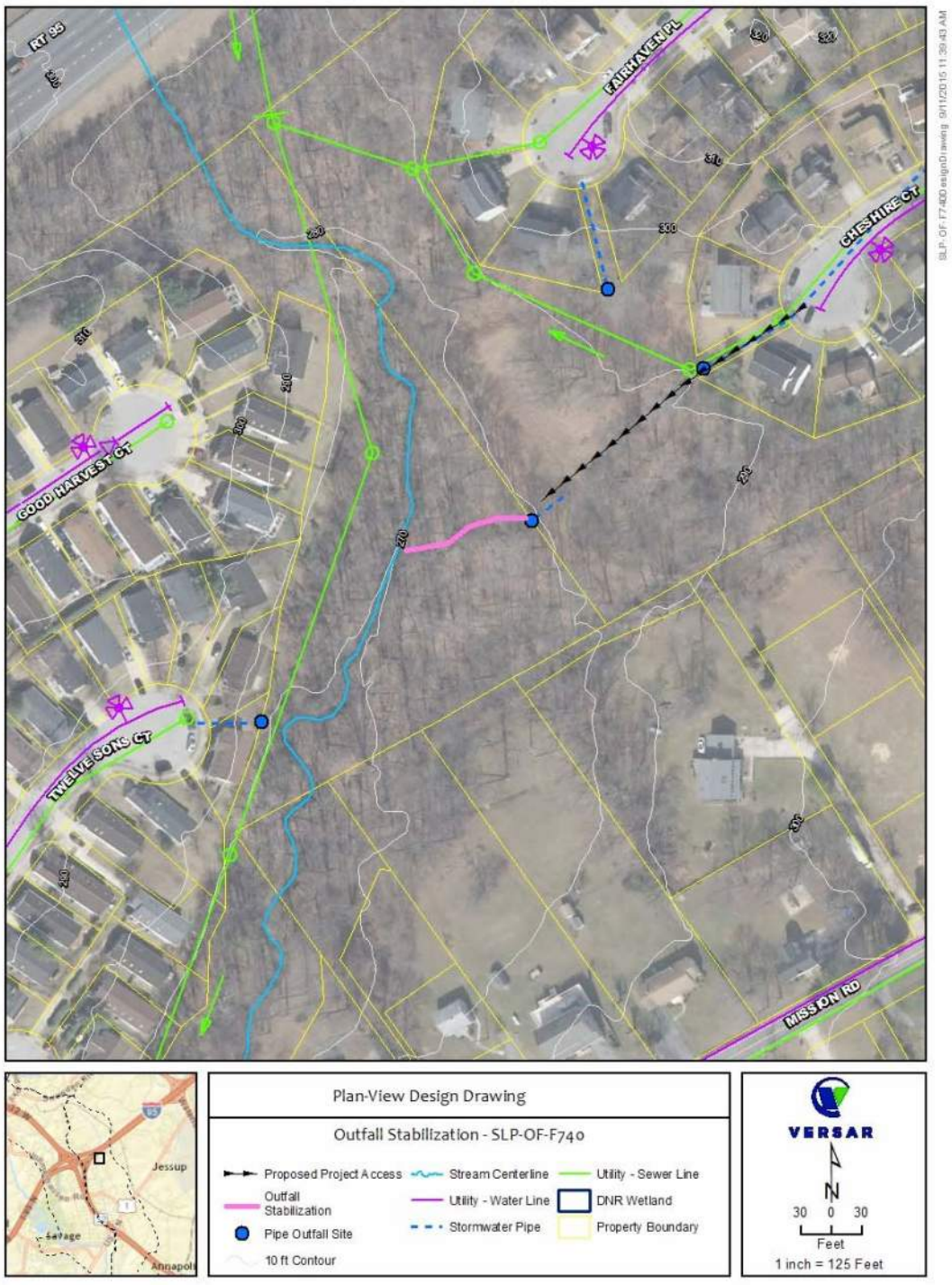
Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F740

Site Name: Cheshire Court

Contractor: Versar

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Outfall Stabilization

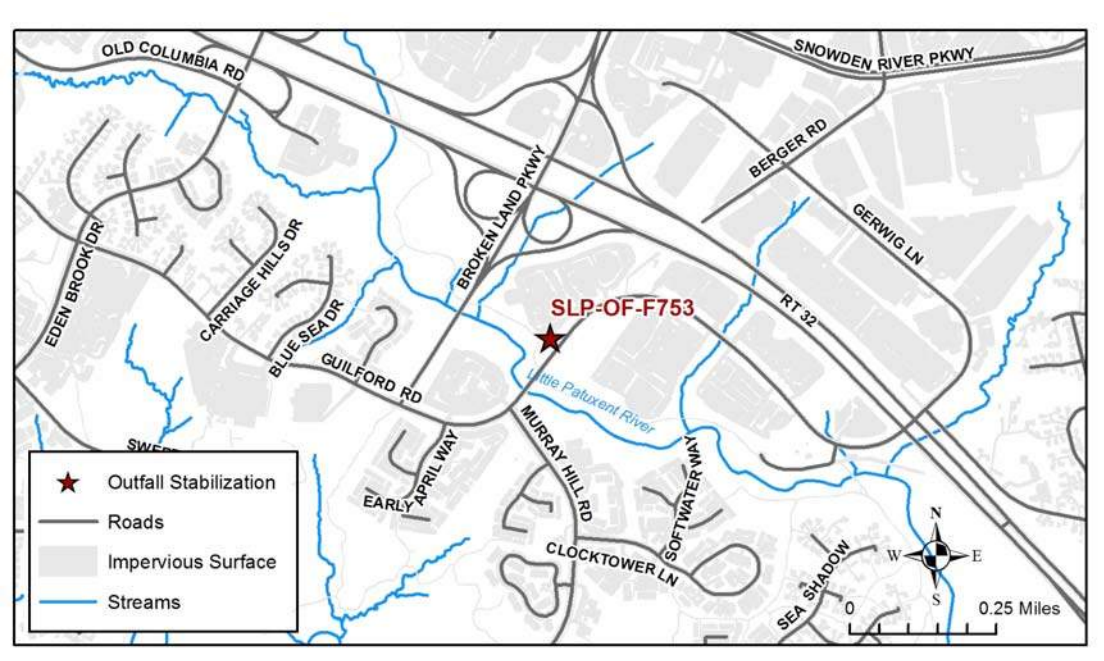
Site ID: SLP-OF-F753
Site Name: 9053 Guilford Road
Contractor: Versar
Watershed: Little Patuxent River

Proposed BMP Type: Outfall Stabilization
Stabilization Type: Riprap
Ownership: Columbia Association
Multiple Owners

Existing Conditions:

The outfall is a concrete endwall with a 27 ft. long riprap apron. In front of the endwall a 13 ft. long, 1.5 ft. deep pool has been formed by the water piling the riprap farther downstream. At the end of the riprap apron, a tree root is holding up a 4 ft. high headcut. The head cut is covered in geotextile, and riprap is present at both the top and the bottom.

Below the headcut at the outfall is an approximately 100 ft. long channel that is incised. About 80 ft. downstream of the headcut, an unknown 6 in. diameter corrugated metal pipe discharges into the channel. At the end of the incised channel the banks slope down, and the channel spreads out on a flat area covered in deposited sediment. The flow meanders through a wetland area, and enters the Little Patuxent River through a 42 in. diameter corrugated plastic pipe under the Patuxent Branch Trail.



Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F753
Site Name: 9053 Guilford Road
Contractor: Versar
Watershed: Little Patuxent River

Downstream of the outfall pipe, in background of photo where erosion starts.

In the eroded area looking downstream at second outfall pipe.

Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F753
Site Name: 9053 Guilford Road
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:
The primary constraint is the trees along the outfall. The tree roots are helping reduce the erosion, and removing them to construct the rock cascade may destabilize the slope. Great care should be taken in planning and constructing the outfall stabilization to minimize the impact on the tree roots.

Concept Description:
A 142 ft. long, rock cascade outfall stabilization is recommended for SLP-OF-753 because the slope is too steep (average slope is 7%)and the length does not allow enough pools for a step pool storm conveyance. The outfall can be accessed from the driveway to 9053 Guilford Road down a 3:1 grassed slope. The bottom of the outfall can also be reached from the Patuxent Branch Trail, however access from here may impact a potential wetland between the trail and outfall.

Nearby Opportunities:
None recommended

Proposed Project Credit	
Length Restored (ft):	142
Impervious Area Treated Credit (ac.):	1.42
Cost Per Impervious Credit Acre:	$176,056.34

Costs	
Estimated Design Cost:	$120,000.00
Estimated Construction Cost:	$100,000.00
30% Contingency:	$30,000.00
Estimated Total Cost:	$250,000.00

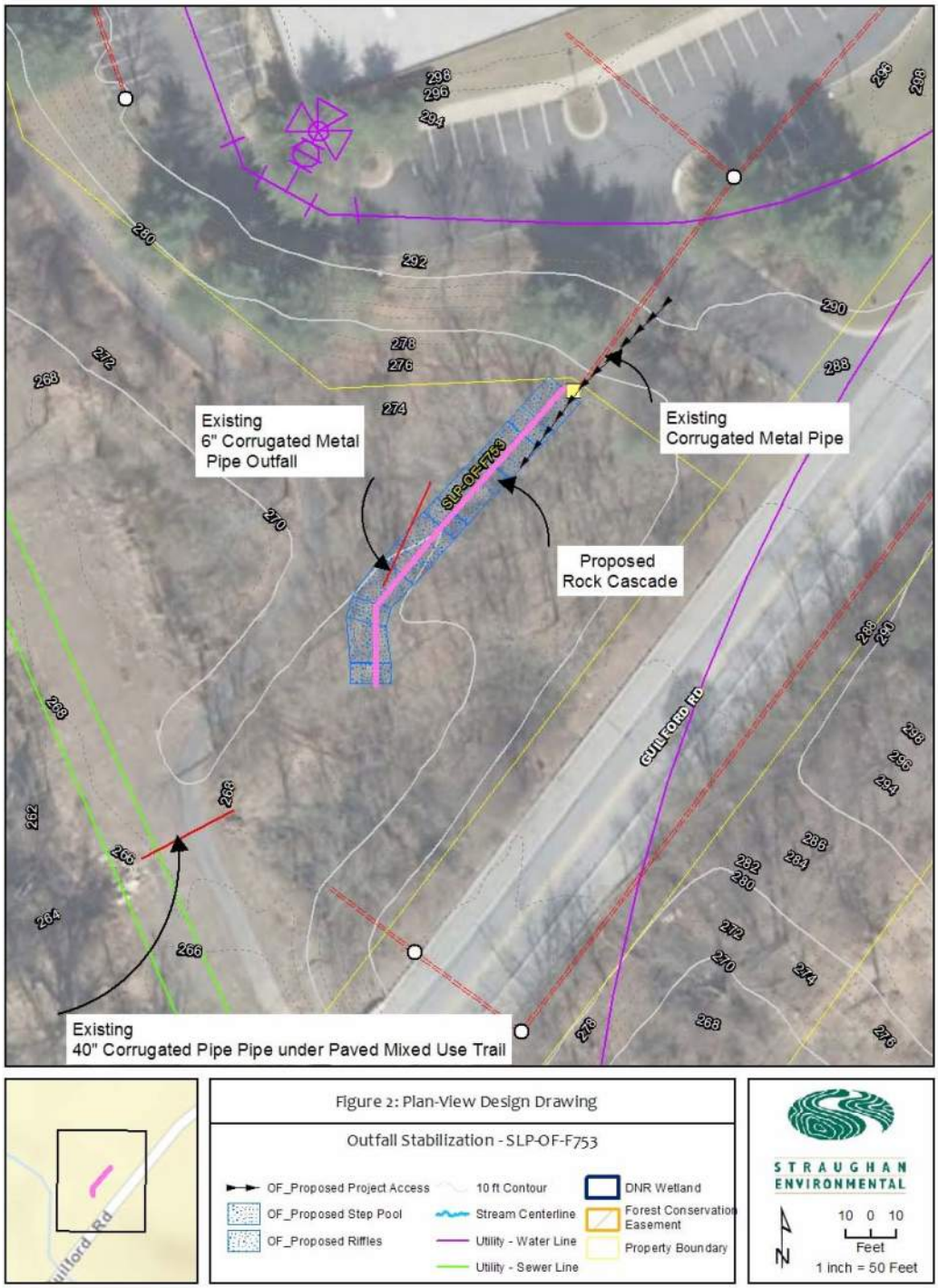
Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F753

Site Name: 9053 Guilford Road

Contractor: Versar

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Outfall Stabilization

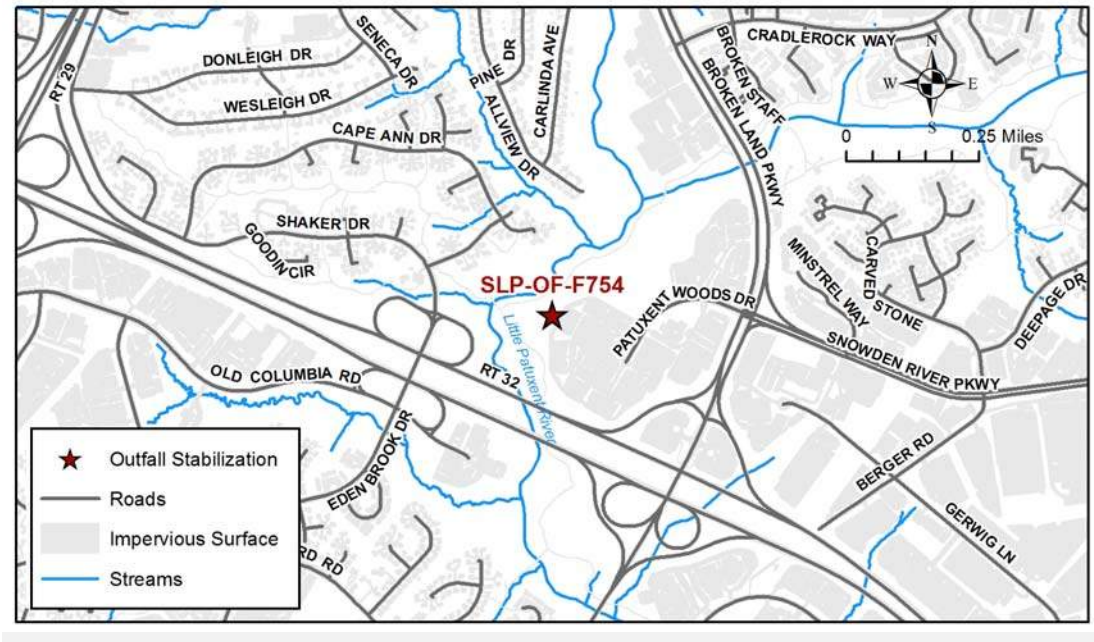
Site ID: SLP-OF-F754
Site Name: 9790 Patuxent Woods Drive
Contractor: Versar
Watershed: Little Patuxent River

Proposed BMP Type: Outfall Stabilization
Stabilization Type: Riprap
Ownership: Columbia Association
Multiple Owners

Existing Conditions:

SLP-OF-F754 is on land owned by Columbia Association but is adjacent to a private commercial property. The outfall is located within Department of Natural Resources and National Wetlands Inventory palustrine wetland boundaries, while the surrounding development is designated as Commercial, Industrial and Medium Density Residential under the 2010 Maryland Department of Planning Land Use/Land Cover.

The outfall is a concrete end section with an apron of crushed stone. The stones are about 3 in. in diameter and are being moved downslope by parking lot runoff. Discharge from the pipe formed a 1.5 ft. deep and 7 ft. long plunge pool in the rocks beneath the end section. The crushed stone is 23 ft. wide. An island of brush is located in the center of the rocks about 26 ft. from the end section. The channel is braided downstream of the island. The rock ends 76 ft. from the endwall, and the channel splits again. Here the outfall channel has a sandy bottom and shallower slope. The channel joins a dry sandy channel 137 ft. from the end section and follows a sewer right of way south to the Little Patuxent River.



Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F754
Site Name: 9790 Patuxent Woods Drive
Contractor: Versar
Watershed: Little Patuxent River

At outfall pipe, upstream end of outfall.

Standing midway along channel looking downstream at area of sediment deposit.

Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F754
Site Name: 9790 Patuxent Woods Drive
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:

The primary constraint is the trees along the outfall. The tree roots are helping reduce the erosion, and removing them to construct the rock cascade may destabilize the slope. Great care should be taken in planning and constructing the outfall stabilization to minimize the impact on the tree roots.

Concept Description:

A 100 ft. long, rock cascade outfall stabilization is recommended for SLP-OF-754 because the slope is too steep (average slope is 11%) and the length does not allow enough pools for a step pool storm conveyance design. The outfall is located directly behind 9790 Patuxent Woods Dr. The end section and top of the outfall is best reached from the commercial property's private parking lot. The bottom of the outfall can also be reached from the sewer right of way however, anew access road will need to be constructed

Nearby Opportunities:

None recommended

Proposed Project Credit	
Length Restored (ft):	100
Impervious Area Treated Credit (ac.):	1
Cost Per Impervious Credit Acre:	$250,000.00

Costs	
Estimated Design Cost:	$120,000.00
Estimated Construction Cost:	$100,000.00
30% Contingency:	$30,000.00
Estimated Total Cost:	$250,000.00

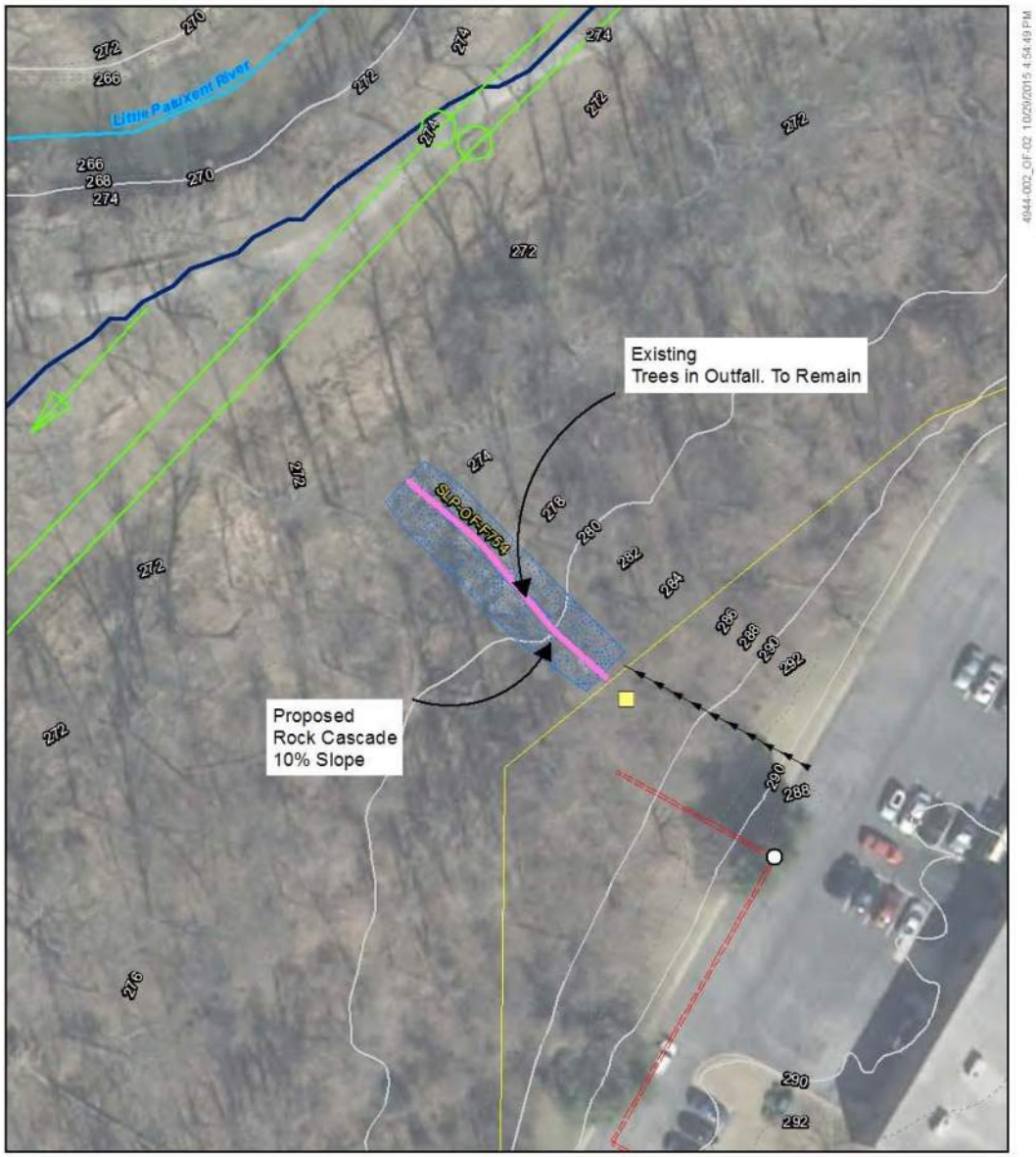
Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F754

Site Name: 9790 Patuxent Woods Drive

Contractor: Versar

Watershed: Little Patuxent River



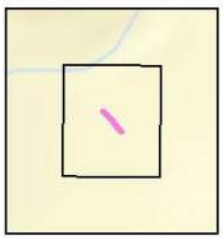


Figure 2: Plan-View Design Drawing

Outfall Stabilization - SLP-OF-F754

OF_Proposed Project Access
OF_Proposed Step Pool
OF_Proposed Riffles
10 ft Contour
Stream Centerline
Utility - Water Line
Utility - Sewer Line
DNR Wetland
Forest Conservation Easement
Property Boundary

STRAUGHAN ENVIRONMENTAL

10 0 10
Feet
1 inch = 50 Feet

Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F773

Site Name: Lightning View Road

Contractor: Versar

Watershed: Little Patuxent River

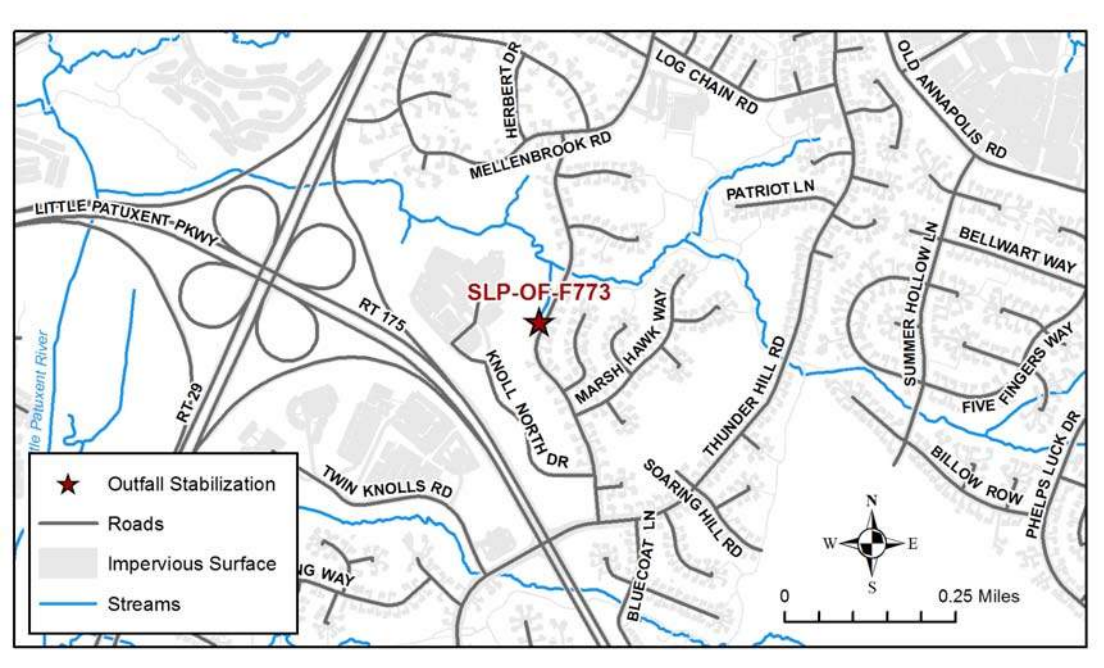
Proposed BMP Type: Outfall Stabilization

Stabilization Type: Riprap

Ownership: Columbia Association
Single Owner

Existing Conditions:

The area recommended for stabilization is fully contained within Columbia Association property, though it abuts the road right-of-way associated with Lightning View Road. The targeted outfall discharges flow onto a failing 20-25 ft. long concrete channel that is located in an intermittent stream.



Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F773
Site Name: Lightning View Road
Contractor: Versar
Watershed: Little Patuxent River

Failing concrete channel downstream of 36 in. outfall. Photo taken looking downstream.

Failing concrete channel downstream of 36 in. outfall. Photo taken looking upstream shows that the stream is starting to cut around the left side of the concrete channel.

Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F773
Site Name: Lightning View Road
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:
Some minor clearing of brush and small trees may be needed to access the channel.

Concept Description:
The proposed project will result in the removal of the failing concrete channel and the stabilization of the stream banks using riprap. The site can be accessed from Lightning View Road.

Nearby Opportunities:
None recommended

Proposed Project Credit		Costs	
Length Restored (ft):	25	**Estimated Design Cost:**	$100,000.00
Impervious Area Treated Credit (ac.):	0.25	**Estimated Construction Cost:**	$100,000.00
Cost Per Impervious Credit Acre:	$920,000.00	**30% Contingency:**	$30,000.00
		Estimated Total Cost:	$230,000.00

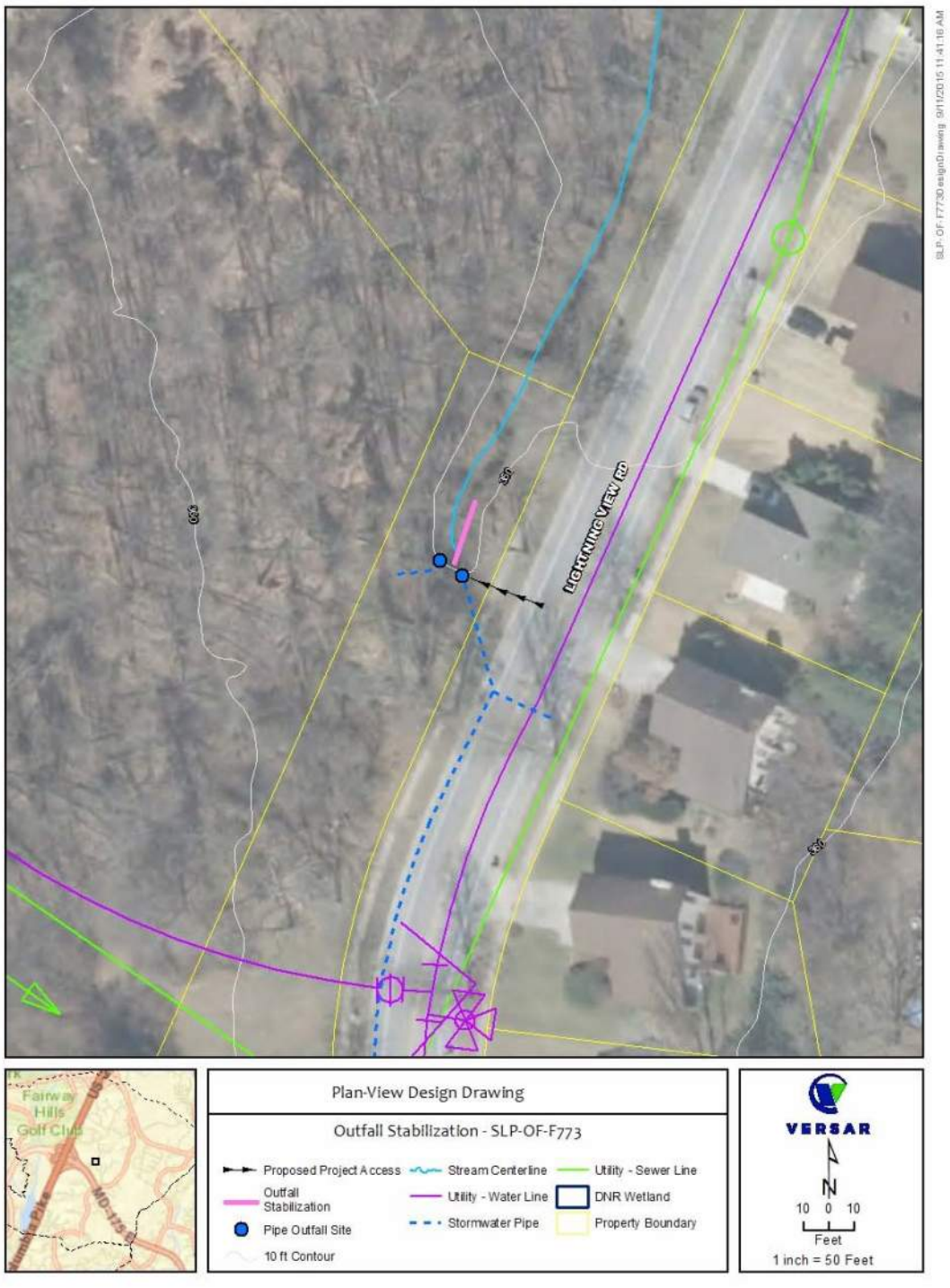
Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F773

Site Name: Lightning View Road

Contractor: Versar

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Outfall Stabilization

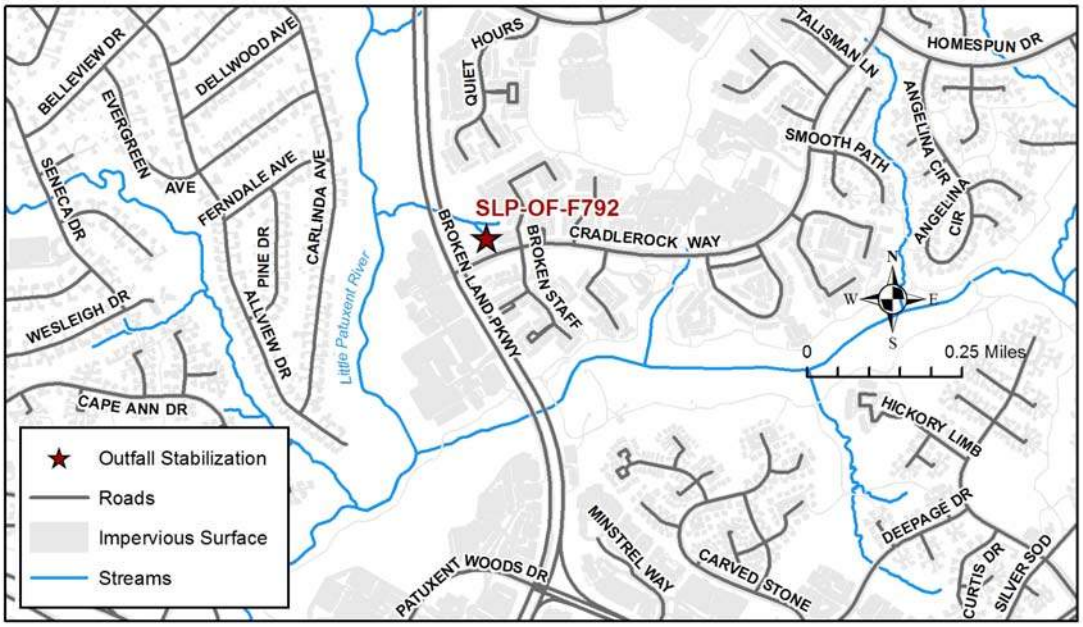
Site ID: SLP-OF-F792
Site Name: 7363-7351 Hickory Log Circle
Contractor: Versar
Watershed: Little Patuxent River

Proposed BMP Type: Outfall Stabilization
Stabilization Type: Riprap
Ownership: Columbia Association
Single Owner

Existing Conditions:

The outfall is located within Maryland Department of Natural Resources and National Wetlands Inventory palustrine wetland boundaries. The surrounding development is designated as Commercial and High Density Residential under the 2010 Maryland Department of Planning Land Use/Land Cover.

The outfall starts at a 3 ft. diameter corrugated metal pipe with a concrete endwall. Water cascades off the endwall into a plunge pool created by erosion. The plunge pool contains the remains of a concrete apron that erosion undermined and destroyed. The outfall is 16.5 ft. wide with 8 to 10 ft. high banks. About 171 ft. from the pipe, the outfall's left bank (looking upstream) is a peninsula between the outfall and a larger channel. The peninsula is about 10 ft. high and less than a foot at its narrowest, with vertical slopes on both sides. The peninsula continues for 34 ft. to the confluence of the outfall and the larger channel.



Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F792

Site Name: 7363-7351 Hickory Log Circle

Contractor: Versar

Watershed: Little Patuxent River

Looking at outfall pipe from top of bank.

Standing on bank downstream of outfall pipe in eroded area.

Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F792
Site Name: 7363-7351 Hickory Log Circle
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:
The primary constraint is the trees along the outfall. The tree roots are helping reduce the erosion, and removing them to construct the rock cascade may destabilize the slope. Great care should be taken in planning and constructing the outfall stabilization to minimize the impact on the tree roots.

Concept Description:
A 166 ft. long, rock cascade outfall stabilization is recommended for SLP-OF-792 although this outfall has a slope < 5%. The primary reason for choosing this option is that it would receive more impervious treatment credit than a step pool storm conveyance. The outfall can be accessed from the parking area for townhouses, 7363-7351 Hickory Log Circle. The outfall is approximately 95 ft. northwest of the parking area.

Nearby Opportunities:
None recommended

Proposed Project Credit		Costs	
Length Restored (ft):	166	**Estimated Design Cost:**	$120,000.00
Impervious Area Treated Credit (ac.):	1.66	**Estimated Construction Cost:**	$100,000.00
		30% Contingency:	$30,000.00
Cost Per Impervious Credit Acre:	$150,602.41	**Estimated Total Cost:**	$250,000.00

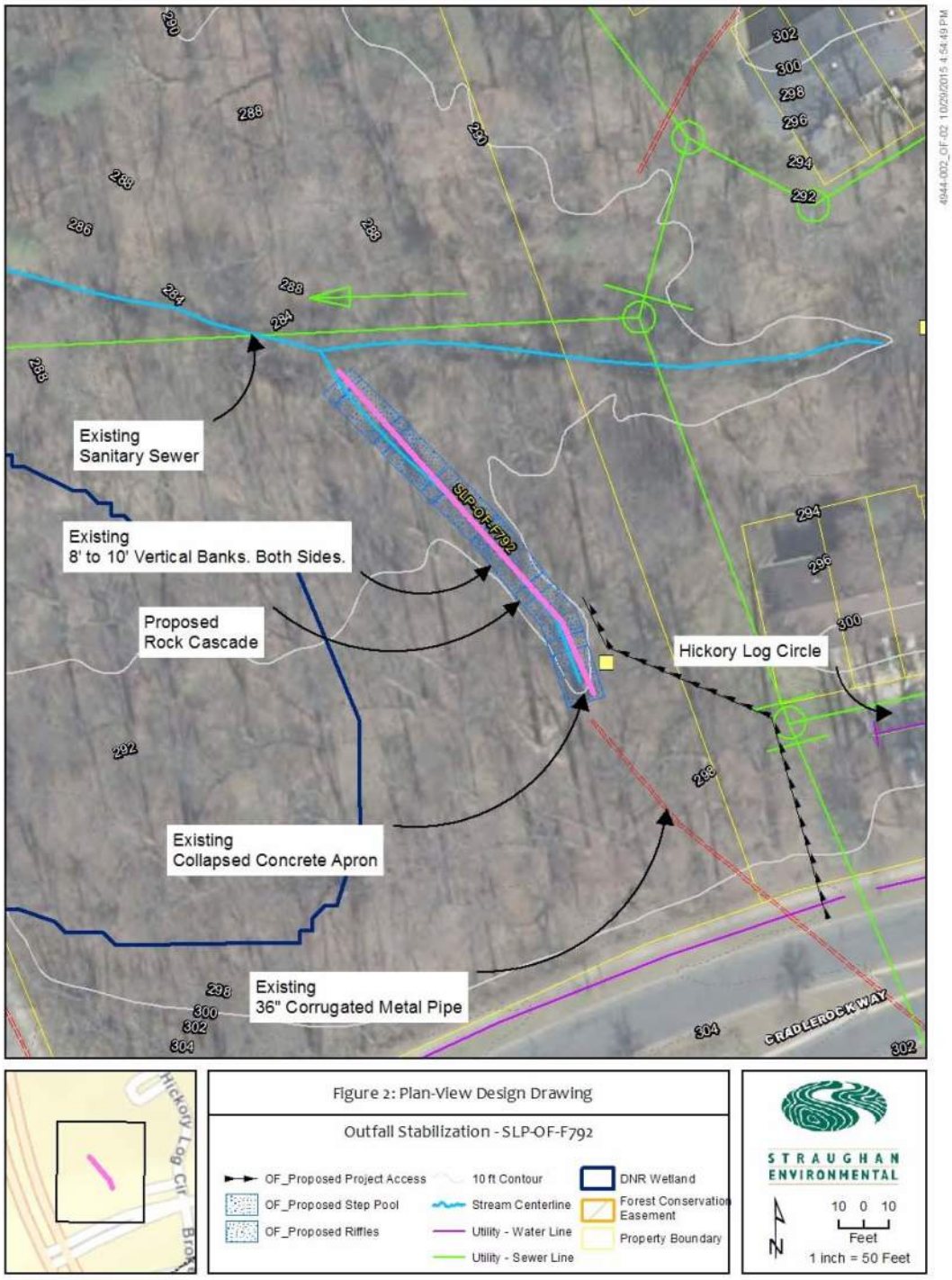
Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F792

Site Name: 7363-7351 Hickory Log Circle

Contractor: Versar

Watershed: Little Patuxent River



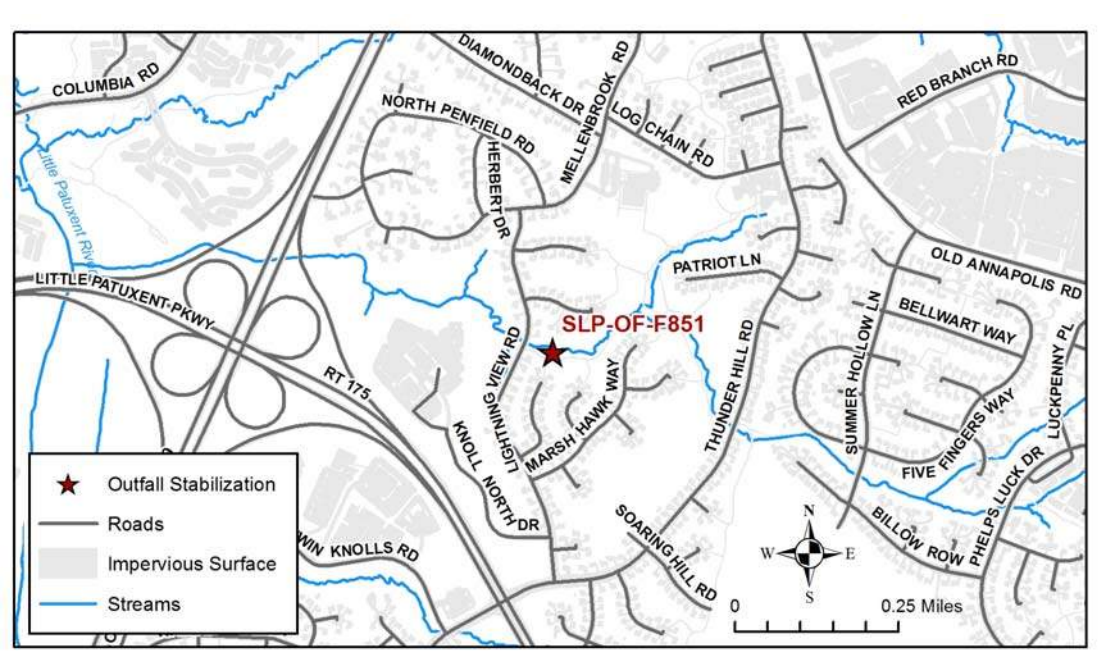
Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F851
Site Name: 5377 Racegate Run
Contractor: Versar
Watershed: Little Patuxent River

Proposed BMP Type: Outfall Stabilization
Stabilization Type: Riprap
Ownership: Columbia Association
Single Owner

Existing Conditions:

SLP-OF-F851 is at the end of Racegate Run and the surrounding development that drains into the outfall is designated as Medium Density Residential under 2010 Maryland Department of Planning Land Use/Land Cover. The outfall starts at a concrete endwall which is completely submerged in a 19 in. deep pool. The pool is formed because the outfall channel downstream is higher than the pipe invert. The pool is 6 ft. wide and 12 ft. long. Several frogs were at the pool, indicating it may regularly remain wet between storms. Drainage travels through a shallow brushy channel downstream of the outfall. A paved, mixed-use path crosses the outfall via a wooden bridge 50 ft. from the pipe. The outfall continues for another 50 ft. downstream of the bridge in a similar shallow channel to a large box elder tree growing in the center of the channel. The box elder is holding back an eroding headcut. The channel enters a more formed channel behind the box elder, and then cuts its way to the stream, which has 5 ft.-10 in. banks.



Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F851
Site Name: 5377 Racegate Run
Contractor: Versar
Watershed: Little Patuxent River

The eroded segment of the outfall looking downstream from the box elder.

The 20 in. diameter box elder at the top of the eroded section, looking upstream.

Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F851
Site Name: 5377 Racegate Run
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:

The primary constraint is the trees along the outfall. The tree roots are helping reduce the erosion, and removing them to construct the rock cascade may destabilize the slope. Great care should be taken in planning and constructing the outfall stabilization to minimize the impact on the tree roots.

Concept Description:

A 53 ft. long, rock cascade outfall stabilization is recommended for SLP-OF-851 although this outfall has a slope of less than 5%. The primary reason for choosing this option is that it will provide more impervious treatment credit than a step pool storm conveyance. The outfall can be reached either from the end of Racegate Run, or from Lightning View Road. Both access paths are owned by the Columbia Association.

Nearby Opportunities:

None recommended

Proposed Project Credit		Costs	
Length Restored (ft):	53	Estimated Design Cost:	$120,000.00
Impervious Area Treated Credit (ac.):	0.53	Estimated Construction Cost:	$100,000.00
		30% Contingency:	$30,000.00
Cost Per Impervious Credit Acre:	$471,698.11	Estimated Total Cost:	$250,000.00

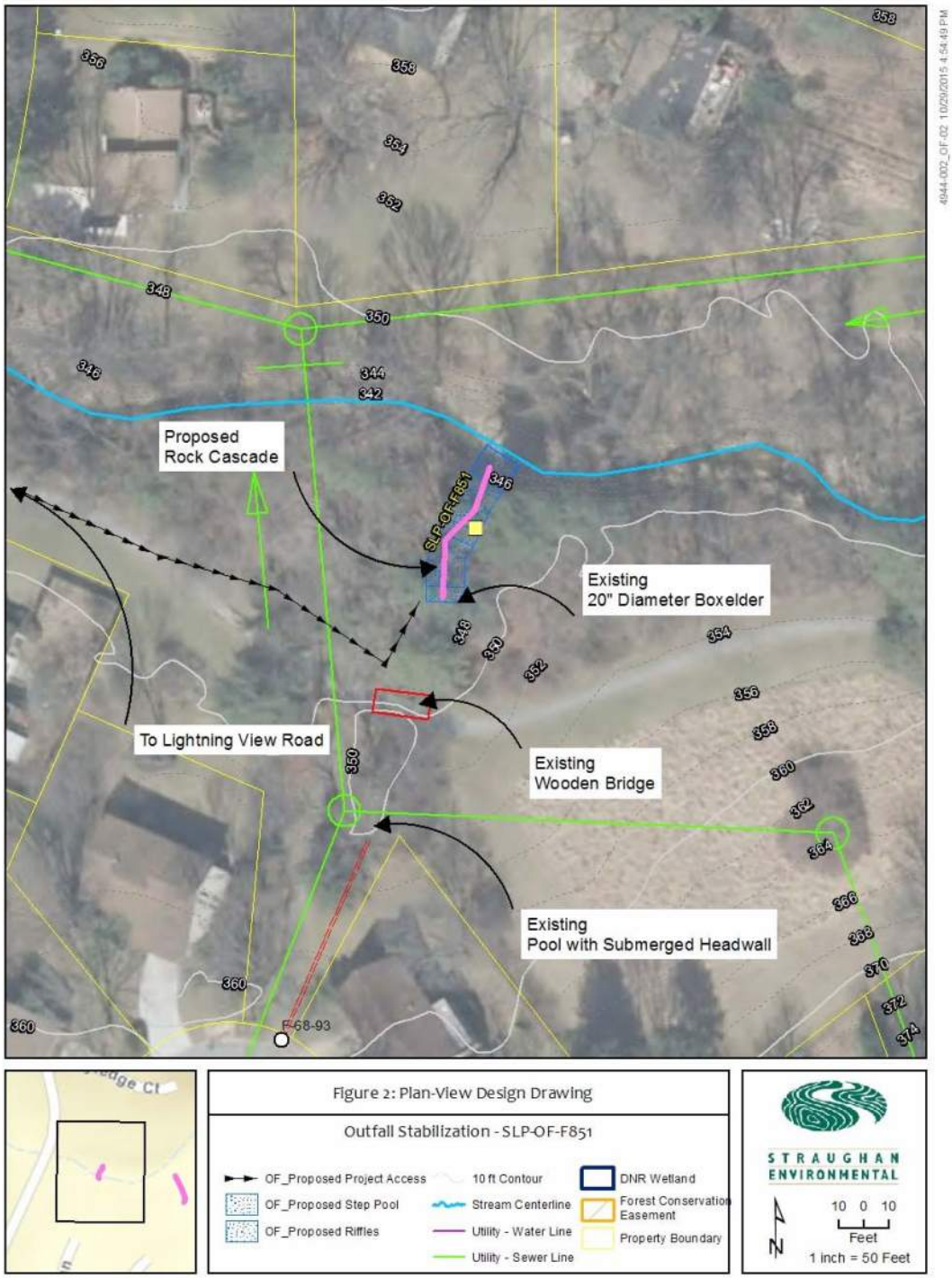
Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F851

Site Name: 5377 Racegate Run

Contractor: Versar

Watershed: Little Patuxent River



Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F852

Site Name: Wolf River Lane and Lightning View Road

Contractor: Versar

Watershed: Little Patuxent River

Proposed BMP Type: Outfall Stabilization

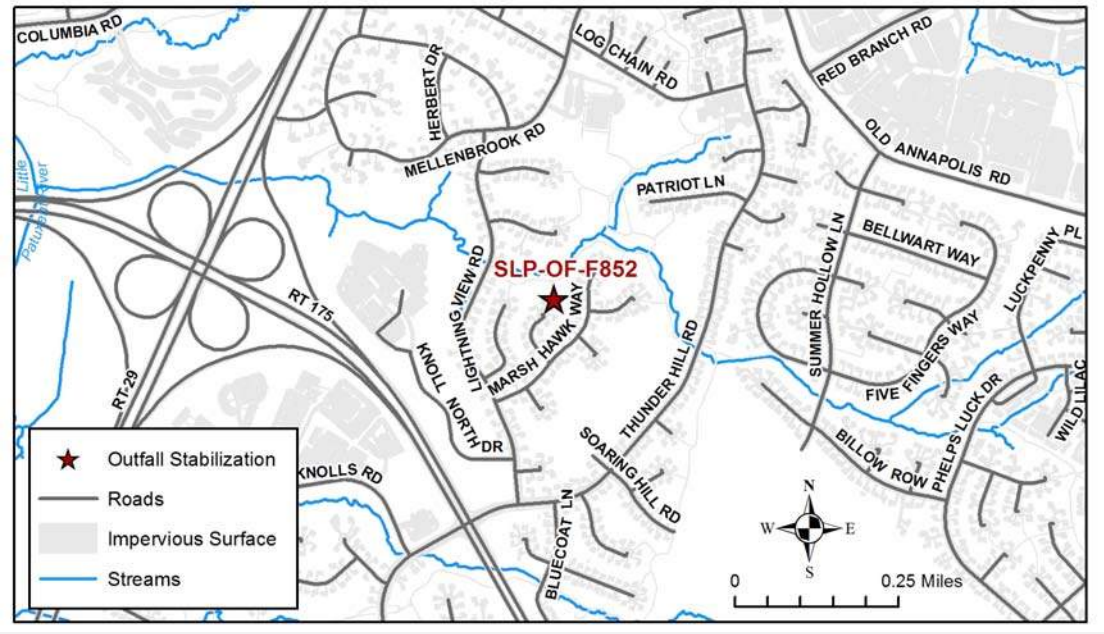
Stabilization Type: Riprap

Ownership: Columbia Association
Single Owner

Existing Conditions:

SLP-OF-F852 is at the end of Wolf River Lane and the surrounding development that drains to the outfall is designated as Medium Density Residential under 2010 Maryland Department of Planning Land Use/Land Cover. SLP-OF-F852 starts at a concrete endwall with a 18 in. reinforced concrete pipe. A concrete apron whose bottom has been eroded out is downstream of the pipe. A pool formed in the apron. Flow runs out of the pool along a shallow channel that is filled with debris, including leaves, riprap, and dumped yard waste. Several large trees grow directly adjacent to the channel, including a mulberry, box elders, ashes, and honey locusts.

SLP-OF-F852 joins with another outfall channel about 100 ft. downstream of the pipe. The other outfall begins at a pipe outlet 266 ft. upstream of the confluence. An unknown corrugated metal pipe discharges into the other outfall channel about 40 ft. upstream from the confluence. The corrugated pipe shows severe erosion around it. Long sections of the corrugated pipe (2 to 10 ft. long), including a metal end section, have disconnected from the pipe and washed farther down the outfall channels. Downstream of the confluence the outfall has 6 to 7 ft. high banks. SLP-OF-F852 has a series of headcuts and cascades upstream of the confluence to match its invert. The combined outfalls pass underneath a wooden bridge on a paved, mixed-use trail about 76 ft. downstream of the confluence. A headcut and heavy erosion is occurring at the bridge, and the banks are almost vertical. The outfalls continue in a steep narrow gully to the stream, which also has 7 ft. vertical banks.



Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F852

Site Name: Wolf River Lane and Lightning View Road

Contractor: Versar

Watershed: Little Patuxent River

Standing on bridge for pedestrian trail looking at area of channel erosion.

Standing downstream of pedestrian bridge looking at eroded area.

Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F852
Site Name: Wolf River Lane and Lightning View Road
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:

The primary constraint is the trees along the outfall. The tree roots are helping reduce the erosion, and removing them to construct the rock cascade may destabilize the slope. Great care should be taken in planning and constructing the outfall stabilization to minimize the impact on the tree roots.

Concept Description:

A 179 ft. long, rock cascade outfall stabilization is recommended for SLP-OF-852, although this outfall has a slope of less than 5%. The primary reason for choosing this option is that it will provide more impervious treatment credit than a step pool storm conveyance. The outfall can be reached either from the end of Wolf River Lane, or from Lightning View Road. Both access paths are owned by the Columbia Association.

Nearby Opportunities:

None recommended

Proposed Project Credit	
Length Restored (ft):	179
Impervious Area Treated Credit (ac.):	1.79
Cost Per Impervious Credit Acre:	$139,664.80

Costs	
Estimated Design Cost:	$120,000.00
Estimated Construction Cost:	$100,000.00
30% Contingency:	$30,000.00
Estimated Total Cost:	$250,000.00

Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F852

Site Name: Wolf River Lane and Lightning View Road

Contractor: Versar

Watershed: Little Patuxent River

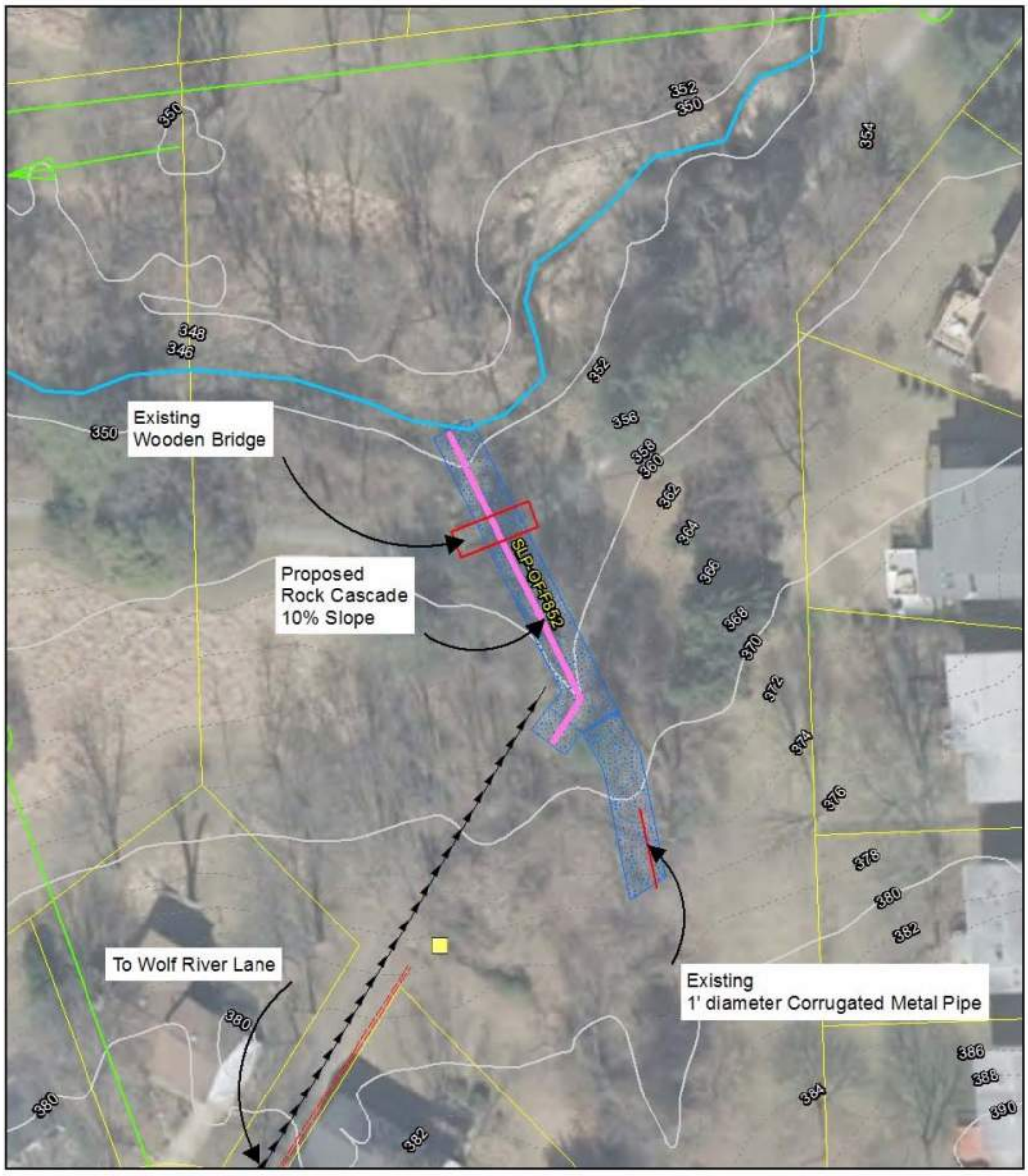


Figure 2: Plan-View Design Drawing

Outfall Stabilization - SLP-OF-F852

OF_Proposed Project Access
OF_Proposed Step Pool
OF_Proposed Riffles
10 ft Contour
Stream Centerline
Utility - Water Line
Utility - Sewer Line
DNR Wetland
Forest Conservation Easement
Property Boundary

STRAUGHAN ENVIRONMENTAL

10 0 10
Feet
1 inch = 50 Feet

Howard County Watershed Assessment Concept Plan: Outfall Stabilization

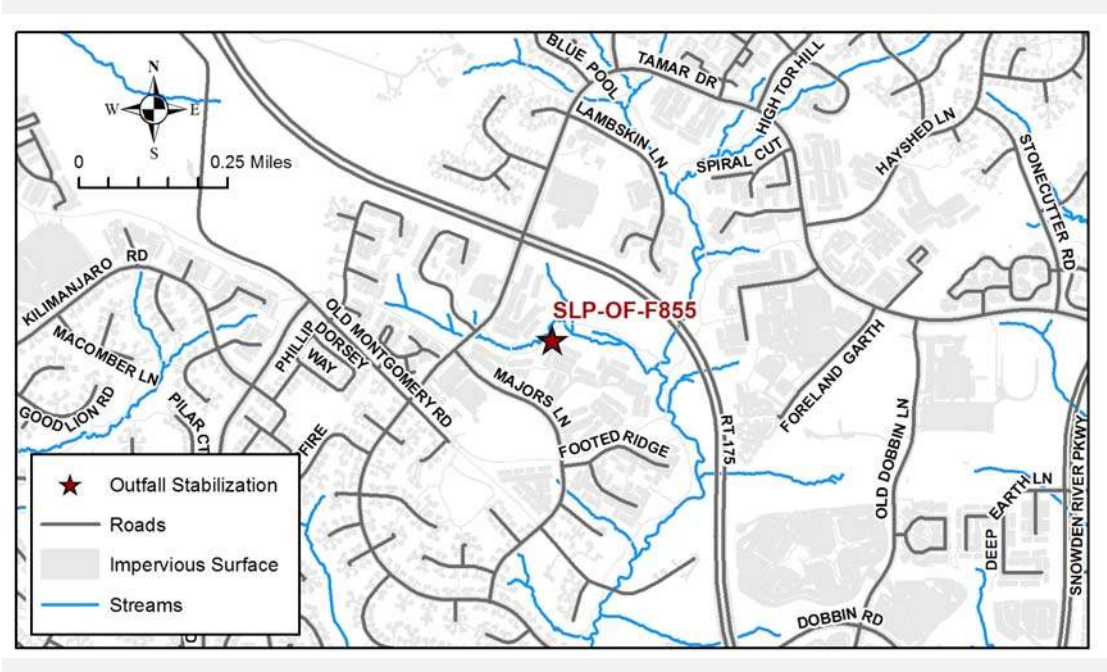
Site ID: SLP-OF-F855
Site Name: 6029 Majors Lane
Contractor: Versar
Watershed: Little Patuxent River

Proposed BMP Type: Outfall Stabilization
Stabilization Type: Riprap
Ownership: Columbia Association
Multiple Owners

Existing Conditions:

SLP-OF-F855 is on land owned by a private gardens style apartment complex. The outfall is behind 6029 Majors Lane. The surrounding development that drains into the outfall is designated as Institutional, Medium and High Density Residential under 2010 Maryland Department of Planning Land Use/Land Cover.

The outfall has a trapezoidal concrete apron with energy dissipaters installed. Downstream of the apron a cascade of debris, chunks of concrete, tree limbs, and trash, and a head cut cause the outfall to fall 5 ft. into a deep gully. Several large trees adjacent to the outfall are supporting the cascade and headcut. A paved, mixed-use trail crosses the gully on wooden bridge downstream of the headcut. The outfall enters a stream about 35 ft. downstream of the bridge.



Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F855
Site Name: 6029 Majors Lane
Contractor: Versar
Watershed: Little Patuxent River

Standing on apron at outfall pipe looking downstream at drop and bridge for pedestrian trail.

Standing under pedestrian bridge looking downstream at eroded bank.

Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F855
Site Name: 6029 Majors Lane
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:
The primary constraint is the trees along the outfall. The tree roots are helping hold reduce the erosion, and removing them to construct the rock cascade may destabilize the slope. Great care should be taken in planning and constructing the outfall stabilization to minimize the impact on the tree roots.
Access and some of the work may require coordination with the apartment complex to gain access to their land.

Concept Description:
A 64 ft. long, rock cascade outfall stabilization is recommended, because the existing outfall is too steep (average slope is 10%) for step pools. The outfall can be reached from the apartment complex, across private land. The SLP-OF-855 can also be reached via the mixed-use path from Tamar Drive, owned by the Columbia Association; however, a new stream crossing will need to be constructed for construction vehicles.

Nearby Opportunities:
None recommended

Proposed Project Credit	
Length Restored (ft):	64
Impervious Area Treated Credit (ac.):	0.64
Cost Per Impervious Credit Acre:	$390,625.00

Costs	
Estimated Design Cost:	$120,000.00
Estimated Construction Cost:	$100,000.00
30% Contingency:	$30,000.00
Estimated Total Cost:	$250,000.00

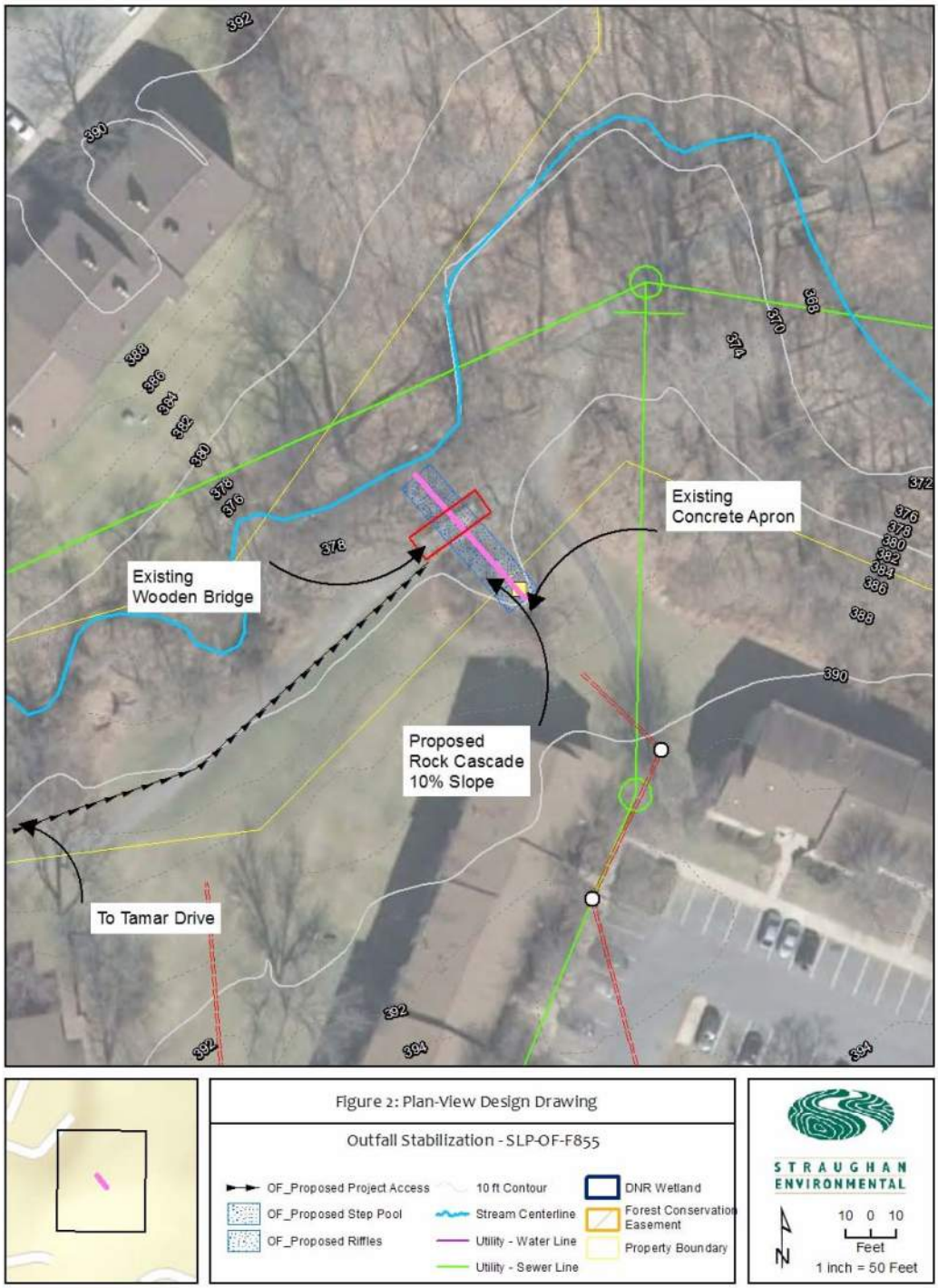
Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F855

Site Name: 6029 Majors Lane

Contractor: Versar

Watershed: Little Patuxent River



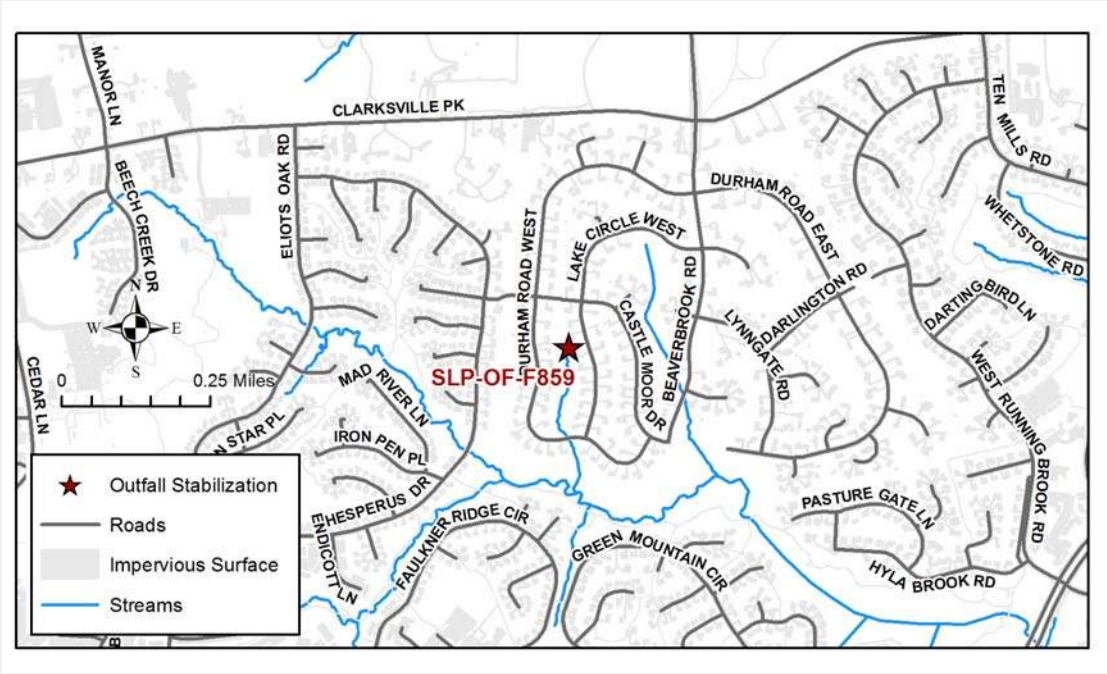
Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F859
Site Name: Lake Circle West
Contractor: Versar
Watershed: Little Patuxent River

Proposed BMP Type: Outfall Stabilization
Stabilization Type: Riprap
Ownership: Private- Residential
Multiple Owners

Existing Conditions:

The area recommended for stabilization is located on an intermittent channel that runs between several private residential yards. Two outfalls discharge into the proposed stabilization reach, one unmapped 30 in. diameter outfall along the right bank that appears to be newly installed, and one 15 in. diameter outfall along the left bank that is currently 2.5 ft. above the stream bed and in danger of collapsing. Stream bank erosion begins between the two outfalls and extends several hundred feet downstream.



Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F859
Site Name: Lake Circle West
Contractor: Versar
Watershed: Little Patuxent River

A 15 in. diameter concrete outfall headwall that is in need of replacement. The outfall currently sits 2.5 ft. above the bottom of the stream bed.

Erosion occurring along the right stream bank. Photo taken just downstream of failing outfall headwall.

Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F859
Site Name: Lake Circle West
Contractor: Versar
Watershed: Little Patuxent River

Constraints/Utilities:

Any work conducted on the proposed stabilization project will need to be coordinated with the owners of the adjacent residential properties. The need to access the site with heavy machinery may result in the removal of a few trees on residential properties.

Concept Description:

The proposed stabilization project will replace the failing concrete outfall headwall with a drop structure that discharges runoff closer to the current height of the stream bed. The project will also stabilize eroding banks along the receiving channel with riprap and minor grading. The site can be accessed by crossing through residential properties from either of the two roadways that it sits between.

Nearby Opportunities:

None recommended

Proposed Project Credit	
Length Restored (ft):	164
Impervious Area Treated Credit (ac.):	1.64
Cost Per Impervious Credit Acre:	$140,243.90

Costs	
Estimated Design Cost:	$100,000.00
Estimated Construction Cost:	$100,000.00
30% Contingency:	$30,000.00
Estimated Total Cost:	$230,000.00

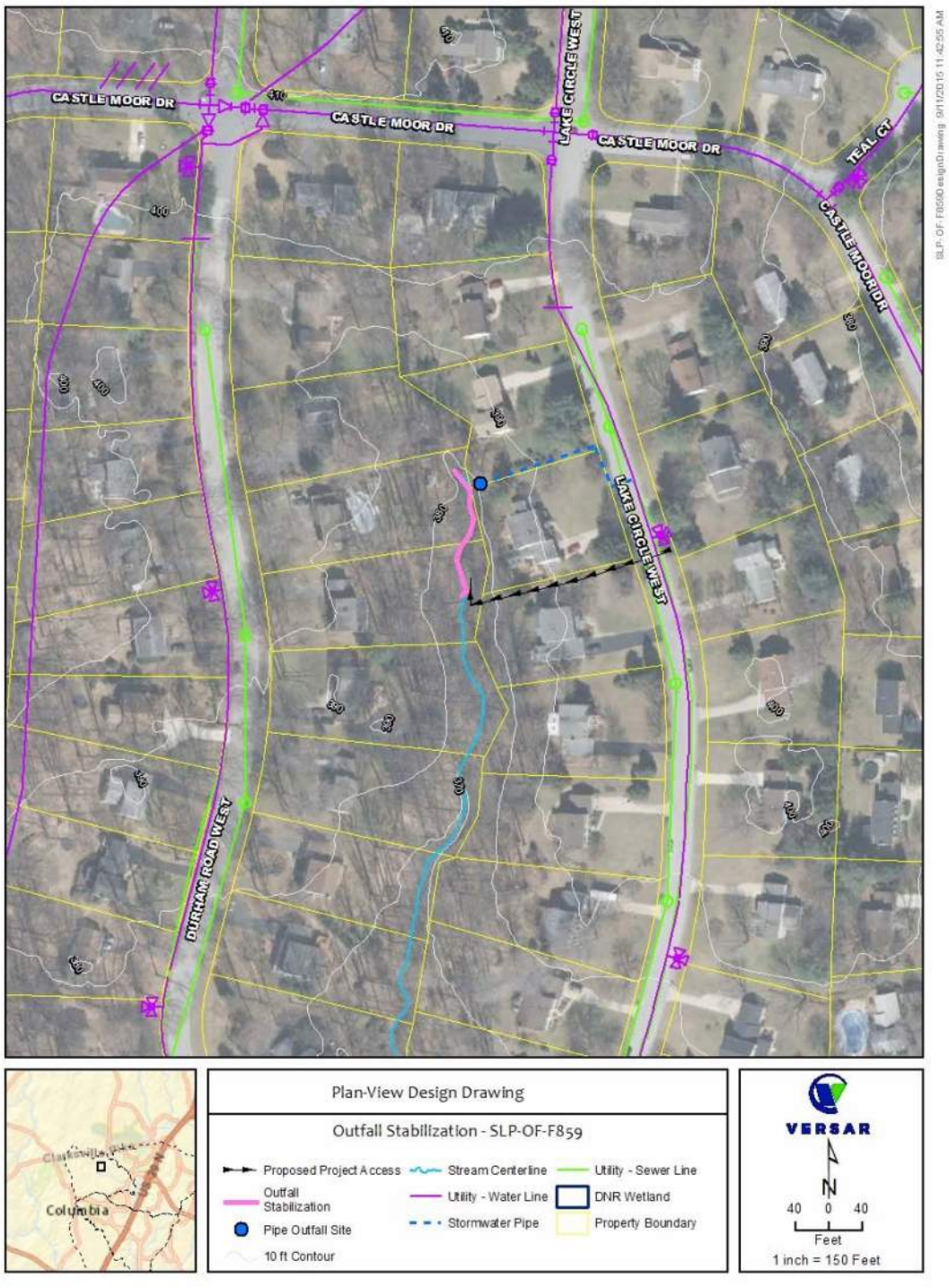
Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SLP-OF-F859

Site Name: Lake Circle West

Contractor: Versar

Watershed: Little Patuxent River



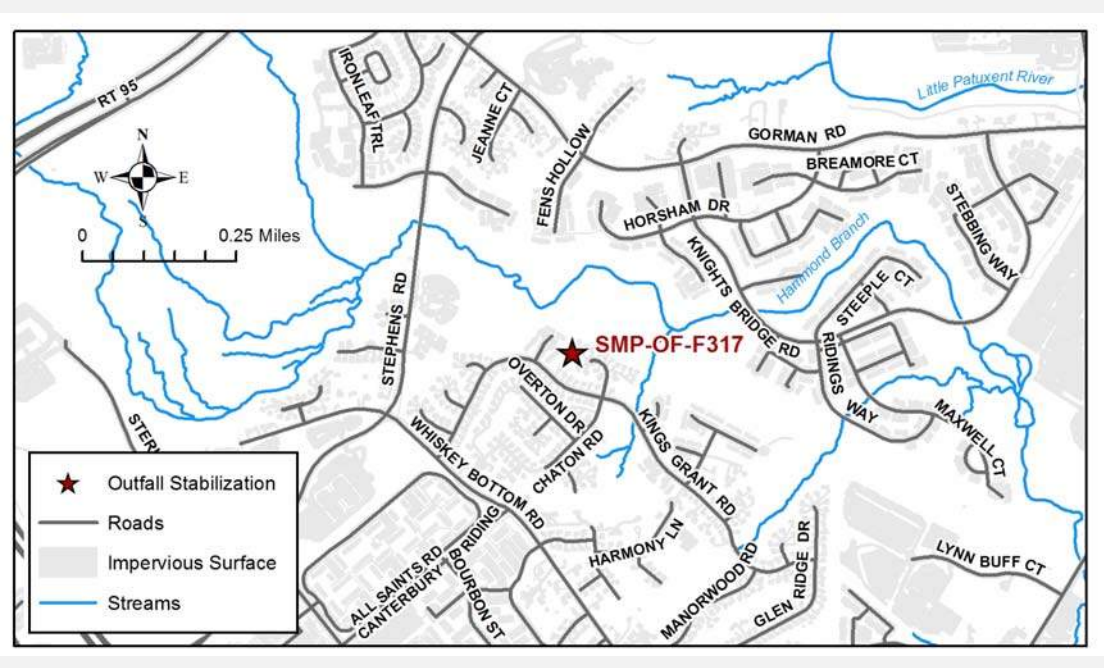
Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SMP-OF-F317
Site Name: End of Queens Guard Ct
Contractor: Biohabitats
Watershed: Little Patuxent River

Proposed BMP Type: Outfall Stabilization
Stabilization Type: Natural Channel Design
Ownership: County Owned
Single Owner

Existing Conditions:

Examination of available plans and GIS, determines that the existing drainage area is approximately 15.6 ac. of which 3.5 are impervious (22%). Land use within the drainage area is primarily commercial development. The 36 in. CMP outfall discharges from an existing wet pond. A 211 lf. outfall channel runs through a wooded section from the end of Queens Guard Ct. down to a wetland/meadow within the BGE high voltage power line corridor . The channel is unstable with active headcuts and areas of erosion and deposition. There are many trees along the channel ranging from 6 to 20 in. diameter at breast height (DBH).



Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SMP-OF-F317

Site Name: End of Queens Guard Ct

Contractor: Biohabitats

Watershed: Little Patuxent River

Downstream view of upper portion.

Downstream view of lower portion.

Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SMP-OF-F317
Site Name: End of Queens Guard Ct
Contractor: Biohabitats
Watershed: Little Patuxent River

Constraints/Utilities:

Tree impacts (more significant in the upper portion of the channel): between 10 and 15 trees that are 6 to 12 in. diameter at breast height (DBH) and appromiately four trees that are 15 to 20 in. DBH. Access through the powerline corridor is a good alternative depending on length of haul route and ownership agreement.

Concept Description:

The proposed Step Pool Storm Conveyance (SPSC) sized to convey the 10 year discharge would require a riffle cross section of approximately 8 ft. wide by 0.8 ft. deep with 6 in. cobble. With a 5 to 6% slope, this option appears to meet the filter bed area requirements (per Maryland Department of Environment) and provide full WQv treatment. Access is proposed off Queen Guards Ct and work would be entirely within the County property. The alternative access would be to use the existing BGE utility access path to the downstream end of the outfall channel. To reduce tree loss, an alternative design approach would be to use step pools or natural channel design sized for the 1 to 2 year discharge. This option would result in a total of 2 impervious ac. treated (rather than 3.5) based on the current credit guidance. This outfall stabilization project may be reclassified as a stream restoration project if the length of channel restored exceeds 200 lf.

Nearby Opportunities:

None recommended

Proposed Project Credit		Costs	
Length Restored (ft):	211	**Estimated Design Cost:**	$100,000.00
Impervious Area Treated Credit (ac.):	2	**Estimated Construction Cost:**	$100,000.00
Cost Per Impervious Credit Acre:	$115,000.00	**30% Contingency:**	$30,000.00
		Estimated Total Cost:	$230,000.00

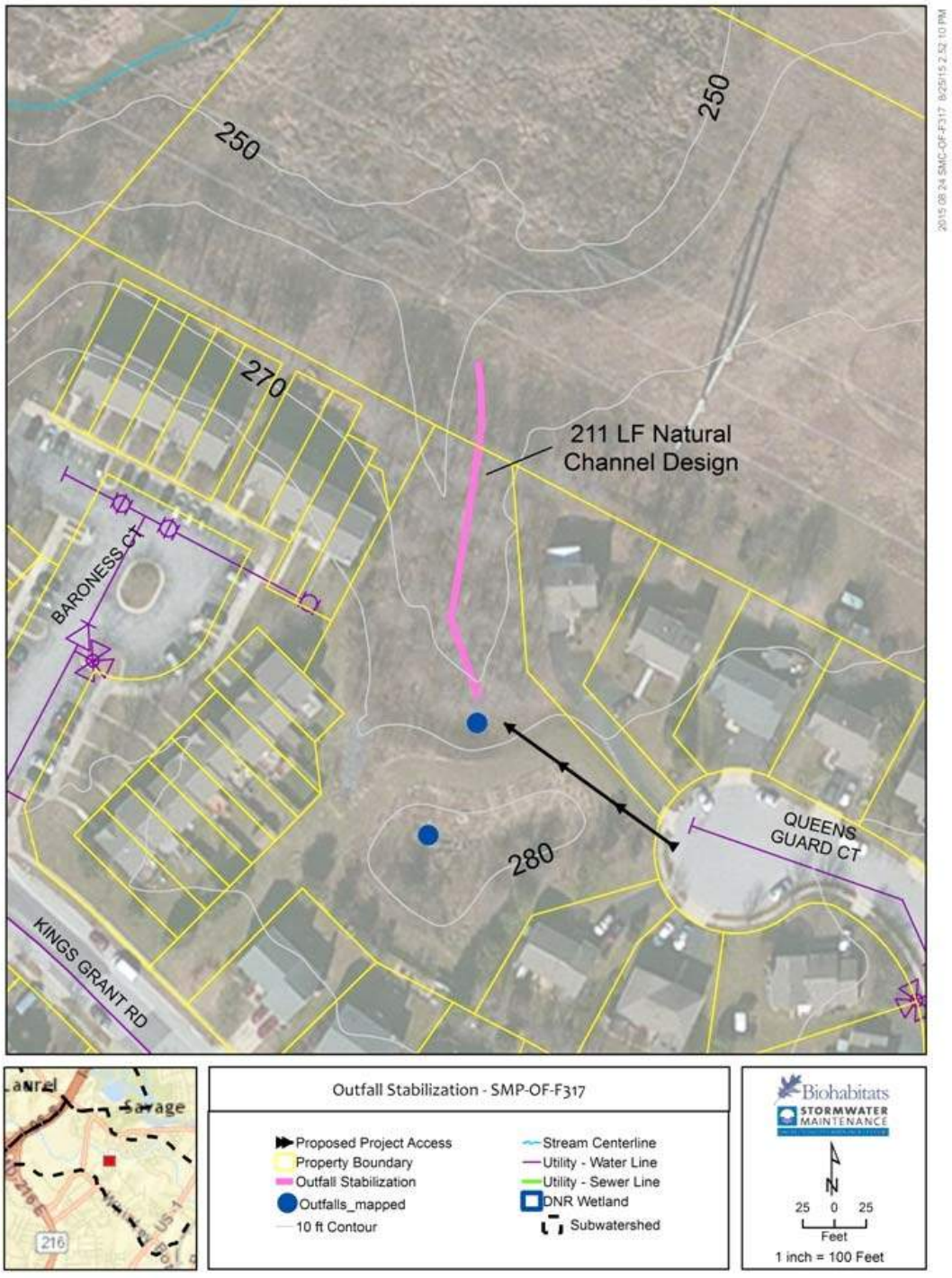
Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SMP-OF-F317

Site Name: End of Queens Guard Ct

Contractor: Biohabitats

Watershed: Little Patuxent River



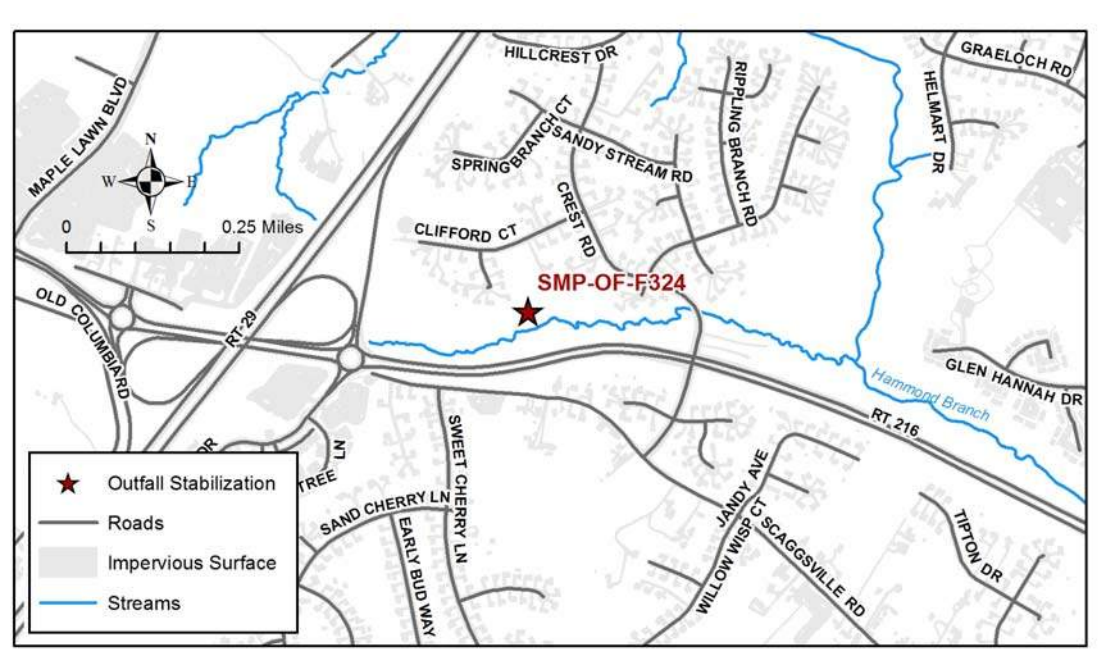
Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SMP-OF-F324
Site Name: End of Elsie's Way
Contractor: Biohabitats
Watershed: Little Patuxent River

Proposed BMP Type: Outfall Stabilization
Stabilization Type: Rock Step Pools & Grade Control
Ownership: County Owned
Multiple Owners

Existing Conditions:

The existing drainage area is 34.3 ac. of which 3.4 are impervious (9.8%), primarily single family residential land use. The dry pond appears to be holding water and discharges via a 30 in. concrete pipe/endwall down a 50 lf. steep eroding outfall channel where it enters a wetland area and the confluence with the mainstem another 90 lf. downstream. The downstream wetland area has small active headcuts. Pond and outfall are on County property with the downstream end potentially on PEPCO property. Gullies/rills observed along the steep slopes along the outside of the pond embankment and around the sewer manhole on the mainstem near the confluence.



Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SMP-OF-F324

Site Name: End of Elsie's Way

Contractor: Biohabitats

Watershed: Little Patuxent River

Downstream view from outfall showing eroded unstable channel.

Upstream view of eroded channel.

Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SMP-OF-F324
Site Name: End of Elsie's Way
Contractor: Biohabitats
Watershed: Little Patuxent River

Constraints/Utilities:
Sanitary sewer line adjacent to channel. Soils appear highly erosive. There may be wetlands downstream requiring additional permits. Potential coordination with PEPCO landowner.

Concept Description:
The proposed design is a rock/boulder step pool stabilization down the steep portion (50 lf.) followed by stabilization using grade control placed to address headcuts (90 lf.). Equipment access would be through County property, or off of Clifford Court through the PEPCO high voltage power line easement. The dry pond could be assessed for BMP conversion potential. In addition, stabilization is required around the pond and mainstem near the confluence, including the significant sink hole associated with the sewer line (not included in cost estimate).

Nearby Opportunities:
SMP-BC-F401 (pond conversion); Repair sinkhole on mainstem at confluence near sewer crossing.

Proposed Project Credit		Costs	
Length Restored (ft):	140	**Estimated Design Cost:**	$120,000.00
Impervious Area Treated Credit (ac.):	1.4	**Estimated Construction Cost:**	$100,000.00
		30% Contingency:	$30,000.00
Cost Per Impervious Credit Acre:	$178,571.43	**Estimated Total Cost:**	$250,000.00

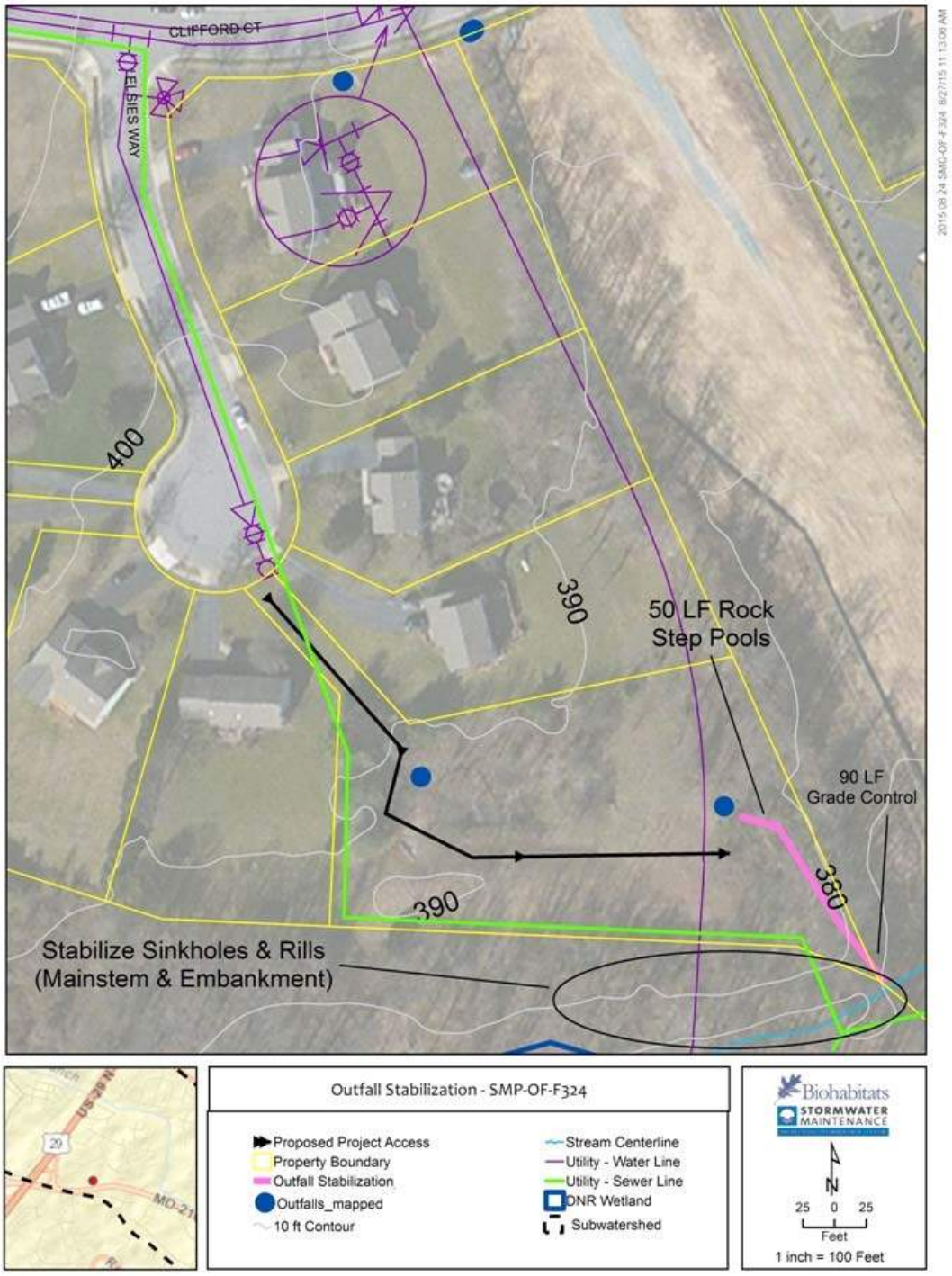
Howard County Watershed Assessment Concept Plan: Outfall Stabilization

Site ID: SMP-OF-F324

Site Name: End of Elsie's Way

Contractor: Biohabitats

Watershed: Little Patuxent River



Project Overview: Dead End of Durham Road East (SLP-BC-D774)

Project Type:	Convert dry pond to an extended detention shallow wetland with micropools and forebays
Total Cost:	$347,175 (updated according to 2015 Cost Estimation spreadsheet)
Location/Address:	Title – "Durham Road East – Section 2, Area 1"; 5th Election District Subdivision – Beaverbrook Address – 5304 Durham Road East Access – End of Durham Road East at T-Turn around ADC Map 15-F03 MS Link 100078
Land Use:	Residential
Ownership:	HOA
Maintenance Responsibility:	Public
Drainage Area:	53.11 acres
Impervious Area:	10.31 acres (19.41%)
Surface Soils:	0.2% Co: Codorus and Hatboro silt loams, 0-3% slopes 62.7% GfB: Gladstone-Urban land complex, 0-8% slopes 14.9% GfC: Gladstone-Urban land complex, 8-15% slopes 22.2% GuB: Glenville-Urban land-Udorthents complex, 0-8% slopes Classification: Hydrologic Soil Group, Type B Hydrologic Soil Group, Type C

Existing Conditions

The dry pond is owned by the homeowners association for the surrounding community. Drainage is collected from Durham Road East, Woodman Court, Lynngate Road, Beavertrail Court, and Flattail Court via a main stormdrain system and discharged into the pond via two outfalls. The two outfalls discharge southern and northern ends of the pond where stormwater runoff is conveyed directly into the dry pond. A 48" RCCP pipe conveys the stormwater under Durham Road East after passing the riser structure where the stormwater is ultimately discharged into the nearby stream.

Conceptual Design

The proposed retrofit concept is to improve water quality performance by converting the existing dry pond to a shallow wetland. The forebays, pilot channels and micropool will be designed to retain existing vegetation to the maximum extent possible. The existing riser will be relocated and modified based on the required micropool and stormwater quantity criteria. A stable outfall will also be provided downstream of the adjusted principal spillway. A more detailed analysis may show that this design could provide channel protection[1].

An extended detention shallow wetland was chosen because the drainage area is sufficient, there is adequate head, and retaining existing vegetation was desirable. Channel protection and flood control can likely be incorporated into this type of retrofit. Shallow wetlands have high community acceptance, provide high habitat quality, are relatively easy to maintain, and are not a safety concern.

The extended detention shallow wetland layout will be similar to Figure G in Appendix B, but it will contain two forebays.

Design Parameter	**Value**
Drainage Area (Ac)	53.11
Percent Impervious (I)	19.41
Volumetric runoff coefficient (R_v)	0.225
Soil specific recharge factor (S)	0.23
Water quality volume (WQ_v) (ft^3)	43,322.24
Recharge Volume (Re_v) (ft^3)	10,002.94
Pretreatment Volume (25% WQ_v) (ft^3)	10,830.56

[1] Channel Protection Volume calculations were not performed as part of this conceptual design analysis.

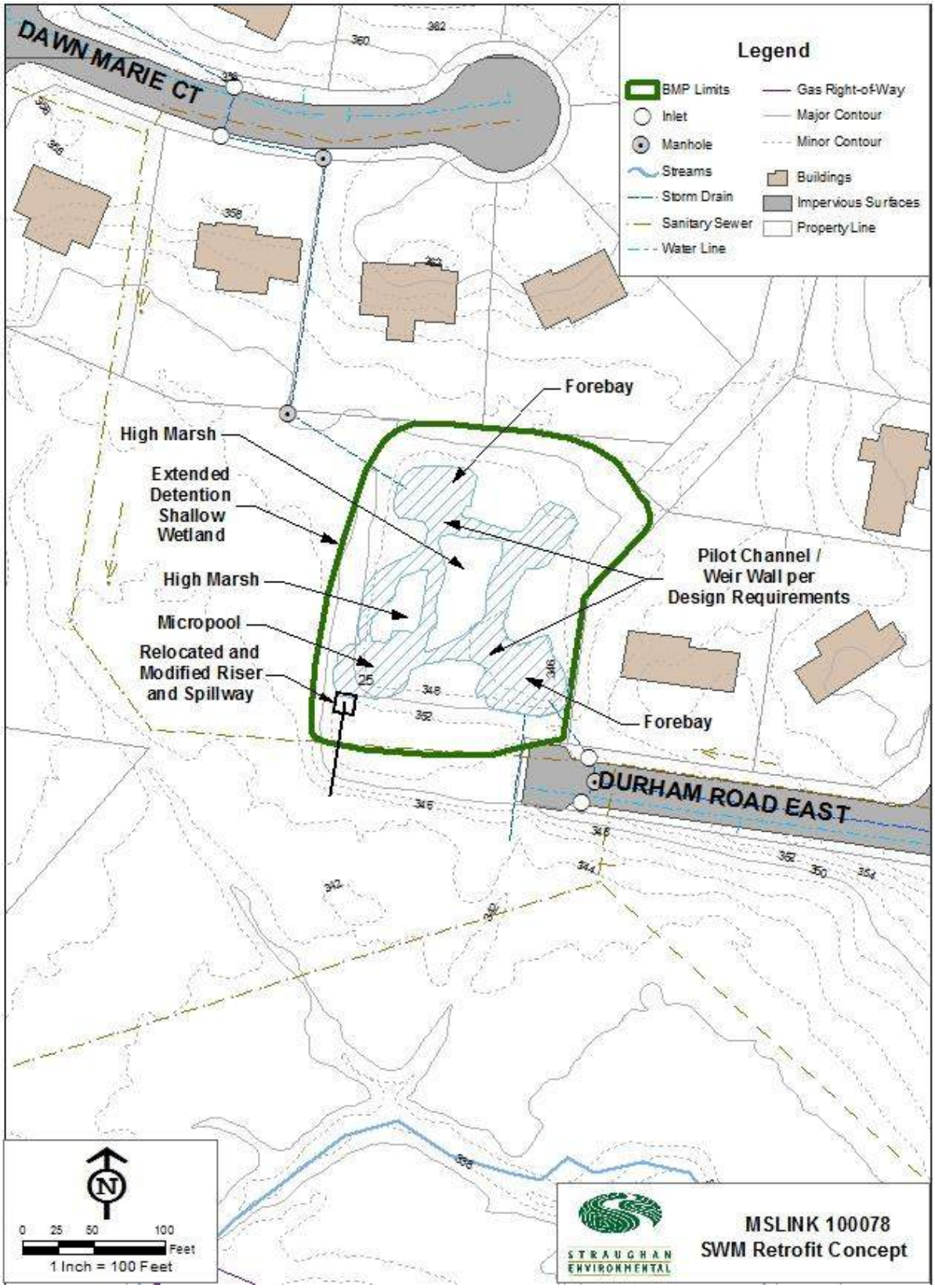


Figure 1. Concept Design Plan View at dead end of Durham Road East, SLP-BC-D774

Cost Estimate

Item Description	Quantity/Units		Unit Cost	Subtotal Cost
SITE PREP				
Mobilization/Demobilization	1	LS	$10,000.00	$10,000.00
Erosion and Sediment Control	1	LS	$8,000.00	$8,000.00
WETLANDS / MICROPOOLS				
Excavate and Remove (incl. transportation)	2000	cy	$40.00	$80,000.00
Earthwork/Grading	1050	cy	$16.00	$16,800.00
Remove Wall	130	lf	$50.00	$6,500.00
Overflow Structure	1	ea	$16,000.00	$16,000.00
48" Storm Sewer	70	lf	$185.00	$12,950.00
Stabilized Outfall (Rip-rap)	50	SY	$250.00	$12,500.00
Planting	0.7	Ac	$12,000.00	$8,400.00
TOTAL CONSTRUCTION COSTS				**$171,150.00**
ENGINEERING MANAGEMENT				
Engineering / Permitting / Construction Mgmt				$200,000.00
Geotech / Soil Borings				$20,000.00
Contingency (30% of Total Construction)				$51,345.00
TOTAL PROJECT COSTS				**$442,495.00**

Constructability

Design & Construction:

Access: End of Durham Road East at T-Turn around

Utilities:

Other impacts:

Existing Condition Photograph

Figure 2. SWM pond at dead end of Durham Road East, SLP-BC-D774

Calculations

PROJECT: Howard County Retrofit
LOCATION: 5304 Durham Road East
DEVELOPER:

DATE: 1/21/2013
COMPUTED BY: ANB
CHECKED BY: EHF

UNIFIED SIZING CRITERIA

COMPUTE WATER QUALITY VOLUME (WQ_v):

$(WQv) = \frac{[(1.0)(R_v)(A)]}{12}$

= **0.9945** **acre-feet**

= **43322.24** **cubic-feet**

where:

P = 1" Rainfall Depth (Eastern Zone)
A = Total Site Area (acres)
Rv = Volumetric Runoff Coefficient
= 0.05 + 0.009 (I)
where I is % Impervious Cover

Impervious Cover = **10.31** acres
Total Site Area = **53.11** acres
% Impervious Cover = **19.41%**

therefore, Rv = **0.225**

COMPUTE RECHARGE VOLUME (Re_v):

$(Rev) = \frac{[(S)(R_v)(A)]}{12}$

= **0.2296** **acre-feet**

= **10002.94** **cubic-feet**

where:

S = Soil Specific Recharge Factor
A = Total Site Area (acres)
Rv = Volumetric Runoff Coefficient
= 0.05 + 0.009 (I) [as calculated above]
= **0.225**

COMPUTE SOIL RECHARGE FACTOR (S):

Acres	Hydrologic Soil Group	Soil Specific Recharge Factor (S)	A*S
	A	0.38	0.00
41.22	B	0.26	10.72
11.89	C	0.13	1.55
	D	0.07	0.00
53.11		**Computed Average S =**	**0.23**

Project Overview: Tree Swallow Court (SLP-BC-D780)

Project Type:	Flood control dry pond to extended detention with micropool and forebay
Total Cost:	$250,000 (updated according to 2015 Cost Estimation spreadsheet)
Location/Address:	Title – "Cedar Acres – Section 1"; 5th Election District Subdivision – Cedar Acres Address – 6047 Tree Swallow Court Access – Between 6047 and 6068 Tree Swallow Court or from Cedar Lane just north of intersection with Hill Top Lane ADC Map 15-C08 MS Link 156992
Land Use:	Residential
Drainage Area:	20.54 acres
Ownership:	HOA
Maintenance Responsibility:	Public
Impervious Area:	6.45 acres (31.40%)
Surface Soils:	100% GfB: Gladstone-Urban land complex, 0-8% slopes Classification: Hydrologic Soil Group, Type B

Existing Conditions

This facility is designed as a dry pond to provide stormwater management associated with the Cedar Acres subdivision development and is owned by this homeowners association. Runoff is conveyed via two main storm drain systems that discharge at two locations into the pond. The facility appears to be an excavated pond with landscaped trees planted on the two sides of pond facing the apartments. Concrete low flow channels direct runoff from the storm drain outfalls to the riser structure near Cedar Lane. The existing 36" RCP principal spillway of the pond connects to an existing 30" RCP storm drain system that immediately crosses under Cedar Lane. Water quality treatment is not currently being provided in this facility.

Conceptual Design

The proposed retrofit concept is to improve water quality performance by converting the existing dry pond to a "Micropool" Extended Detention Pond. The forebay, pilot channel, and Micropool (3 to 4 feet deep) will be designed to retain adjacent vegetation to the maximum extent possible. The pond bottom is to be excavated to increase capacity and the existing outfall structure modified to store the required management volumes. A more detailed analysis may show that this design could provide channel protection while satisfying freeboard requirements[1]. The 36" RCP principal spillway of the pond connects to an existing 30" RCP storm drain system that immediately crosses under Cedar Lane. A detailed hydraulic gradient analysis of this downstream storm drain is necessary to determine the effects on peak discharge capacity and on water surface elevations in the pond.

An extended detention pond with micropool was chosen because the drainage area to the facility is greater than 10 acres and the available dry storage capacity that can be reallocated to meet the current regulations to the maximum extent practicable.

The micropool extended detention pond layout will be similar to Figure A in Appendix B.

Design Parameter	**Value**
Drainage Area (Ac)	20.54
Percent Impervious (I)	31.40
Volumetric runoff coefficient (R_v)	0.333
Soil specific recharge factor (S)	0.26
Water quality volume (WQ_v) (ft^3)	24,800.16
Recharge Volume (Re_v) (ft^3)	6,448.04
Pretreatment Volume (25% WQ_v) (ft^3)	6,200.04

[1] Channel Protection Volume calculations were not performed as part of this conceptual design analysis.

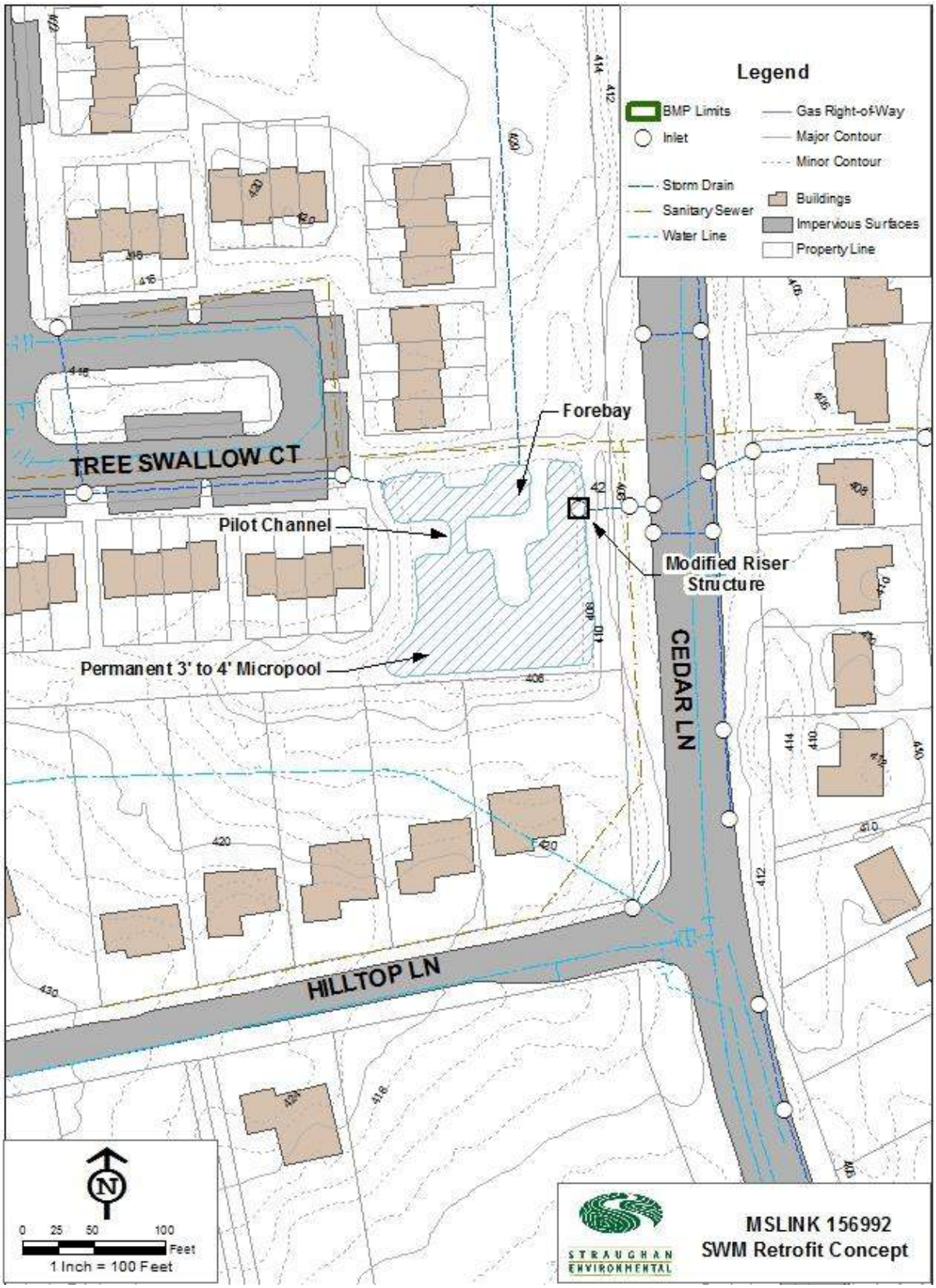


Figure 1. Concept Design Plan View at 6047 Tree Swallow Court, SLP-BC-D780

Cost Estimate

Item Description	Quantity/Units		Unit Cost	Subtotal Cost
SITE PREP				
Mobilization/Demobilization	1	LS	$10,000.00	$10,000.00
Erosion and Sediment Control	1	LS	$8,000.00	$8,000.00
EXTENDED DETENTION WITH FOREBAY				
Excavate and Remove (incl. transportation)	1150	cy	$40.00	$46,000.00
Modify Overflow Structure	1	LS	$5,000.00	$5,000.00
Plants (Seeding, Trees, Shrubs, etc.)	1	LS	$10,000.00	$10,000.00
TOTAL CONSTRUCTION COSTS				**$79,000.00**
ENGINEERING AND MANAGEMENT				
Engineering / Permitting / Construction Mgmt.				$100,000.00
Geotech / Soil Borings				$20,000.00
Contingency (30% of Total Construction)				$23,700.00
TOTAL PROJECT COSTS				**$222,700.00**

Constructability

Design & Construction:

Access: Between 6047 and 6068 Tree Swallow Court, or from Cedar Lane just north of intersection with Hilltop Lane.

Utilities: Howard County GIS suggests that there is a sewer main immediately north of the facility that crosses a storm drain system draining into the pond and a sewer main immediately east of the facility that crosses the principal spillway.

Other Impacts:

Existing Condition Photograph

Figure 2. SWM pond at 6047 Tree Swallow Court, SLP-BC-D780

Calculations

PROJECT: Howard County Retrofit
LOCATION: 6047 Tree Swallow Court
DEVELOPER:

DATE: 1/21/2013
COMPUTED BY: ANB
CHECKED BY: EHF

UNIFIED SIZING CRITERIA

COMPUTE WATER QUALITY VOLUME (WQ_v):

$$(WQv) = \frac{[(1.0)(R_v)(A)]}{12}$$

= **0.5693** **acre-feet**
= **24800.16** **cubic-feet**

where:
P = 1" Rainfall Depth (Eastern Zone)
A = Total Site Area (acres)
Rv = Volumetric Runoff Coefficient
= 0.05 + 0.009 (I)
where I is % Impervious Cover
Impervious Cover = **6.45** acres
Total Site Area = **20.54** acres
% Impervious Cover = **31.40%**
therefore, Rv = **0.333**

COMPUTE RECHARGE VOLUME (Re_v):

$$(Rev) = \frac{[(S)(R_v)(A)]}{12}$$

= **0.1480** **acre-feet**
= **6448.04** **cubic-feet**

where:
S = Soil Specific Recharge Factor
A = Total Site Area (acres)
Rv = Volumetric Runoff Coefficient
= 0.05 + 0.009 (I) [as calculated above]
= **0.333**

COMPUTE SOIL RECHARGE FACTOR (S):

Acres	Hydrologic Soil Group	Soil Specific Recharge Factor (S)	A*S
	A	0.38	0.00
20.54	B	0.26	5.34
	C	0.13	0.00
	D	0.07	0.00
20.54		**Computed Average S =**	**0.26**

Project Overview: 6480 Dobbin Road, Dobbin Road Commercial Business Center (SLP-BC-D792)

Project Type:	Convert dry pond to extended detention pond with micropool and forebay
Total Cost:	$271,359 (updated according to 2015 Cost Estimation spreadsheet)
Location/Address:	Title – "Commercial Business Center– Section 1, Area 1"; 6th Election District Subdivision – Dobbin Road Commercial Business Center Address - 6480 Dobbin Road Access – 6480 Dobbin Road from south side parking lot ADC Map 16-C10 MS Link 1732
Land Use:	Commercial
Ownership:	Private
Maintenance Responsibility:	Private
Drainage Area:	14.77 acres
Impervious Area:	9.35 acres (63.30%)
Surface Soils:	92.7% UuB: Urban land-Udorthents complex, 0-8% slopes 5.2% UcD: Urban land-Udorthents complex, 8-25% slopes 2.1% WcB: Watchung silt loam, 3-8% slopes Classification: Hydrologic Soil Group, Type D

Existing Conditions

The facility is privately owned and is believed to be owned by the Columbia Business Center C/O Greenfield Partners LLC Association. Drainage is collected from the Dobbin Road Commercial Business Center via a main stormdrain system and discharges directly in front of the riser structure. The majority of the stormwater runoff is short circuiting due to the outfall's proximity to the existing riser structure, where it discharges directly into the nearby steam.

Conceptual Design

The proposed retrofit concept is to improve water quality performance by converting the existing dry pond to a "Micropool" Extended Detention Pond. The forebay, pilot channel, and micropool will be designed to retain existing vegetation to the maximum extent possible. A flow splitter is to be installed to allow the stormwater pipe to discharge to the forebay and micropool. An apron will be installed where the stormdrain discharges to the micropool. The existing riser will be moved to the east side of the pond based on the required micropool and stormwater quantity requirements. A stable outfall also will be provided downstream of the adjusted principal spillway. A more detailed analysis may show that this design could provide channel protection[1].

An extended detention pond with micropool with a forebay was chosen because an anti-clogging device will be installed (since the drainage area is less than 10 acres), adequate head is available, and since space is limited a micropool ED requires a relatively small footprint. The limited footprint available for water quality control limits us to treatment of 2/3rd of the WQv or 22,129.32 ft^3.

The micropool extended detention pond layout will be similar to Figure A in Appendix B.

Design Parameter	**Value**
Drainage Area (Ac)	14.77
Percent Impervious (I)	63.30
Volumetric runoff coefficient (R_v)	0.620
Soil specific recharge factor (S)	0.07
Water quality volume (WQ_v) (ft^3)	33,227.21
Expected maximum WQv treatment (ft^3)	*22,129.32*
Recharge Volume (Re_v) (ft^3)	2,325.90
Pretreatment Volume (25% WQ_v) (ft^3)	8,306.81

[1] Channel Protection Volume calculations were not performed as part of this conceptual design analysis.

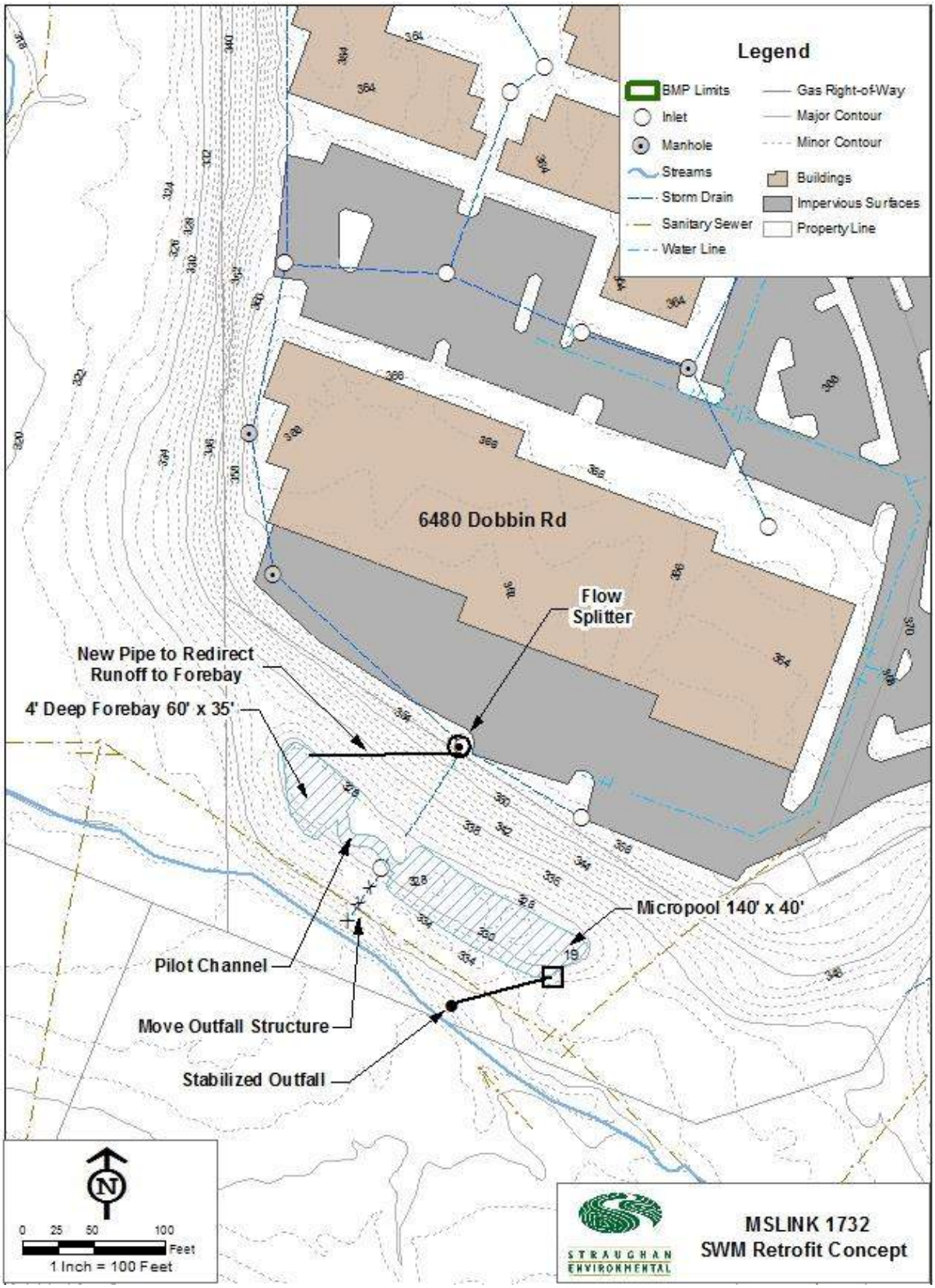


Figure 1. Concept Design Plan View 6480 Dobbin Road, Dobbin Road Commercial Business Center, SLP-BC-D792

Cost Estimate

Item Description	Quantity/Units		Unit Cost	Subtotal Cost
SITE PREP				
Mobilization/Demobilization	1	LS	$10,000.00	$10,000.00
Erosion and Sediment Control	1	LS	$8,000.00	$8,000.00
EXTENDED DETENTION/MICROPOOL WITH FOREBAY				
Excavate and Remove (incl. transportation)	1025	cy	$40.00	$41,000.00
Modify MH with Flow splitter	1	LS	$5,000.00	$5,000.00
Remove 36" Storm Sewer	50	lf	$35.00	$1,750.00
Overflow Structure	1	LS	$16,000.00	$16,000.00
24" Storm Sewer	100	lf	$96.00	$9,600.00
36" Storm Sewer	70	lf	$144.00	$10,080.00
Stabilization of Outfall (Rip-rap)	20	sy	$250.00	$5,000.00
Plants (Seeding, Trees, Shrubs, etc.)	1	LS	$10,000.00	$10,000.00
TOTAL CONSTRUCTION COSTS				**$116,430.00**
ENGINEERING AND MANAGEMENT				
Engineering / Permitting / Construction Management				$200,000.00
Geotech / Soil Borings				$20,000.00
Contingency (30% of Total Construction)				$34,929.00
TOTAL PROJECT COSTS				**$371,359.00**

Constructability

Design & Construction:	None
Access:	6480 Dobbin Road from south side parking lot
Utilities:	A sewer line appears to exist along the southern and eastern sides of the pond and should be considered during final design
Other Impacts:	Possible wetland impacts. Wetland delineation may be required.

Existing Condition Photograph

Figure 2. SWM pond at 6480 Dobbin Road, Dobbin Road Commercial Business Center, short circuiting dewatering structure, SLP-BC-D792

Calculations

PROJECT: Howard County Retrofit
LOCATION: 6480 Dobbin Road
DEVELOPER:

DATE: 1/21/2013
COMPUTED BY: ANB
CHECKED BY: EHF

UNIFIED SIZING CRITERIA

COMPUTE WATER QUALITY VOLUME (WQ_v):

$(WQv) = \frac{[(1.0)(R_v)(A)]}{12}$

= **0.7628** **acre-feet**

= **33227.21** **cubic-feet**

where:

P = 1" Rainfall Depth (Eastern Zone)
A = Total Site Area (acres)
Rv = Volumetric Runoff Coefficient
= 0.05 + 0.009 (I)
where I is % Impervious Cover
Impervious Cover = **9.35** acres
Total Site Area = **14.77** acres
% Impervious Cover = **63.30%**

therefore, Rv = **0.620**

COMPUTE RECHARGE VOLUME (Re_v):

$(Rev) = \frac{[(S)(R_v)(A)]}{12}$

= **0.0534** **acre-feet**

= **2325.90** **cubic-feet**

where:

S = Soil Specific Recharge Factor
A = Total Site Area (acres)
Rv = Volumetric Runoff Coefficient
= 0.05 + 0.009 (I) [as calculated above]
= **0.620**

COMPUTE SOIL RECHARGE FACTOR (S):

Acres	Hydrologic Soil Group	Soil Specific Recharge Factor (S)	A*S
	A	0.38	0.00
	B	0.26	0.00
	C	0.13	0.00
14.77	D	0.07	1.03
14.77		**Computed Average S =**	**0.07**

Project Overview: Golden Coin Court (SLP-BC-D798)

Project Type:	Flood control dry pond conversion to extended detention pond with micropool
Total Cost:	$250,000 (updated according to 2015 Cost Estimation spreadsheet)
Location/Address:	Title – "Oakland Mills Road – Section 1, Area 3"; 6th Election District Subdivision – Marbella Address – 6527 Golden Coin Court Access – Between 6256 & 6257 Golden Coin Court ADC Map 16-A08 MS Link 2331
Land Use:	Residential
Ownership:	HOA
Maintenance Responsibility:	Public
Drainage Area:	31.71 acres
Impervious Area:	9.92 acres (31.28%)
Surface Soils:	87.1% GhB: Glenelg-Urban land complex, 0-8% slopes 12.9% GuB: Glenville-Urban land-Udorthents complex, 0-8% slopes Classification: Hydrologic Soil Group, Type B Hydrologic Soil Group, Type C

Existing Conditions

This facility is designed as a dry pond to provide storm water management associated with the Marbella subdivision development. Drainage from roadways and residential development along Light Point Place, Golden Coin Court, and Fairwell Road discharges via a stormdrain system which outfalls on the south side of the facility onto a riprap apron. Two drainage channels also enter on the west and east sides of the facility. An underground storage reservoir is present beneath the facility. The dry pond discharges via a riser into a 21" BCCMP that connects to the existing stormdrain system. No water quality improvement is being provided by the pond.

Conceptual Design

The proposed retrofit concept is to improve water quality performance by converting the existing dry pond to a "Micropool" Extended Detention Pond. The pond bottom is to be excavated to increase capacity, and the existing outfall structure is to be modified based on the required micropool storage and stormwater management quantities. Due to right-of-way constraints, a forebay or safety bench will not be feasible and the permanent pool depth will be limited to four feet. Therefore, only a portion of the required water quality volume will be provided. The pond will continue to discharge into an existing stormdrain system. A more detailed analysis may show that this design could provide channel protection[1].

An extended detention pond with micropool was chosen because the drainage area is greater than 10 acres, adequate head is available, and since space is limited a micropool ED requires a relatively small footprint. We anticipate being able to treat 1/3rd or 12,708.61 ft^3 of the WQv.

The micropool extended detention pond layout will be similar to Figure A in Appendix B, but without a forebay.

Design Parameter	**Value**
Drainage Area (Ac)	31.71
Percent Impervious (I)	31.28
Volumetric runoff coefficient (R_v)	0.332
Soil specific recharge factor (S)	0.24
Water quality volume (WQ_v) (ft^3)	38,164.01
Expected maximum WQv treatment (ft^3)	*12,708.61*
Recharge Volume (Re_v) (ft^3)	9,282.72
Pretreatment Volume (25% WQ_v) (ft^3)	9,541.01

[1] Channel Protection Volume calculations were not performed as part of this conceptual design analysis.

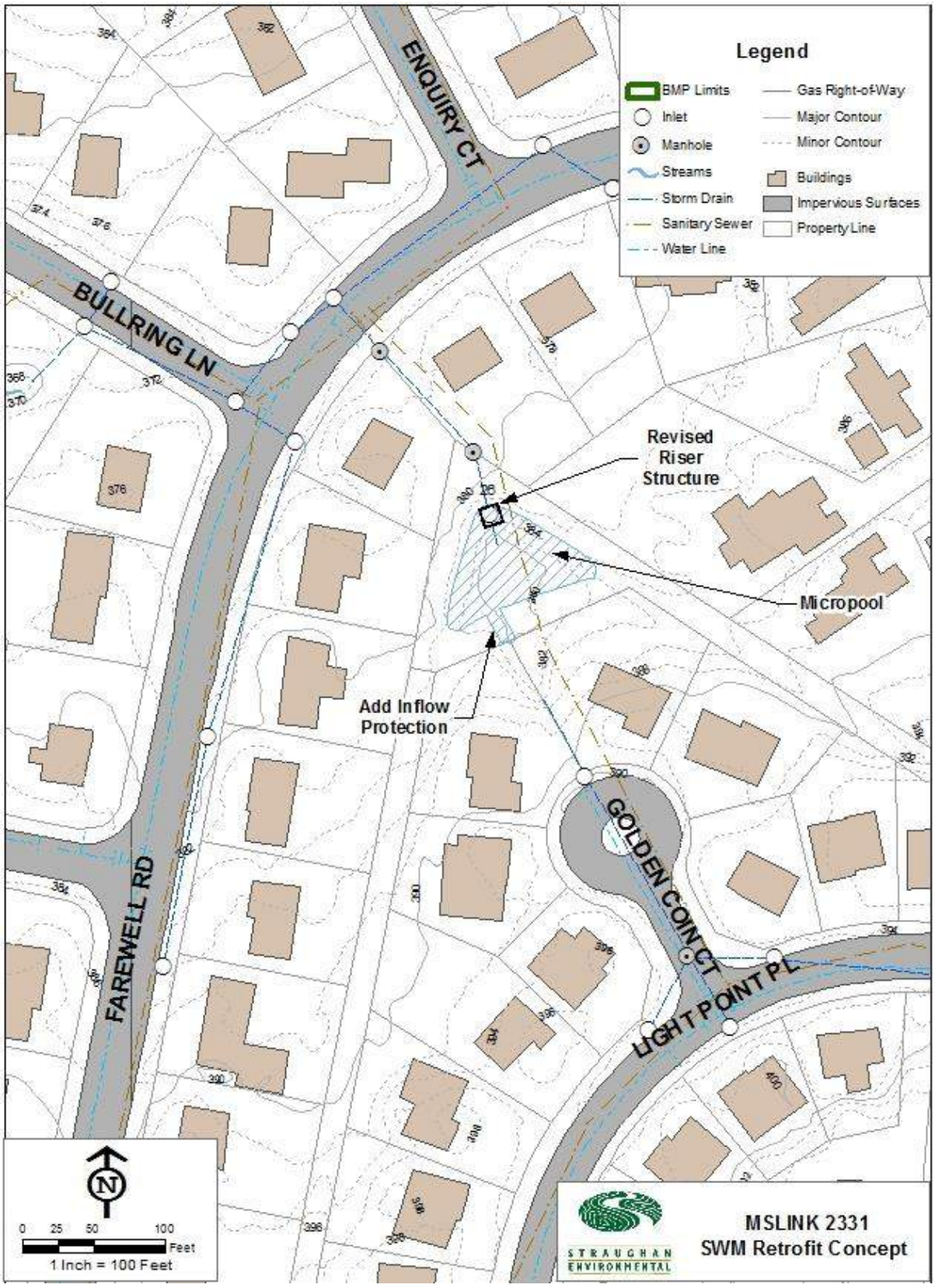


Figure 1. Concept Design Plan View at 6527 Golden Coin Court, SLP-BC-D798

Cost Estimate

Item Description	Quantity/Units		Unit Cost	Subtotal Cost
SITE PREP				
Mobilization/Demobilization	1	LS	$10,000.00	$10,000.00
Erosion and Sediment Control	1	LS	$8,000.00	$8,000.00
EXTENDED DETENTION				
Excavate and Remove (incl. transportation)	475	cy	$40.00	$19,000.00
Channel Protection	80	sy	$35.00	$2,800.00
Modify Overflow structure	1	ea	$5,000.00	$5,000.00
PLANTING				
Plants (Seeding, Trees, Shrubs, etc.)	1	LS	$10,000.00	$10,000.00
TOTAL CONSTRUCTION COSTS				**$54,800.00**
ENGINEERING AND MANAGEMENT				
Engineering / Permitting / Construction Mgmt.				$100,000.00
Geotech / Soil Borings				$20,000.00
Contingency (30% of Total Construction)				$16,440.00
TOTAL PROJECT COSTS				**$191,240.00**

Constructability

Design & Construction:

Access:	Between 6256 & 6257 Golden Coin Court.
Utilities:	Howard County GIS indicates that a sewer line crosses under the pond. Depending on the depth of the sewer line, the position of the micropool may need to be modified.
Other Impacts:	Some existing trees will be impacted. Aesthetics need to be considered carefully given prominence of existing pond.

Existing Condition Photograph

Figure 2. SWM pond at 6527 Golden Coin Court, SLP-BC-D798

Calculations

PROJECT: Howard County Retrofit
LOCATION: 6257 Golden Coin Court
DEVELOPER:

DATE: 1/21/2013
COMPUTED BY: ANB
CHECKED BY: EHF

UNIFIED SIZING CRITERIA

COMPUTE WATER QUALITY VOLUME (WQ_v):

$(WQv) = \frac{[(1.0)(R_v)(A)]}{12}$

= **0.8761** **acre-feet**

= **38164.01** **cubic-feet**

where:

P = 1" Rainfall Depth (Eastern Zone)
A = Total Site Area (acres)
Rv = Volumetric Runoff Coefficient
= 0.05 + 0.009 (I)
where I is % Impervious Cover

Impervious Cover = **9.92** acres
Total Site Area = **31.71** acres
% Impervious Cover = **31.28%**

therefore, Rv = **0.332**

COMPUTE RECHARGE VOLUME (Re_v):

$(Rev) = \frac{[(S)(R_v)(A)]}{12}$

= **0.2131** **acre-feet**

= **9282.72** **cubic-feet**

where:

S = Soil Specific Recharge Factor
A = Total Site Area (acres)
Rv = Volumetric Runoff Coefficient
= 0.05 + 0.009 (I) [as calculated above]
= **0.332**

COMPUTE SOIL RECHARGE FACTOR (S):

Acres	Hydrologic Soil Group	Soil Specific Recharge Factor (S)	A*S
	A	0.38	0.00
27.62	B	0.26	7.18
4.09	C	0.13	0.53
	D	0.07	0.00
31.71		**Computed Average S =**	**0.24**

Project Overview: Old Annapolis Road (SLP-BC-D802)

Project Type:	Flood control dry pond to extended detention pond with micropool and forebay
Total Cost:	$262,480 (updated according to 2015 Cost Estimation spreadsheet)
Location/Address:	Title – "Oakland Ridge / Manekin" Subdivision – Oakland Ridge / Manekin Address – 9030 Old Annapolis Road Access – Behind 8970 Old Annapolis Road (Rear Northwest Corner of Property) ADC Map 16-C04 MS Link 188
Land Use:	Commercial
Ownership:	Private
Maintenance Responsibility:	Private
Drainage Area:	20.45 acres
Impervious Area:	14.50 acres (70.90%)
Surface Soils:	< 0.1% BaA: Bale silt loam, 0-3% slopes 100.0% UtD: Urban land-Udorthents complex, 0-15% slopes Classification: Hydrologic Soil Group, Type D

Existing Conditions

The facility is privately owned and is believed to be owned by the surrounding commercial development. Drainage is collected from the buildings parking lots from this development via two stormdrain systems, both of which discharge on the south end of the pond. Surface runoff from the adjacent parking lot also drains directly into the pond. The pond discharges into a headwater stream via a riser structure. As-builts are not available for this pond, so the specific outfall details are not known.

Conceptual Design

The proposed retrofit concept is to improve water quality performance by converting the existing dry pond to a "Micropool" extended detention pond. The forebay, pilot channel, and micropool will be designed to retain existing perimeter vegetation to the maximum extent possible. The existing outfall structure will be modified based on the micropool and stormwater quantity requirements. A more detailed analysis may show that this design could provide channel protection[1].

An extended detention pond with micropool was chosen because the drainage area is greater than 10 acres, and because little space is available, and a micropool ED requires a relatively small footprint. Due to size constraints of the existing stormwater detention pond, the actual treatable WQv is estimated to be approximately 2/3rds of the required WQv (51,082.18 ft^3), or about 34,020.73 ft^3.

The micropool extended detention pond layout will be similar to Figure A in Appendix B.

Design Parameter	**Value**
Drainage Area (Ac)	20.45
Percent Impervious (I)	70.90
Volumetric runoff coefficient (R_v)	0.688
Soil specific recharge factor (S)	0.07
Water quality volume (WQ_v) (ft^3)	51,083.18
Expected maximum WQv treatment	*34,020.73*
Recharge Volume (Re_v) (ft^3)	3,575.82
Pretreatment Volume (25% WQ_v) (ft^3)	12,770.79

[1] Channel Protection Volume calculations were not performed as part of this conceptual design analysis.

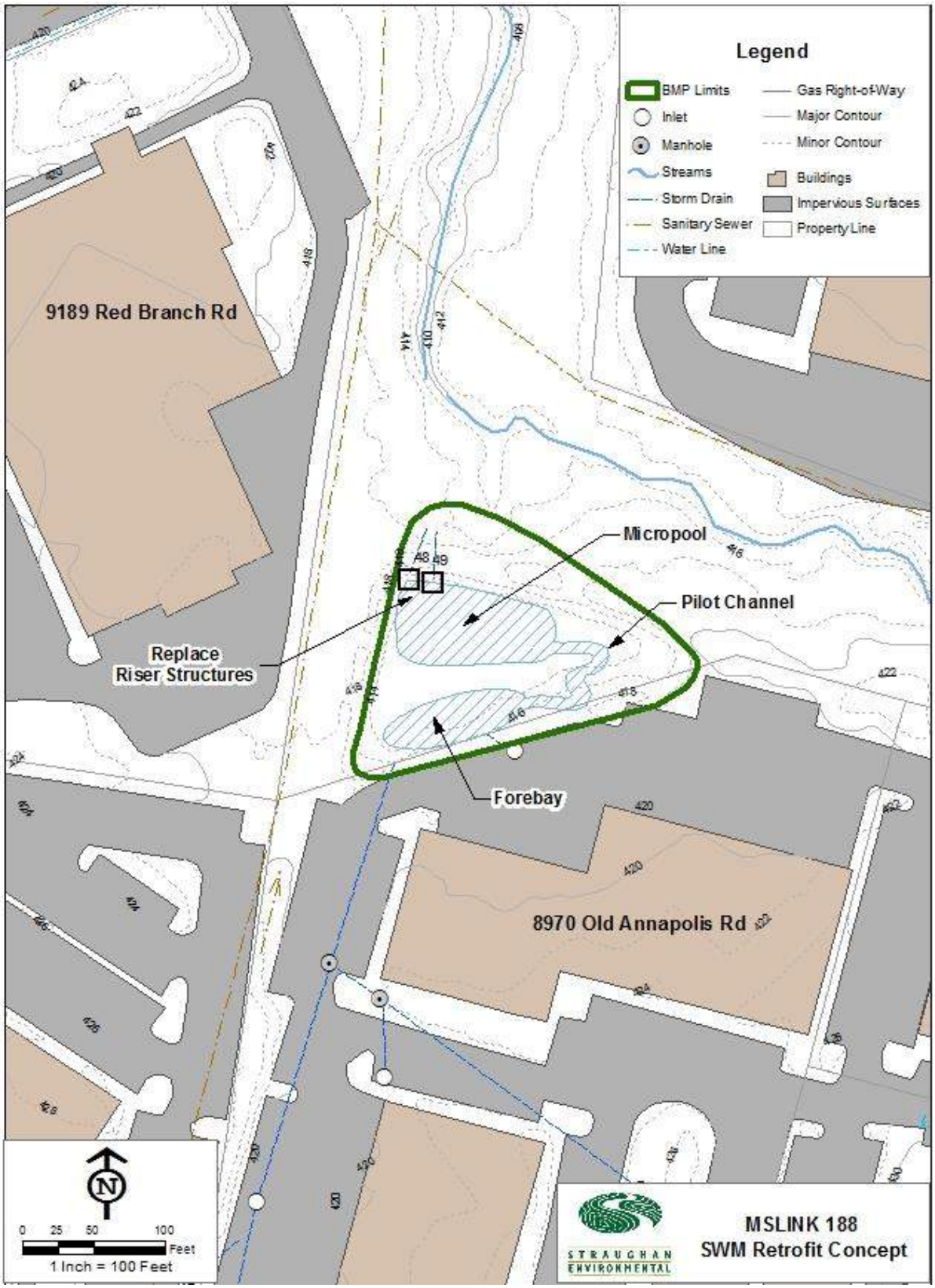


Figure 1. Concept Design Plan View for 8970 Old Annapolis Road, SLP-BC-D802

Cost Estimate

Item Description	Quantity/Units		Unit Cost	Subtotal Cost
SITE PREP				
Mobilization/Demobilization	1	LS	$10,000.00	$10,000.00
Erosion and Sediment Control	1	LS	$8,000.00	$8,000.00
EXTENDED WET DETENTION & FOREBAY				
Excavate and Remove (incl. transportation)	1200	cy	$40.00	$48,000.00
Grading/Earthwork	100	cy	$16.00	$1,600.00
Overflow Structure	2	ea	$16,000.00	$32,000.00
Plants (Seeding, Trees, Shrubs, etc.)	1	LS	$10,000.00	$10,000.00
TOTAL CONSTRUCTION COSTS				**$109,600.00**
ENGINEERING AND MANAGEMENT				
Engineering / Permitting / Construction Mgmt.				$100,000.00
Geotech / Soil Borings				$20,000.00
Contingency (30% of Total Construction)				$32,880.00
TOTAL PROJECT COSTS				**$262,480.00**

Constructability

Design & Construction:

Access: Behind 8970 Old Annapolis Road (Rear Northwest Corner of Property)

Utilities:

Other Impacts: Some trees will need to be removed

Existing Condition Photograph

Figure 2. SWM pond at 8970 Old Annapolis Road, SLP-BC-D802

Calculations

PROJECT: Howard County Retrofit
LOCATION: 9030 Old Annapolis Road
DEVELOPER:

DATE: 1/30/2013
COMPUTED BY: ANB
CHECKED BY: EHF

UNIFIED SIZING CRITERIA

COMPUTE WATER QUALITY VOLUME (WQ_v):

$$(WQv) = \frac{[(1.0)(R_v)(A)]}{12}$$

= **1.1727** **acre-feet**
= **51083.18** **cubic-feet**

where:
P = 1" Rainfall Depth (Eastern Zone)
A = Total Site Area (acres)
Rv = Volumetric Runoff Coefficient
= 0.05 + 0.009 (I)
where I is % Impervious Cover
Impervious Cover = **14.50** acres
Total Site Area = **20.45** acres
% Impervious Cover = **70.90%**
therefore, Rv = **0.688**

COMPUTE RECHARGE VOLUME (Re_v):

$$(Rev) = \frac{[(S)(R_v)(A)]}{12}$$

= **0.0821** **acre-feet**
= **3575.82** **cubic-feet**

where:
S = Soil Specific Recharge Factor
A = Total Site Area (acres)
Rv = Volumetric Runoff Coefficient
= 0.05 + 0.009 (I) [as calculated above]
= **0.688**

COMPUTE SOIL RECHARGE FACTOR (S):

Acres	Hydrologic Soil Group	Soil Specific Recharge Factor (S)	A*S
	A	0.38	0.00
	B	0.26	0.00
	C	0.13	0.00
20.45	D	0.07	1.43
20.45		**Computed Average S =**	**0.07**

Project Overview: Jaclyn Court (SMP-BC-D332)

Project Type:	Convert dry pond to shallow wetland
Total Cost:	$251,300 (updated according to 2015 Cost Estimation spreadsheet)
Location/Address:	Title - Robinson's Promise. 6th Election District Subdivision – Robinson's Promise Address – 9518 Jaclyn Court Access – From Fens Hollow Court and through woods into pond ADC Map 19-K08 MS Link 76
Land Use:	Residential
Ownership:	HOA
Maintenance Responsibility:	Public
Drainage Area:	27.64 acres
Impervious Area:	9.89 acres (35.78%)
Surface Soils:	3.5% Fa: Fallsington sandy loam, 0-2% slopes 3.9% LeC: Legore silt loam, 8-15% slopes 0.4% SaC: Sassafras loam, 5-10% slopes 91.2% UcB: Udorthents, Highway, 0-5% slopes 0.4% UcD: Udorthents, Highway, 5-15% slopes 0.6% UsB: Urban land-Sassafras-Beltsville complex, 0-5% slopes Classification: Hydrologic Soil Group, Type B Hydrologic Soil Group, Type D

Existing Conditions

The dry pond is owned by the homeowners association for the surrounding community. Drainage is collected from Gorman Road, Jeanne Court, Jaclyn Court, and Jennifer Court via a main storm drain system and discharged into two concrete pilot channels located at the north and west ends of the pond. The two channels converge at the southern end of the pond where stormwater runoff is conveyed to a mowed dry stormwater management pond basin and ultimately discharged into the nearby steam via a riser structure.

Conceptual Design

The proposed retrofit concept is to improve water quality performance by converting the existing dry pond to a Shallow Wetland. The forebays, pilot channels and micropool will be designed to retain existing vegetation to the maximum extent possible. The existing riser will be modified based on the required micropool and storm water quantity management storages including channel protection. A stable outfall will also be provided downstream of the adjusted principal spillway. If additional channel protection is desired, the embankment can be shifted to the southwest to increase the size of the micropool.

A shallow wetland was chosen because the drainage area is sufficient, because there is adequate head, and because retaining existing vegetation was desirable. Shallow wetlands have high community acceptance, provide high habitat quality, are relatively easy to maintain, and are not a safety concern.

The shallow wetland layout will be similar to Figure G in Appendix B, with two forebays instead of one.

Design Parameter	**Value**
Drainage Area (Ac)	27.64
Percent Impervious (I)	35.78
Volumetric runoff coefficient (R_v)	0.372
Soil specific recharge factor (S)	0.08
Water quality volume (WQ_v) (ft^3)	37,327.29
Recharge Volume (Re_v) (ft^3)	2,915.69
Pretreatment Volume (25% WQ_v) (ft^3)	9,331.82

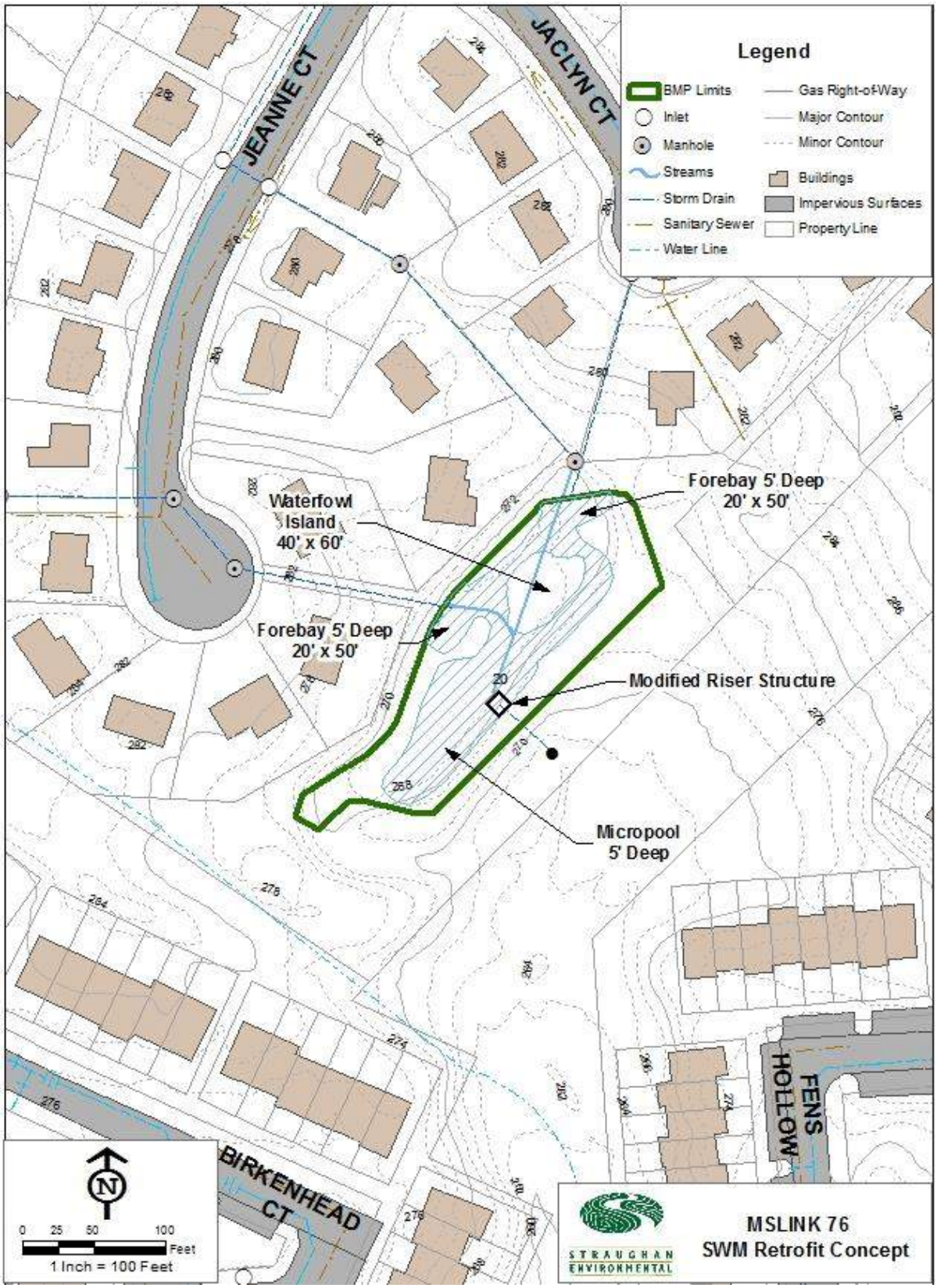


Figure 1. Concept Design Plan View at 9518 Jaclyn Court, access via Fens Hollow Court and through woods, SMP-BC-D332

Cost Estimate

Item Description	Quantity/Units		Unit Cost	Subtotal Cost
SITE PREP				
Mobilization/Demobilization	1	LS	$10,000.00	$10,000.00
Erosion and Sediment Control	1	LS	$8,000.00	$8,000.00
WETLANDS / MICROPOOLS				
Earthwork/Grading	750	cy	$16.00	$12,000.00
Excavate and Remove Soil (Inc. transportation)	1400	cy	$40.00	$56,000.00
Modify Riser	1	ea	$5,000.00	$5,000.00
Planting	0.6	Ac	$10,000.00	$10,000.00
TOTAL CONSTRUCTION COSTS				**$101,000.00**
ENGINEERING AND MANAGEMENT				
Engineering / Permitting / Construction Mgmt.				$200,000.00
Geotech / Soil Borings				$20,000.00
Contingency (30% of Total Construction)				$18,640.00
TOTAL PROJECT COSTS				**$339,640.00**

Constructability

Design & Construction:

Access: Fens Hollow Court and through woods into pond. Formal easement is between 9514 and 9518 Jaclyn Court. Access via fenced areas will need to be negotiated as easement has been fenced off.

Utilities:

Other Impacts:

Existing Condition Photograph

Figure 2. SWM pond at 9518 Jaclyn Court, access via Fens Hollow Court, SMP-BC-D332

Calculations

PROJECT: Howard County Retrofit
LOCATION: 9518 Jaclyn Court
DEVELOPER:

DATE: 1/21/2013
COMPUTED BY: ANB
CHECKED BY: EHF

UNIFIED SIZING CRITERIA

COMPUTE WATER QUALITY VOLUME (WQ_v):

$(WQv) = \frac{[(1.0)(R_v)(A)]}{12}$

= **0.8569** **acre-feet**

= **37327.29** **cubic-feet**

where:

P = 1" Rainfall Depth (Eastern Zone)
A = Total Site Area (acres)
Rv = Volumetric Runoff Coefficient
= 0.05 + 0.009 (I)
where I is % Impervious Cover
Impervious Cover = **9.89** acres
Total Site Area = **27.64** acres
% Impervious Cover = **35.78%**

therefore, Rv = **0.372**

COMPUTE RECHARGE VOLUME (Re_v):

$(Rev) = \frac{[(S)(R_v)(A)]}{12}$

= **0.0669** **acre-feet**

= **2915.69** **cubic-feet**

where:

S = Soil Specific Recharge Factor
A = Total Site Area (acres)
Rv = Volumetric Runoff Coefficient
= 0.05 + 0.009 (I) [as calculated above]
= **0.372**

COMPUTE SOIL RECHARGE FACTOR (S):

Acres	Hydrologic Soil Group	Soil Specific Recharge Factor (S)	A*S
	A	0.38	0.00
1.18	B	0.26	0.31
	C	0.13	0.00
26.46	D	0.07	1.85
27.64		**Computed Average S =**	**0.08**

Project Overview: Crest Drive and Route 216 (SMP-BC-D333)

Project Type:	Dry pond to be retrofit with one filtration dry-swale with check dams and one wet-swale with check dams and storage forebay
Total Cost:	$250,000 (updated according to 2015 Cost Estimation spreadsheet)
Location/Address:	Title – Hammond Hills Roadway, Storm Drain, & Storm Water Management 6th Election District Subdivision – Hammond Hills Address – 8303 Honeyhill Road Access – SHA right of way/Easement at Crest Drive, behind sound wall. No access from Honey Hill Road ADC Map – 19-C06 MS Link 157009
Land Use:	Single family residential subdivision
Ownership:	Public
Maintenance Responsibility:	Public
Drainage Area:	12.60 acres
Impervious Area:	3.16 acres (25.08%)
Surface Soils:	27% GgC: Glenelg loam, 8-15% slopes 49% GhB: Glenelg-Urban land complex, 0-8% slopes 23% GuB: Glenville-Urban land-Udorthents complex, 0-8% slopes 1% MaC: Manor loam, 8-15% slopes Classification: Hydrologic Soil Group, Type B Hydrologic Soil Group, Type C

Existing Conditions

This facility is designed as a dry pond to provide storm water management associated with the Hammond Hills Subdivision. Most of the development runoff is from Honeyhill Road. The street runoff is collected into a storm drain system and discharges into the pond via an 18" RCCP pipe. The rest of the drainage area discharges to the pond via a rip rap channel located on the east side of the pond, and another rip rap channel located on the west side of the pond. These three inlets lead directly to the riser at the north side of the pond. A 48" RCP spillway discharges to an existing swale before entering a nearby stream. No water quality improvement is being provided by the pond.

Conceptual Design

The proposed concept design is to remove both riprap-lined channels and replace them with a dry swale with check dams along lots 15 and 16 and a wet swale with check dams outside lots 10 and 11 within the 20' drainage and utility easements. A pretreatment forebay is also proposed to stabilize the pipe inflow and provide a measure of water quality for the pipe's drainage area.

Swales upstream of the facility were chosen since there was limited space available for pond expansion and the existing swale locations were within easily accessible easements. Swales typically have low maintenance and high community acceptance. The type of swale was estimated based on existing site conditions.

The dry and wet swale will be similar to Figures K and L, respectively, in Appendix B, with check dams to provide required WQv.

Design Parameter	**Value**
Drainage Area (Ac)	12.60
Percent Impervious (I)	25.08
Volumetric runoff coefficient (R_v)	0.276
Soil specific recharge factor (S)	0.23
Water quality volume (WQ_v) (ft^3)	12,610.62
Recharge Volume (Re_v) (ft^3)	2,923.56
Pretreatment Volume (25% WQ_v) ($ft^{3)}$	3,152.66
Filter soil depth, sand (d_f) (ft)	2
Coefficient of permeability (k) (ft/day)	3.5
Avg. Ponding depth (h_f) (ft)	1
Drain time (t_f) (day)	2

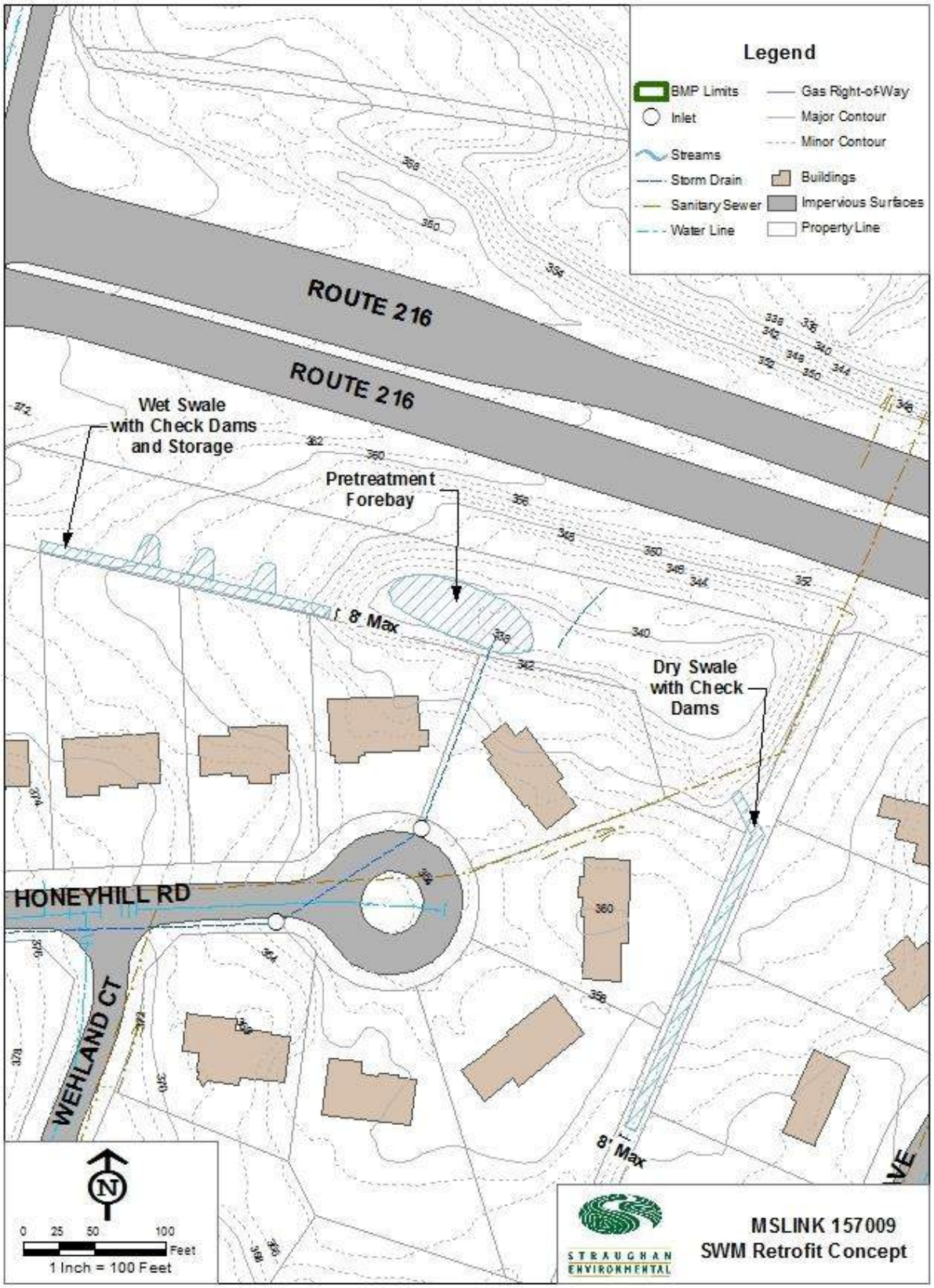


Figure 1. Concept Design Plan View for Crest Drive and Route 216, SMP-BC-D333

Cost Estimate

Item Description	Quantity/Units		Unit Cost	Subtotal Cost
SITE PREP				
Mobilization/Demobilization	1	LS	$10,000.00	$10,000.00
Erosion and Sediment Control	1	LS	$8,000.00	$8,000.00
Plants (Seeding, Wetland plantings, etc.)	1	LS	$10,000.00	$10,000.00
DRY SWALE				
Excavate and Remove (incl. transportation)	460	cy	$40.00	$18,400.00
4" Perforated underdrain	250	lf	$16.00	$4,000.00
Crushed Stone Fill	20	cy	$65.00	$1,300.00
Sand Fill	80	cy	$115.00	$9,200.00
Check dams	5	ea	$250.00	$1,250.00
WET SWALE				
Excavate and Remove (incl. transportation)	120	cy	$40.00	$4,800.00
Check dams	4	ea	$250.00	$1,000.00
TOTAL CONSTRUCTION COSTS				**$67,950.00**
ENGINEERING AND MANAGEMENT				
Engineering / Permitting / Construction Mgmt.				$100,000.00
Geotech / Soil Boring				$20,000.00
Contingency (30% of Total Construction)				$12,220.00
TOTAL PROJECT COSTS				**$200,170.00**

Constructability

Design & Construction:

Access: 216 and Crest Drive behind sound wall. No access from Honey Hill Road

Utilities: A sewer line is present between the swale and the facility along the southeast side of the facility.

Other Impacts:

Existing Condition Photograph

Figure 2. SWM pond at Crest Drive and Route 216, SMP-BC-D333

Calculations

PROJECT:	Howard County Retrofit	DATE:	12/31/2012
LOCATION:	8303 Honeyhill Road	COMPUTED BY:	ANB
DEVELOPER:		CHECKED BY:	EHF

UNIFIED SIZING CRITERIA

COMPUTE WATER QUALITY VOLUME (WQ_v):

$$(WQv) = \frac{[(1.0)(R_v)(A)]}{12}$$

where:

P = 1" Rainfall Depth (Eastern Zone)
A = Total Site Area (acres)
Rv = Volumetric Runoff Coefficient
= 0.05 + 0.009 (I)
where I is % Impervious Cover

= **0.2895** **acre-feet**
= **12610.62** **cubic-feet**

Impervious Cover = **3.16** acres
Total Site Area = **12.60** acres
% Impervious Cover = **25.08%**

therefore, Rv = **0.276**

COMPUTE RECHARGE VOLUME (Re_v):

$$(Rev) = \frac{[(S)(R_v)(A)]}{12}$$

where:

S = Soil Specific Recharge Factor
A = Total Site Area (acres)
Rv = Volumetric Runoff Coefficient
= 0.05 + 0.009 (I) [as calculated above]
= **0.276**

= **0.0671** **acre-feet**
= **2923.56** **cubic-feet**

COMPUTE SOIL RECHARGE FACTOR (S):

Acres	Hydrologic Soil Group	Soil Specific Recharge Factor (S)	A*S
0	A	0.38	0.00
9.87	B	0.26	2.57
2.73	C	0.13	0.35
0	D	0.07	0.00
12.60		**Computed Average S =**	**0.23**

I. Pollutant Load Reduction Calculations for Individual BMP Projects

Table I-1. Stormwater Management Facility (SWM) conversions proposed for the Little Patuxent Watershed and potential pollutant load reductions, for individual sites

Site ID	SWM Facility Conversion Type and Priority	Imper-vious DA (acres)	Pervious DA (acres)	Total Nitrogen			Total Phosphorus			Sediment		
				Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)
SMP-BC-D333	02131105,DryPonds to BioSwale,Concept	3.47	9.13	144.8	65%	94.1	9.6	65%	6.2	9,594.2	70%	6,716.0
SLP-BC-D780	02131105,DryPonds to ExtDryPonds,Concept	6.87	13.68	243.0	15%	36.5	17.7	10%	1.8	17,744.0	50%	8,872.0
SLP-BC-D802	02131105,DryPonds to ExtDryPonds,Concept	14.87	5.58	287.7	15%	43.1	31.2	10%	3.1	31,540.8	50%	15,770.4
SLP-BC-D792	02131105,DryPonds to ExtDryPonds,Concept	9.72	5.05	201.9	15%	30.3	20.8	10%	2.1	21,013.9	50%	10,506.9
SLP-BC-D798	02131105,DryPonds to ExtDryPonds,Concept	10.61	21.10	375.2	15%	56.3	27.3	10%	2.7	27,400.0	50%	13,700.0
SLP-BC-F701	02131105,DryPonds to WetPondWetland ,Concept	4.48	15.48	223.7	15%	33.6	13.4	35%	4.7	13,455.9	50%	6,727.9
SLP-BC-F758	02131105,DryPonds to WetPondWetland ,Concept	1.59	1.43	39.0	15%	5.9	3.6	35%	1.3	3,609.5	50%	1,804.7
SLP-BC-F734	02131105,DryPonds to WetPondWetland ,Concept	3.72	1.18	69.8	15%	10.5	7.7	35%	2.7	7,822.5	50%	3,911.2
DOR-BC-F942	02131105,DryPonds to WetPondWetland ,Concept	6.97	2.02	128.9	15%	19.3	14.5	35%	5.1	14,616.1	50%	7,308.0
SMP-BC-D332	02131105,DryPonds to WetPondWetland ,Concept	10.90	16.74	336.4	15%	50.5	26.6	35%	9.3	26,736.0	50%	13,368.0
SLP-BC-D774	02131105,DryPonds to WetPondWetland ,Concept	10.76	42.35	588.5	15%	88.3	33.8	35%	11.8	33,788.2	50%	16,894.1
SMP-BC-F314	02131105,ExtDryPonds to Filter,Concept	3.60	4.75	103.4	20%	20.7	8.6	40%	3.4	8,608.4	20%	1,721.7
DOR-BC-F943	02131105,ExtDryPonds to Filter,Concept	5.21	5.88	139.8	20%	28.0	12.1	40%	4.8	12,173.8	20%	2,434.8
SLP-BC-F772	02131105,ExtDryPonds to WetPondWetland ,Concept	1.81	3.68	64.8	0%	0.0	4.7	25%	1.2	4,695.9	0%	0.0
SLP-BC-F728	02131105,ExtDryPonds to WetPondWetland ,Concept	7.95	4.36	167.4	0%	0.0	17.1	25%	4.3	17,254.0	0%	0.0
DOR-BC-F917	02131105,DryPonds to BioRetUDAB,No Concept	4.97	2.26	100.0	65%	65.0	10.5	65%	6.9	10,646.4	70%	7,452.5
SLP-BC-F773	02131105,DryPonds to BioRetUDCD,No Concept	0.37	0.22	8.0	20%	1.6	0.8	35%	0.3	816.3	45%	367.3
SLP-BC-F708	02131105,DryPonds to BioRetUDCD,No Concept	0.13	0.16	3.6	20%	0.7	0.3	35%	0.1	307.7	45%	138.4
SLP-BC-F715	02131105,DryPonds to BioRetUDCD,No Concept	0.37	1.80	23.6	20%	4.7	1.3	35%	0.4	1,252.5	45%	563.6
SLP-BC-F751	02131105,DryPonds to BioRetUDCD,No Concept	0.35	0.18	7.2	20%	1.4	0.7	35%	0.3	746.6	45%	336.0
DOR-BC-F913	02131105,DryPonds to BioRetUDCD,No Concept	0.95	0.49	19.7	20%	3.9	2.0	35%	0.7	2,053.3	45%	924.0

Site ID	SWM Facility Conversion Type and Priority	Imper-vious DA (acres)	Pervious DA (acres)	Total Nitrogen			Total Phosphorus			Sediment		
				Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)
DOR-BC-F906	02131105,DryPonds to BioRetUDCD,No Concept	0.64	1.64	26.2	20%	5.2	1.7	35%	0.6	1,755.1	45%	789.8
DOR-BC-D945	02131105,DryPonds to BioRetUDCD,No Concept	0.15	1.16	13.9	20%	2.8	0.6	35%	0.2	635.7	45%	286.1
NLP-BC-D517	02131105,DryPonds to BioRetUDCD,No Concept	1.16	2.54	43.3	20%	8.7	3.0	35%	1.1	3,061.8	45%	1,377.8
SLP-BC-F742	02131105,DryPonds to BioSwale,No Concept	1.42	0.95	31.7	65%	20.6	3.1	65%	2.0	3,135.1	70%	2,194.5
DOR-BC-F941	02131105,DryPonds to BioSwale,No Concept	1.58	1.57	40.2	65%	26.1	3.6	65%	2.3	3,628.1	70%	2,539.6
DOR-BC-F927	02131105,DryPonds to BioSwale,No Concept	3.04	1.10	58.5	65%	38.0	6.4	65%	4.1	6,442.6	70%	4,509.8
DOR-BC-F912	02131105,DryPonds to BioSwale,No Concept	0.29	0.31	7.6	65%	4.9	0.7	65%	0.4	671.5	70%	470.0
SLP-BC-D784	02131105,DryPonds to ExtDryPonds,No Concept	2.66	1.39	55.3	15%	8.3	5.7	10%	0.6	5,748.3	50%	2,874.1
SLP-BC-D788	02131105,DryPonds to ExtDryPonds,No Concept	1.55	1.85	42.7	15%	6.4	3.6	10%	0.4	3,661.4	50%	1,830.7
DOR-BC-D944	02131105,DryPonds to ExtDryPonds,No Concept	4.94	9.82	174.6	15%	26.2	12.7	10%	1.3	12,763.0	50%	6,381.5
NLP-BC-D513	02131105,DryPonds to ExtDryPonds,No Concept	3.30	15.96	210.0	15%	31.5	11.2	10%	1.1	11,215.2	50%	5,607.6
SLP-BC-D778	02131105,DryPonds to ExtDryPonds,No Concept	6.35	9.93	197.8	15%	29.7	15.5	10%	1.6	15,633.8	50%	7,816.9
SLP-BC-F760	02131105,DryPonds to Filter,No Concept	0.18	1.09	13.7	35%	4.8	0.7	50%	0.3	675.4	70%	472.8
SLP-BC-F743	02131105,DryPonds to Filter,No Concept	0.56	0.93	18.0	35%	6.3	1.4	50%	0.7	1,394.1	70%	975.9
SLP-BC-F749	02131105,DryPonds to Filter,No Concept	1.59	0.40	28.8	35%	10.1	3.3	50%	1.6	3,315.2	70%	2,320.6
SLP-BC-F750	02131105,DryPonds to Filter,No Concept	1.06	0.52	21.7	35%	7.6	2.3	50%	1.1	2,289.2	70%	1,602.4
SLP-BC-F759	02131105,DryPonds to Filter,No Concept	1.74	1.67	43.7	35%	15.3	4.0	50%	2.0	3,981.7	70%	2,787.2
SLP-BC-F730	02131105,DryPonds to Filter,No Concept	2.82	2.04	64.3	35%	22.5	6.2	50%	3.1	6,261.2	70%	4,382.8
SLP-BC-F761	02131105,DryPonds to Filter,No Concept	0.68	1.17	22.2	35%	7.8	1.7	50%	0.8	1,702.1	70%	1,191.4
SLP-BC-F741	02131105,DryPonds to Filter,No Concept	1.83	1.32	41.8	35%	14.6	4.0	50%	2.0	4,071.4	70%	2,850.0
SLP-BC-F719	02131105,DryPonds to Filter,No Concept	0.80	0.70	19.4	35%	6.8	1.8	50%	0.9	1,808.4	70%	1,265.8
SLP-BC-F726	02131105,DryPonds to Filter,No Concept	1.21	0.46	23.4	35%	8.2	2.5	50%	1.3	2,565.8	70%	1,796.1
SLP-BC-F709	02131105,DryPonds to Filter,No Concept	0.89	0.87	22.6	35%	7.9	2.0	50%	1.0	2,050.1	70%	1,435.1
SLP-BC-F732	02131105,DryPonds to Filter,No Concept	6.99	1.92	128.3	35%	44.9	14.5	50%	7.2	14,631.9	70%	10,242.4
SLP-BC-F733	02131105,DryPonds to Filter,No Concept	0.40	0.63	12.6	35%	4.4	1.0	50%	0.5	993.8	70%	695.6
SLP-BC-F757	02131105,DryPonds to Filter,No Concept	1.96	5.34	83.6	35%	29.3	5.5	50%	2.7	5,477.6	70%	3,834.3
SLP-BC-F703	02131105,DryPonds to Filter,No Concept	2.19	3.84	72.2	35%	25.3	5.5	50%	2.7	5,497.6	70%	3,848.3

Site ID	SWM Facility Conversion Type and Priority	Imper-vious DA (acres)	Pervious DA (acres)	Total Nitrogen			Total Phosphorus			Sediment		
				Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)
NLP-BC-F508	02131105,DryPonds to Filter,No Concept	0.93	1.08	25.3	35%	8.9	2.2	50%	1.1	2,187.4	70%	1,531.2
DOR-BC-F931	02131105,DryPonds to Filter,No Concept	4.43	0.52	74.3	35%	26.0	9.0	50%	4.5	9,062.3	70%	6,343.6
DOR-BC-F909	02131105,DryPonds to Filter,No Concept	1.03	1.05	26.5	35%	9.3	2.3	50%	1.2	2,366.8	70%	1,656.8
DOR-BC-F934	02131105,DryPonds to Filter,No Concept	0.28	0.20	6.4	35%	2.2	0.6	50%	0.3	622.4	70%	435.7
DOR-BC-F935	02131105,DryPonds to Filter,No Concept	0.33	0.26	7.7	35%	2.7	0.7	50%	0.4	735.3	70%	514.7
SLP-BC-D781	02131105,DryPonds to Filter,No Concept	2.75	0.96	52.4	35%	18.4	5.8	50%	2.9	5,808.8	70%	4,066.2
NLP-BC-D521	02131105,DryPonds to Filter,No Concept	1.20	4.01	58.6	35%	20.5	3.6	50%	1.8	3,566.3	70%	2,496.4
SLP-BC-D783	02131105,DryPonds to Filter,No Concept	2.89	1.08	55.9	35%	19.6	6.1	50%	3.0	6,134.9	70%	4,294.4
SMP-BC-D323	02131105,DryPonds to Filter,No Concept	2.30	4.85	84.0	35%	29.4	6.0	50%	3.0	6,013.4	70%	4,209.4
SLP-BC-D785	02131105,DryPonds to Filter,No Concept	2.87	1.06	55.3	35%	19.3	6.0	50%	3.0	6,073.9	70%	4,251.7
DOR-BC-D947	02131105,DryPonds to Filter,No Concept	7.35	4.22	156.6	35%	54.8	15.9	50%	7.9	16,001.8	70%	11,201.3
SLP-BC-D794	02131105,DryPonds to Filter,No Concept	7.94	3.73	161.1	35%	56.4	16.9	50%	8.5	17,063.5	70%	11,944.4
NLP-BC-D531	02131105,DryPonds to Filter,No Concept	3.19	9.25	141.6	35%	49.6	9.0	50%	4.5	9,068.1	70%	6,347.7
SLP-BC-D803	02131105,DryPonds to Filter,No Concept	2.57	6.03	99.9	35%	35.0	6.9	50%	3.4	6,891.5	70%	4,824.0
SLP-BC-F739	02131105,DryPonds to Infiltration,No Concept	0.69	1.25	23.3	75%	17.5	1.7	75%	1.3	1,757.2	85%	1,493.6
SLP-BC-F754	02131105,DryPonds to Infiltration,No Concept	0.64	0.63	16.3	75%	12.2	1.5	75%	1.1	1,475.9	85%	1,254.5
SLP-BC-F740	02131105,DryPonds to Infiltration,No Concept	0.46	0.23	9.4	75%	7.0	1.0	75%	0.7	986.4	85%	838.4
SLP-BC-F765	02131105,DryPonds to Infiltration,No Concept	1.05	1.56	31.9	75%	23.9	2.5	75%	1.9	2,559.8	85%	2,175.9
SLP-BC-F711	02131105,DryPonds to Infiltration,No Concept	0.91	1.45	28.6	75%	21.5	2.2	75%	1.7	2,253.4	85%	1,915.4
NLP-BC-F506	02131105,DryPonds to Infiltration,No Concept	0.20	0.63	9.4	75%	7.0	0.6	75%	0.4	581.4	85%	494.2
DOR-BC-F926	02131105,DryPonds to Infiltration,No Concept	0.07	0.56	6.6	75%	5.0	0.3	75%	0.2	300.4	85%	255.3
SLP-BC-D805	02131105,DryPonds to Infiltration,No Concept	1.80	8.83	115.8	75%	86.8	6.2	75%	4.6	6,150.3	85%	5,227.8
SLP-BC-F764	02131105,DryPonds to WetPondWetland ,No Concept	5.00	2.01	98.1	15%	14.7	10.5	35%	3.7	10,648.5	50%	5,324.3
SLP-BC-F748	02131105,DryPonds to WetPondWetland ,No Concept	3.42	1.24	65.7	15%	9.9	7.2	35%	2.5	7,242.2	50%	3,621.1
SLP-BC-F762	02131105,DryPonds to WetPondWetland ,No Concept	1.21	0.70	25.9	15%	3.9	2.6	35%	0.9	2,644.8	50%	1,322.4
SLP-BC-F710	02131105,DryPonds to WetPondWetland ,No Concept	3.93	15.08	211.1	15%	31.7	12.2	35%	4.3	12,227.2	50%	6,113.6
SLP-BC-F770	02131105,DryPonds to WetPondWetland ,No Concept	4.98	1.14	89.1	15%	13.4	10.2	35%	3.6	10,353.9	50%	5,177.0

Site ID	SWM Facility Conversion Type and Priority	Imper-vious DA (acres)	Pervious DA (acres)	Total Nitrogen			Total Phosphorus			Sediment		
				Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)
SLP-BC-F767	02131105,DryPonds to WetPondWetland ,No Concept	7.59	1.74	135.8	15%	20.4	15.6	35%	5.5	15,786.5	50%	7,893.2
SLP-BC-F752	02131105,DryPonds to WetPondWetland ,No Concept	0.43	0.45	11.2	15%	1.7	1.0	35%	0.3	1,002.9	50%	501.5
SLP-BC-F712	02131105,DryPonds to WetPondWetland ,No Concept	4.92	9.41	170.2	15%	25.5	12.5	35%	4.4	12,595.8	50%	6,297.9
SLP-BC-F731	02131105,DryPonds to WetPondWetland ,No Concept	0.51	0.73	15.2	15%	2.3	1.2	35%	0.4	1,234.1	50%	617.0
SLP-BC-F705	02131105,DryPonds to WetPondWetland ,No Concept	1.52	2.11	44.7	15%	6.7	3.6	35%	1.3	3,667.8	50%	1,833.9
SLP-BC-F851	02131105,DryPonds to WetPondWetland ,No Concept	2.22	0.90	43.6	15%	6.5	4.7	35%	1.6	4,723.4	50%	2,361.7
SMP-BC-F309	02131105,DryPonds to WetPondWetland ,No Concept	0.99	0.19	17.3	15%	2.6	2.0	35%	0.7	2,044.1	50%	1,022.0
NLP-BC-F511	02131105,DryPonds to WetPondWetland ,No Concept	0.80	1.20	24.3	15%	3.6	1.9	35%	0.7	1,947.8	50%	973.9
NLP-BC-F507	02131105,DryPonds to WetPondWetland ,No Concept	1.99	0.49	36.0	15%	5.4	4.1	35%	1.4	4,152.9	50%	2,076.5
NLP-BC-F651	02131105,DryPonds to WetPondWetland ,No Concept	4.01	4.23	104.7	15%	15.7	9.2	35%	3.2	9,296.0	50%	4,648.0
DOR-BC-F910	02131105,DryPonds to WetPondWetland ,No Concept	1.33	0.48	25.5	15%	3.8	2.8	35%	1.0	2,810.8	50%	1,405.4
DOR-BC-F930	02131105,DryPonds to WetPondWetland ,No Concept	11.10	3.95	212.5	15%	31.9	23.3	35%	8.1	23,483.1	50%	11,741.5
DOR-BC-F911	02131105,DryPonds to WetPondWetland ,No Concept	1.79	1.13	39.1	15%	5.9	3.9	35%	1.4	3,926.3	50%	1,963.1
DOR-BC-F918	02131105,DryPonds to WetPondWetland ,No Concept	6.70	3.69	141.2	15%	21.2	14.4	35%	5.0	14,544.1	50%	7,272.0
DOR-BC-F914	02131105,DryPonds to WetPondWetland ,No Concept	1.04	0.42	20.4	15%	3.1	2.2	35%	0.8	2,219.3	50%	1,109.7
DOR-BC-F921	02131105,DryPonds to WetPondWetland ,No Concept	3.73	2.14	79.5	15%	11.9	8.1	35%	2.8	8,130.5	50%	4,065.3
DOR-BC-F937	02131105,DryPonds to WetPondWetland ,No Concept	6.15	2.24	118.3	15%	17.7	12.9	35%	4.5	13,023.6	50%	6,511.8
DOR-BC-F928	02131105,DryPonds to WetPondWetland ,No Concept	6.08	1.51	109.9	15%	16.5	12.5	35%	4.4	12,670.7	50%	6,335.4
DOR-BC-F929	02131105,DryPonds to WetPondWetland ,No Concept	3.40	0.91	62.1	15%	9.3	7.0	35%	2.5	7,105.0	50%	3,552.5
DOR-BC-F932	02131105,DryPonds to WetPondWetland ,No Concept	3.70	3.13	88.8	15%	13.3	8.3	35%	2.9	8,340.7	50%	4,170.4
DOR-BC-F904	02131105,DryPonds to WetPondWetland ,No Concept	0.62	0.42	13.8	15%	2.1	1.4	35%	0.5	1,365.7	50%	682.9

Site ID	SWM Facility Conversion Type and Priority	Imper-vious DA (acres)	Pervious DA (acres)	Total Nitrogen			Total Phosphorus			Sediment		
				Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)
DOR-BC-F903	02131105,DryPonds to WetPondWetland ,No Concept	1.55	3.92	63.1	15%	9.5	4.2	35%	1.5	4,234.6	50%	2,117.3
DOR-BC-F907	02131105,DryPonds to WetPondWetland ,No Concept	3.01	7.02	116.6	15%	17.5	8.0	35%	2.8	8,059.8	50%	4,029.9
DOR-BC-F905	02131105,DryPonds to WetPondWetland ,No Concept	1.80	3.75	65.3	15%	9.8	4.7	35%	1.6	4,690.9	50%	2,345.5
DOR-BC-D946	02131105,DryPonds to WetPondWetland ,No Concept	8.83	4.38	181.4	15%	27.2	18.9	35%	6.6	19,028.5	50%	9,514.2
SLP-BC-D795	02131105,DryPonds to WetPondWetland ,No Concept	13.59	20.19	412.6	15%	61.9	32.9	35%	11.5	33,134.6	50%	16,567.3
SMP-BC-D322	02131105,DryPonds to WetPondWetland ,No Concept	1.69	6.30	89.0	15%	13.4	5.2	35%	1.8	5,215.8	50%	2,607.9
NLP-BC-D512	02131105,DryPonds to WetPondWetland ,No Concept	16.23	47.27	722.8	15%	108.4	46.1	35%	16.1	46,216.0	50%	23,108.0
NLP-BC-D528	02131105,DryPonds to WetPondWetland ,No Concept	23.66	61.11	976.1	15%	146.4	64.9	35%	22.7	65,127.7	50%	32,563.8
NLP-BC-D524	02131105,DryPonds to WetPondWetland ,No Concept	9.79	4.30	195.6	15%	29.3	20.7	35%	7.3	20,949.8	50%	10,474.9
SLP-BC-D804	02131105,DryPonds to WetPondWetland ,No Concept	4.40	9.01	158.1	15%	23.7	11.4	35%	4.0	11,436.8	50%	5,718.4
NLP-BC-D526	02131105,DryPonds to WetPondWetland ,No Concept	1.97	0.84	39.2	15%	5.9	4.2	35%	1.5	4,216.5	50%	2,108.2
NLP-BC-D527	02131105,DryPonds to WetPondWetland ,No Concept	4.97	16.70	243.4	15%	36.5	14.8	35%	5.2	14,793.0	50%	7,396.5
NLP-BC-D532	02131105,DryPonds to WetPondWetland ,No Concept	2.40	9.76	134.4	15%	20.2	7.6	35%	2.7	7,626.6	50%	3,813.3
NLP-BC-D525	02131105,DryPonds to WetPondWetland ,No Concept	3.32	5.37	105.1	15%	15.8	8.2	35%	2.9	8,211.7	50%	4,105.8
DOR-BC-F915	02131105,ExtDryPonds to BioRetUDAB,No Concept	1.69	4.26	68.7	50%	34.3	4.6	55%	2.5	4,619.7	20%	923.9
SLP-BC-F771	02131105,ExtDryPonds to BioRetUDCD,No Concept	1.17	2.15	39.6	5%	2.0	3.0	25%	0.7	2,967.4	-5%	-148.4
NLP-BC-D538	02131105,ExtDryPonds to BioRetUDCD,No Concept	3.06	4.59	93.3	5%	4.7	7.4	25%	1.9	7,470.3	-5%	-373.5
SLP-BC-F747	02131105,ExtDryPonds to BioRetUDCD,No Concept	0.39	0.68	12.9	5%	0.6	1.0	25%	0.2	983.6	-5%	-49.2
SLP-BC-F744	02131105,ExtDryPonds to BioRetUDCD,No Concept	0.40	0.20	8.2	5%	0.4	0.9	25%	0.2	862.0	-5%	-43.1
SLP-BC-D797	02131105,ExtDryPonds to BioRetUDCD,No Concept	2.75	6.84	110.9	5%	5.5	7.5	25%	1.9	7,501.4	-5%	-375.1
SLP-BC-F721	02131105,ExtDryPonds to BioSwale,No Concept	0.56	0.49	13.7	50%	6.8	1.3	55%	0.7	1,274.7	20%	254.9

Site ID	SWM Facility Conversion Type and Priority	Imper-vious DA (acres)	Pervious DA (acres)	Total Nitrogen			Total Phosphorus			Sediment		
				Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)
SLP-BC-F714	02131105,ExtDryPonds to BioSwale,No Concept	0.37	0.21	8.0	50%	4.0	0.8	55%	0.4	814.4	20%	162.9
DOR-BC-F940	02131105,ExtDryPonds to BioSwale,No Concept	2.97	0.96	55.8	50%	27.9	6.2	55%	3.4	6,246.4	20%	1,249.3
DOR-BC-F939	02131105,ExtDryPonds to BioSwale,No Concept	2.95	0.73	53.3	50%	26.6	6.1	55%	3.3	6,142.5	20%	1,228.5
SLP-BC-F745	02131105,ExtDryPonds to Filter,No Concept	0.98	0.39	19.2	20%	3.8	2.1	40%	0.8	2,091.6	20%	418.3
SLP-BC-F746	02131105,ExtDryPonds to Filter,No Concept	0.70	0.12	12.2	20%	2.4	1.4	40%	0.6	1,448.1	20%	289.6
SLP-BC-F766	02131105,ExtDryPonds to Filter,No Concept	2.97	3.39	80.1	20%	16.0	6.9	40%	2.8	6,954.8	20%	1,391.0
SLP-BC-F735	02131105,ExtDryPonds to Filter,No Concept	2.37	0.57	42.7	20%	8.5	4.9	40%	2.0	4,939.4	20%	987.9
SLP-BC-F723	02131105,ExtDryPonds to Filter,No Concept	0.68	0.41	14.6	20%	2.9	1.5	40%	0.6	1,480.0	20%	296.0
SLP-BC-F724	02131105,ExtDryPonds to Filter,No Concept	0.42	0.79	14.3	20%	2.9	1.1	40%	0.4	1,064.7	20%	212.9
SMP-BC-F316	02131105,ExtDryPonds to Filter,No Concept	0.61	0.29	12.5	20%	2.5	1.3	40%	0.5	1,318.0	20%	263.6
SMP-BC-F315	02131105,ExtDryPonds to Filter,No Concept	0.33	2.12	26.2	20%	5.2	1.3	40%	0.5	1,274.3	20%	254.9
DOR-BC-F908	02131105,ExtDryPonds to Filter,No Concept	0.13	0.43	6.3	20%	1.3	0.4	40%	0.2	383.9	20%	76.8
SMP-BC-D335	02131105,ExtDryPonds to Filter,No Concept	2.94	13.94	184.3	20%	36.9	9.9	40%	4.0	9,905.0	20%	1,981.0
NLP-BC-D540	02131105,ExtDryPonds to Filter,No Concept	2.22	5.11	85.5	20%	17.1	5.9	40%	2.4	5,942.0	20%	1,188.4
SLP-BC-D796	02131105,ExtDryPonds to Filter,No Concept	3.68	6.88	125.8	20%	25.2	9.3	40%	3.7	9,386.1	20%	1,877.2
SLP-BC-F725	02131105,ExtDryPonds to Infiltration,No Concept	2.36	6.45	100.8	60%	60.5	6.6	65%	4.3	6,587.7	35%	2,305.7
SLP-BC-F722	02131105,ExtDryPonds to Infiltration,No Concept	0.55	0.23	10.9	60%	6.5	1.2	65%	0.8	1,172.0	35%	410.2
SMP-BC-F301	02131105,ExtDryPonds to Infiltration,No Concept	0.41	1.54	21.7	60%	13.0	1.3	65%	0.8	1,265.9	35%	443.1
DOR-BC-F925	02131105,ExtDryPonds to SW to the MEP - SPSC,No Concept	1.66	4.37	69.3	37%	25.6	4.6	46%	2.1	4,589.7	10%	459.0
SLP-BC-F716	02131105,ExtDryPonds to WetPondWetland ,No Concept	0.84	0.80	21.1	0%	0.0	1.9	25%	0.5	1,927.2	0%	0.0
SLP-BC-F768	02131105,ExtDryPonds to WetPondWetland ,No Concept	1.43	1.20	34.3	0%	0.0	3.2	25%	0.8	3,221.1	0%	0.0
SLP-BC-F718	02131105,ExtDryPonds to WetPondWetland ,No Concept	1.34	0.74	28.2	0%	0.0	2.9	25%	0.7	2,901.0	0%	0.0
SLP-BC-F737	02131105,ExtDryPonds to WetPondWetland ,No Concept	1.20	0.91	27.7	0%	0.0	2.6	25%	0.7	2,670.5	0%	0.0
SLP-BC-F753	02131105,ExtDryPonds to WetPondWetland ,No Concept	0.84	0.30	16.0	0%	0.0	1.8	25%	0.4	1,767.8	0%	0.0
SLP-BC-F755	02131105,ExtDryPonds to WetPondWetland ,No Concept	4.93	1.80	95.0	0%	0.0	10.3	25%	2.6	10,452.6	0%	0.0

Site ID	SWM Facility Conversion Type and Priority	Imper-vious DA (acres)	Pervious DA (acres)	Total Nitrogen			Total Phosphorus			Sediment		
				Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)
SLP-BC-F713	02131105,ExtDryPonds to WetPondWetland ,No Concept	31.65	22.77	720.4	0%	0.0	69.7	25%	17.4	70,252.7	0%	0.0
SLP-BC-F852	02131105,ExtDryPonds to WetPondWetland ,No Concept	8.28	4.53	174.2	0%	0.0	17.8	25%	4.4	17,962.7	0%	0.0
NLP-BC-F503	02131105,ExtDryPonds to WetPondWetland ,No Concept	1.81	2.72	55.2	0%	0.0	4.4	25%	1.1	4,418.5	0%	0.0
NLP-BC-F509	02131105,ExtDryPonds to WetPondWetland ,No Concept	2.78	1.78	61.1	0%	0.0	6.1	25%	1.5	6,104.9	0%	0.0
NLP-BC-F510	02131105,ExtDryPonds to WetPondWetland ,No Concept	0.84	0.92	22.3	0%	0.0	1.9	25%	0.5	1,951.8	0%	0.0
NLP-BC-F501	02131105,ExtDryPonds to WetPondWetland ,No Concept	1.14	4.96	67.1	0%	0.0	3.7	25%	0.9	3,716.8	0%	0.0
NLP-BC-F502	02131105,ExtDryPonds to WetPondWetland ,No Concept	3.03	2.03	67.5	0%	0.0	6.6	25%	1.7	6,688.7	0%	0.0
DOR-BC-F938	02131105,ExtDryPonds to WetPondWetland ,No Concept	3.36	2.13	73.6	0%	0.0	7.3	25%	1.8	7,383.3	0%	0.0
DOR-BC-F920	02131105,ExtDryPonds to WetPondWetland ,No Concept	9.92	4.71	201.6	0%	0.0	21.1	25%	5.3	21,318.3	0%	0.0
DOR-BC-F916	02131105,ExtDryPonds to WetPondWetland ,No Concept	4.71	1.80	91.4	0%	0.0	9.9	25%	2.5	9,995.7	0%	0.0
DOR-BC-F936	02131105,ExtDryPonds to WetPondWetland ,No Concept	14.91	3.78	270.4	0%	0.0	30.8	25%	7.7	31,106.5	0%	0.0
DOR-BC-F901	02131105,ExtDryPonds to WetPondWetland ,No Concept	2.62	0.73	48.2	0%	0.0	5.4	25%	1.4	5,484.1	0%	0.0
DOR-BC-F922	02131105,ExtDryPonds to WetPondWetland ,No Concept	13.35	3.89	247.0	0%	0.0	27.7	25%	6.9	27,984.9	0%	0.0
DOR-BC-F924	02131105,ExtDryPonds to WetPondWetland ,No Concept	5.92	3.14	123.7	0%	0.0	12.7	25%	3.2	12,820.5	0%	0.0
DOR-BC-F919	02131105,ExtDryPonds to WetPondWetland ,No Concept	4.09	1.97	83.4	0%	0.0	8.7	25%	2.2	8,795.9	0%	0.0
SLP-BC-D782	02131105,ExtDryPonds to WetPondWetland ,No Concept	4.10	2.20	85.9	0%	0.0	8.8	25%	2.2	8,891.3	0%	0.0
SLP-BC-D776	02131105,ExtDryPonds to WetPondWetland ,No Concept	0.33	2.48	29.8	0%	0.0	1.4	25%	0.3	1,378.1	0%	0.0
NLP-BC-D516	02131105,ExtDryPonds to WetPondWetland ,No Concept	1.35	6.04	81.0	0%	0.0	4.4	25%	1.1	4,439.6	0%	0.0
NLP-BC-D529	02131105,ExtDryPonds to WetPondWetland ,No Concept	1.36	4.24	63.3	0%	0.0	3.9	25%	1.0	3,944.6	0%	0.0
NLP-BC-D518	02131105,ExtDryPonds to WetPondWetland ,No Concept	3.35	6.06	112.6	0%	0.0	8.4	25%	2.1	8,486.1	0%	0.0
NLP-BC-D515	02131105,ExtDryPonds to WetPondWetland ,No Concept	1.55	4.76	71.5	0%	0.0	4.5	25%	1.1	4,487.0	0%	0.0

Site ID	SWM Facility Conversion Type and Priority	Imper-vious DA (acres)	Pervious DA (acres)	Total Nitrogen			Total Phosphorus			Sediment		
				Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)
NLP-BC-D523	02131105,ExtDryPonds to WetPondWetland ,No Concept	1.88	3.60	65.0	0%	0.0	4.8	25%	1.2	4,813.2	0%	0.0
NLP-BC-D539	02131105,ExtDryPonds to WetPondWetland ,No Concept	9.99	31.84	472.1	0%	0.0	29.2	25%	7.3	29,225.3	0%	0.0
NLP-BC-D533	02131105,ExtDryPonds to WetPondWetland ,No Concept	1.33	2.68	47.4	0%	0.0	3.4	25%	0.9	3,448.9	0%	0.0
	TOTAL	577	743			2,721			454			514,420

Table I-2. Proposed Stormwater Management (SWM) facilities for the Little Patuxent Watershed showing potential pollutant load reduction for individual sites

Site ID	SWM Facility Type and Priority	IMP DA (acres)	PERVIOUS DA (acres	Total Nitrogen			Total Phosphorus			Sediment		
				Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)
SLP-NB-F711b	02131105,BioRetUDCD,Concept	1.78	1.90	47.3	25%	11.8	4.1	45%	1.8	4128	55%	2270
SLP-NB-F712c	02131105,BioRetUDCD,Concept	2.85	0.32	33.3	25%	8.3	5.8	45%	2.6	5830	55%	3207
SLP-NB-F731a	02131105,Filter,Concept	1.27	0.16	15.1	40%	6.0	2.6	60%	1.5	2603	80%	2082
SLP-NB-F739b	02131105,Filter,Concept	7.43	0.45	80.8	40%	32.3	14.9	60%	9.0	15090	80%	12072
SLP-NB-F722d	02131105,Filter,Concept	2.29	0.27	27.0	40%	10.8	4.6	60%	2.8	4689	80%	3751
DOR-NB-F912a	02131105,Filter,Concept	2.00	0.00	19.9	40%	7.9	4.0	60%	2.4	4027	80%	3222
SLP-NB-F740a	02131105,WetPondWetland ,Concept	5.25	5.04	130.8	20%	26.2	11.9	45%	5.4	12014	60%	7208
SLP-NB-F715b	02131105,WetPondWetland ,Concept	3.20	1.35	52.9	20%	10.6	6.8	45%	3.0	6830	60%	4098
SLP-NB-F711a	02131105,WetPondWetland ,Concept	1.13	0.48	18.7	20%	3.7	2.4	45%	1.1	2413	60%	1448
SLP-NB-F712a	02131105,WetPondWetland ,Concept	6.27	2.69	104.3	20%	20.9	13.3	45%	6.0	13395	60%	8037
SLP-NB-F754a	02131105,BioRetUDAB,No Concept	1.01	0.19	12.9	70%	9.1	2.1	75%	1.5	2085	80%	1668
SLP-NB-F770a	02131105,BioRetUDAB,No Concept	0.05	1.92	30.4	70%	21.3	0.7	75%	0.5	649	80%	519
SLP-NB-F770b	02131105,BioRetUDAB,No Concept	0.04	0.95	15.2	70%	10.6	0.4	75%	0.3	357	80%	285
NLP-NB-F502B	02131105,BioRetUDAB,No Concept	0.40	0.15	6.3	70%	4.4	0.8	75%	0.6	846	80%	677
NLP-NB-F521	02131105,BioRetUDAB,No Concept	1.40	0.37	19.7	70%	13.8	2.9	75%	2.2	2920	80%	2336
DOR-NB-F910a	02131105,BioRetUDAB,No Concept	1.02	0.57	19.0	70%	13.3	2.2	75%	1.6	2215	80%	1772
DOR-NB-F919a	02131105,BioRetUDAB,No Concept	1.46	0.16	17.0	70%	11.9	2.9	75%	2.2	2980	80%	2384
SLP-NB-F753b	02131105,BioRetUDCD,No Concept	0.29	0.03	3.3	25%	0.8	0.6	45%	0.3	594	55%	327
SLP-NB-F751a	02131105,BioRetUDCD,No Concept	0.27	0.02	3.0	25%	0.8	0.6	45%	0.2	558	55%	307
SLP-NB-F750a	02131105,BioRetUDCD,No Concept	0.24	0.01	2.6	25%	0.6	0.5	45%	0.2	492	55%	270
SLP-NB-F750b	02131105,BioRetUDCD,No Concept	0.21	0.17	4.8	25%	1.2	0.5	45%	0.2	473	55%	260
SLP-NB-F749b	02131105,BioRetUDCD,No Concept	0.49	0.03	5.3	25%	1.3	1.0	45%	0.4	993	55%	546
SLP-NB-F745b	02131105,BioRetUDCD,No Concept	0.29	0.24	6.5	25%	1.6	0.6	45%	0.3	648	55%	357
SLP-NB-F742c	02131105,BioRetUDCD,No Concept	0.06	0.02	0.9	25%	0.2	0.1	45%	0.1	133	55%	73
SLP-NB-F743a	02131105,BioRetUDCD,No Concept	0.70	0.44	13.9	25%	3.5	1.5	45%	0.7	1542	55%	848

Site ID	SWM Facility Type and Priority	IMP DA (acres)	PERVIOUS DA (acres	Total Nitrogen			Total Phosphorus			Sediment		
				Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)
SLP-NB-F771a	02131105,BioRetUDCD,No Concept	0.72	0.48	14.6	25%	3.6	1.6	45%	0.7	1590	55%	874
SLP-NB-F773a	02131105,BioRetUDCD,No Concept	0.66	0.04	7.1	25%	1.8	1.3	45%	0.6	1338	55%	736
SLP-NB-F773b	02131105,BioRetUDCD,No Concept	0.18	0.02	2.0	25%	0.5	0.4	45%	0.2	359	55%	197
SLP-NB-F773c	02131105,BioRetUDCD,No Concept	0.12	0.02	1.6	25%	0.4	0.3	45%	0.1	253	55%	139
SLP-NB-F757b	02131105,BioRetUDCD,No Concept	0.12	0.04	1.8	25%	0.5	0.3	45%	0.1	252	55%	139
SLP-NB-F767c	02131105,BioRetUDCD,No Concept	0.53	0.39	11.4	25%	2.9	1.2	45%	0.5	1186	55%	652
SLP-NB-F768a	02131105,BioRetUDCD,No Concept	0.93	0.27	13.4	25%	3.3	1.9	45%	0.9	1946	55%	1070
SLP-NB-F737c	02131105,BioRetUDCD,No Concept	0.72	0.33	12.3	25%	3.1	1.5	45%	0.7	1543	55%	848
SLP-NB-F766a	02131105,BioRetUDCD,No Concept	1.11	0.01	11.1	25%	2.8	2.2	45%	1.0	2232	55%	1227
SLP-NB-F720a	02131105,BioRetUDCD,No Concept	0.16	0.01	1.7	25%	0.4	0.3	45%	0.1	319	55%	176
SLP-NB-F720c	02131105,BioRetUDCD,No Concept	0.69	0.23	10.5	25%	2.6	1.4	45%	0.6	1459	55%	802
SLP-NB-F759a	02131105,BioRetUDCD,No Concept	1.94	0.48	26.7	25%	6.7	4.0	45%	1.8	4036	55%	2220
SLP-NB-F758a	02131105,BioRetUDCD,No Concept	0.94	0.20	12.4	25%	3.1	1.9	45%	0.9	1940	55%	1067
SLP-NB-F759b	02131105,BioRetUDCD,No Concept	0.61	0.28	10.5	25%	2.6	1.3	45%	0.6	1315	55%	723
SLP-NB-F755a	02131105,BioRetUDCD,No Concept	0.46	0.20	7.8	25%	1.9	1.0	45%	0.4	993	55%	546
SLP-NB-F701a	02131105,BioRetUDCD,No Concept	1.94	0.56	28.0	25%	7.0	4.0	45%	1.8	4067	55%	2237
SLP-NB-F729a	02131105,BioRetUDCD,No Concept	1.40	0.39	20.0	25%	5.0	2.9	45%	1.3	2925	55%	1609
SLP-NB-F765a	02131105,BioRetUDCD,No Concept	2.17	0.95	36.4	25%	9.1	4.6	45%	2.1	4636	55%	2550
SLP-NB-F739c	02131105,BioRetUDCD,No Concept	0.92	0.43	15.8	25%	4.0	2.0	45%	0.9	1975	55%	1086
SLP-NB-F764a	02131105,BioRetUDCD,No Concept	2.53	0.37	30.9	25%	7.7	5.1	45%	2.3	5201	55%	2861
SLP-NB-F726a	02131105,BioRetUDCD,No Concept	0.64	0.19	9.3	25%	2.3	1.3	45%	0.6	1347	55%	741
SLP-NB-F724b	02131105,BioRetUDCD,No Concept	0.45	0.30	9.2	25%	2.3	1.0	45%	0.4	984	55%	541
SLP-NB-F722c	02131105,BioRetUDCD,No Concept	0.15	0.11	3.2	25%	0.8	0.3	45%	0.1	336	55%	185
SLP-NB-F722b	02131105,BioRetUDCD,No Concept	0.79	0.07	8.9	25%	2.2	1.6	45%	0.7	1609	55%	885
SLP-NB-F723a	02131105,BioRetUDCD,No Concept	1.51	0.30	19.6	25%	4.9	3.1	45%	1.4	3132	55%	1722
SLP-NB-F713b	02131105,BioRetUDCD,No Concept	1.48	0.68	25.3	25%	6.3	3.1	45%	1.4	3174	55%	1746
NLP-NB-F541A	02131105,BioRetUDCD,No Concept	0.25	0.06	3.3	25%	0.8	0.5	45%	0.2	510	55%	280
NLP-NB-F541B	02131105,BioRetUDCD,No Concept	0.25	0.02	2.8	25%	0.7	0.5	45%	0.2	519	55%	285

Site ID	SWM Facility Type and Priority	IMP DA (acres)	PERVIOUS DA (acres	Total Nitrogen			Total Phosphorus			Sediment		
				Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)
NLP-NB-F541C	02131105,BioRetUDCD,No Concept	0.16	0.02	1.9	25%	0.5	0.3	45%	0.1	323	55%	178
NLP-NB-F537A	02131105,BioRetUDCD,No Concept	0.20	0.00	2.0	25%	0.5	0.4	45%	0.2	396	55%	218
NLP-NB-F537B	02131105,BioRetUDCD,No Concept	0.18	0.00	1.8	25%	0.5	0.4	45%	0.2	372	55%	205
NLP-NB-F537C	02131105,BioRetUDCD,No Concept	0.20	0.00	1.9	25%	0.5	0.4	45%	0.2	394	55%	216
NLP-NB-F537D	02131105,BioRetUDCD,No Concept	0.18	0.02	2.0	25%	0.5	0.4	45%	0.2	366	55%	201
NLP-NB-F539A	02131105,BioRetUDCD,No Concept	0.11	0.00	1.1	25%	0.3	0.2	45%	0.1	220	55%	121
NLP-NB-F539B	02131105,BioRetUDCD,No Concept	0.11	0.00	1.1	25%	0.3	0.2	45%	0.1	217	55%	119
NLP-NB-F539E	02131105,BioRetUDCD,No Concept	0.31	0.01	3.1	25%	0.8	0.6	45%	0.3	617	55%	340
DOR-NB-F943s	02131105,BioRetUDCD,No Concept	0.05	0.26	4.6	25%	1.1	0.2	45%	0.1	180	55%	99
DOR-NB-F943t	02131105,BioRetUDCD,No Concept	0.10	0.15	3.3	25%	0.8	0.2	45%	0.1	243	55%	134
SLP-NB-F721a	02131105,BioRetUDCD,No Concept	0.46	0.67	15.1	25%	3.8	1.1	45%	0.5	1124	55%	618
SLP-NB-F760b	02131105,BioRetUDCD,No Concept	0.26	0.39	8.6	25%	2.2	0.6	45%	0.3	637	55%	350
SLP-NB-F761a	02131105,BioRetUDCD,No Concept	0.82	0.17	10.8	25%	2.7	1.7	45%	0.8	1700	55%	935
SLP-NB-F761b	02131105,BioRetUDCD,No Concept	1.18	0.45	18.7	25%	4.7	2.5	45%	1.1	2513	55%	1382
SLP-NB-F762a	02131105,BioRetUDCD,No Concept	0.56	0.04	6.2	25%	1.5	1.1	45%	0.5	1135	55%	625
SLP-NB-F725a	02131105,BioRetUDCD,No Concept	1.17	0.67	22.1	25%	5.5	2.5	45%	1.1	2539	55%	1397
SLP-NB-F712b	02131105,BioRetUDCD,No Concept	0.46	0.32	9.6	25%	2.4	1.0	45%	0.5	1014	55%	557
SLP-NB-F744a	02131105,BioRetUDCD,No Concept	0.22	0.05	2.9	25%	0.7	0.4	45%	0.2	452	55%	249
SLP-NB-F774a	02131105,BioRetUDCD,No Concept	0.12	0.86	14.7	25%	3.7	0.5	45%	0.2	498	55%	274
SLP-NB-F744b	02131105,BioRetUDCD,No Concept	0.35	0.18	6.2	25%	1.6	0.7	45%	0.3	749	55%	412
SLP-NB-F744d	02131105,BioRetUDCD,No Concept	0.43	0.97	19.3	25%	4.8	1.1	45%	0.5	1134	55%	624
SLP-NB-F774c	02131105,BioRetUDCD,No Concept	0.22	0.10	3.8	25%	0.9	0.5	45%	0.2	479	55%	264
SLP-NB-F774b	02131105,BioRetUDCD,No Concept	0.23	0.07	3.3	25%	0.8	0.5	45%	0.2	474	55%	260
SLP-NB-F746b	02131105,BioRetUDCD,No Concept	0.48	0.30	9.5	25%	2.4	1.0	45%	0.5	1049	55%	577
SLP-NB-F746a	02131105,BioRetUDCD,No Concept	0.09	0.16	3.4	25%	0.8	0.2	45%	0.1	223	55%	123
SLP-NB-F750d	02131105,BioRetUDCD,No Concept	0.84	0.23	12.0	25%	3.0	1.7	45%	0.8	1761	55%	969
NLP-NB-F549	02131105,BioRetUDCD,No Concept	0.34	0.02	3.8	25%	1.0	0.7	45%	0.3	701	55%	385
DOR-NB-F915c	02131105,BioRetUDCD,No Concept	0.85	0.03	9.0	25%	2.2	1.7	45%	0.8	1728	55%	951

Site ID	SWM Facility Type and Priority	IMP DA (acres)	PERVIOUS DA (acres	Total Nitrogen			Total Phosphorus			Sediment		
				Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)
DOR-NB-F913c	02131105,BioRetUDCD,No Concept	0.53	0.00	5.2	25%	1.3	1.0	45%	0.5	1058	55%	582
DOR-NB-F903b	02131105,BioRetUDCD,No Concept	0.29	0.04	3.6	25%	0.9	0.6	45%	0.3	604	55%	332
DOR-NB-F903a	02131105,BioRetUDCD,No Concept	0.37	0.06	4.7	25%	1.2	0.8	45%	0.3	766	55%	421
DOR-NB-F941h	02131105,BioRetUDCD,No Concept	0.12	0.02	1.5	25%	0.4	0.2	45%	0.1	248	55%	136
DOR-NB-F943c	02131105,BioRetUDCD,No Concept	0.29	0.27	7.1	25%	1.8	0.7	45%	0.3	662	55%	364
DOR-NB-F943l	02131105,BioRetUDCD,No Concept	0.66	0.28	11.0	25%	2.8	1.4	45%	0.6	1411	55%	776
DOR-NB-F943v	02131105,BioRetUDCD,No Concept	0.88	0.72	19.9	25%	5.0	2.0	45%	0.9	1971	55%	1084
DOR-NB-F943x	02131105,BioRetUDCD,No Concept	0.52	0.69	16.0	25%	4.0	1.2	45%	0.6	1243	55%	684
dor-nb-f932h	02131105,BioRetUDCD,No Concept	0.43	0.02	4.6	25%	1.2	0.9	45%	0.4	879	55%	483
DOR-NB-F931k	02131105,BioRetUDCD,No Concept	0.08	0.01	1.0	25%	0.3	0.2	45%	0.1	169	55%	93
DOR-NB-F929a	02131105,BioRetUDCD,No Concept	2.17	0.01	21.6	25%	5.4	4.3	45%	1.9	4362	55%	2399
DOR-NB-F925g	02131105,BioRetUDCD,No Concept	0.20	0.01	2.2	25%	0.5	0.4	45%	0.2	403	55%	222
DOR-NB-F920a	02131105,BioRetUDCD,No Concept	3.55	0.17	37.8	25%	9.5	7.1	45%	3.2	7200	55%	3960
SLP-NB-F754b	02131105,BioSwale,No Concept	0.14	0.01	1.4	70%	1.0	0.3	75%	0.2	276	80%	221
NLP-NB-F508	02131105,BioSwale,No Concept	0.74	0.10	8.9	70%	6.2	1.5	75%	1.1	1510	80%	1208
NLP-NB-F525	02131105,BioSwale,No Concept	0.04	0.01	0.7	70%	0.5	0.1	75%	0.1	90	80%	72
SMP-NB-F325	02131105,BioSwale,No Concept	0.74	1.00	22.9	70%	16.0	1.8	75%	1.3	1777	80%	1422
NLP-NB-F522A	02131105,BioSwale,No Concept	0.83	0.12	10.2	70%	7.1	1.7	75%	1.3	1702	80%	1362
NLP-NB-F522B	02131105,BioSwale,No Concept	0.20	0.06	3.0	70%	2.1	0.4	75%	0.3	420	80%	336
NLP-NB-F542	02131105,BioSwale,No Concept	0.83	1.17	26.5	70%	18.6	2.0	75%	1.5	1997	80%	1598
NLP-NB-F550A	02131105,BioSwale,No Concept	0.38	0.57	12.7	70%	8.9	0.9	75%	0.7	925	80%	740
NLP-NB-F550B	02131105,BioSwale,No Concept	0.20	0.42	8.5	70%	6.0	0.5	75%	0.4	514	80%	411
NLP-NB-F548A	02131105,BioSwale,No Concept	0.02	0.08	1.5	70%	1.0	0.1	75%	0.1	71	80%	57
NLP-NB-F548B	02131105,BioSwale,No Concept	0.10	0.00	1.1	70%	0.7	0.2	75%	0.2	209	80%	167
NLP-NB-F505	02131105,BioSwale,No Concept	0.23	0.37	8.1	70%	5.7	0.6	75%	0.4	577	80%	461
NLP-NB-D557	02131105,BioSwale,No Concept	0.33	0.33	8.4	70%	5.9	0.8	75%	0.6	759	80%	607
DOR-NB-F916	02131105,BioSwale,No Concept	3.38	0.12	35.5	70%	24.9	6.8	75%	5.1	6851	80%	5481
DOR-NB-F902a	02131105,BioSwale,No Concept	0.08	0.18	3.6	70%	2.5	0.2	75%	0.2	204	80%	163

Site ID	SWM Facility Type and Priority	IMP DA (acres)	PERVIOUS DA (acres	Total Nitrogen			Total Phosphorus			Sediment		
				Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)
DOR-NB-F902b	02131105,BioSwale,No Concept	0.12	0.54	9.6	70%	6.7	0.4	75%	0.3	404	80%	323
DOR-NB-F902c	02131105,BioSwale,No Concept	0.05	0.25	4.5	70%	3.1	0.2	75%	0.1	175	80%	140
DOR-NB-F902d	02131105,BioSwale,No Concept	0.75	0.56	16.2	70%	11.3	1.7	75%	1.2	1668	80%	1334
DOR-NB-F943a	02131105,BioSwale,No Concept	0.25	0.66	12.9	70%	9.0	0.7	75%	0.5	702	80%	561
DOR-NB-F943r	02131105,BioSwale,No Concept	0.17	0.76	13.5	70%	9.5	0.6	75%	0.4	554	80%	443
DOR-NB-F943w	02131105,BioSwale,No Concept	0.58	1.54	29.8	70%	20.8	1.6	75%	1.2	1612	80%	1289
DOR-NB-F943y	02131105,BioSwale,No Concept	0.37	0.46	10.8	70%	7.6	0.9	75%	0.6	871	80%	697
DOR-NB-F943z	02131105,BioSwale,No Concept	0.19	0.53	10.2	70%	7.2	0.5	75%	0.4	536	80%	429
DOR-NB-F934a	02131105,BioSwale,No Concept	0.11	0.58	10.1	70%	7.0	0.4	75%	0.3	377	80%	301
DOR-NB-F905a	02131105,BioSwale,No Concept	0.84	0.06	9.2	70%	6.5	1.7	75%	1.3	1707	80%	1366
DOR-NB-F905b	02131105,BioSwale,No Concept	2.13	0.08	22.4	70%	15.7	4.3	75%	3.2	4306	80%	3445
DOR-NB-F919b	02131105,BioSwale,No Concept	0.89	0.44	15.7	70%	11.0	1.9	75%	1.4	1910	80%	1528
DOR-NB-F917c	02131105,BioSwale,No Concept	0.30	0.32	8.0	70%	5.6	0.7	75%	0.5	692	80%	554
DOR-NB-F920d	02131105,BioSwale,No Concept	1.12	0.54	19.7	70%	13.8	2.4	75%	1.8	2416	80%	1933
DOR-NB-F907a	02131105,BioSwale,No Concept	2.15	0.31	26.1	70%	18.3	4.4	75%	3.3	4409	80%	3527
DOR-NB-F907b	02131105,BioSwale,No Concept	4.14	0.43	47.9	70%	33.5	8.4	75%	6.3	8463	80%	6770
SLP-NB-F757a	02131105,DryPonds,No Concept	0.73	0.27	11.4	5%	0.6	1.5	10%	0.2	1538	10%	154
SLP-NB-F737a	02131105,DryPonds,No Concept	0.43	0.07	5.4	5%	0.3	0.9	10%	0.1	877	10%	88
SLP-NB-F753a	02131105,Filter,No Concept	2.30	0.08	24.0	40%	9.6	4.6	60%	2.8	4647	80%	3718
SLP-NB-F747a	02131105,Filter,No Concept	0.92	0.13	11.3	40%	4.5	1.9	60%	1.1	1898	80%	1518
SLP-NB-F750c	02131105,Filter,No Concept	1.02	0.20	13.3	40%	5.3	2.1	60%	1.3	2121	80%	1696
SLP-NB-F752a	02131105,Filter,No Concept	0.72	0.05	8.0	40%	3.2	1.5	60%	0.9	1473	80%	1179
SLP-NB-F749a	02131105,Filter,No Concept	0.92	0.09	10.5	40%	4.2	1.9	60%	1.1	1876	80%	1501
SLP-NB-F745a	02131105,Filter,No Concept	0.49	0.33	10.1	40%	4.0	1.1	60%	0.6	1090	80%	872
SLP-NB-F742a	02131105,Filter,No Concept	1.29	0.41	19.2	40%	7.7	2.7	60%	1.6	2710	80%	2168
SLP-NB-F769b	02131105,Filter,No Concept	0.26	0.13	4.7	40%	1.9	0.6	60%	0.3	556	80%	445
SLP-NB-F754c	02131105,Filter,No Concept	0.54	0.46	12.5	40%	5.0	1.2	60%	0.7	1224	80%	979
SLP-NB-F767a	02131105,Filter,No Concept	1.67	0.45	23.6	40%	9.4	3.5	60%	2.1	3497	80%	2797

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				Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)
SLP-NB-F741a	02131105,Filter,No Concept	0.92	0.18	12.0	40%	4.8	1.9	60%	1.1	1905	80%	1524
SLP-NB-F741b	02131105,Filter,No Concept	1.23	0.35	17.7	40%	7.1	2.6	60%	1.5	2580	80%	2064
SLP-NB-F732a	02131105,Filter,No Concept	1.06	0.38	16.5	40%	6.6	2.2	60%	1.3	2242	80%	1794
SLP-NB-F702a	02131105,Filter,No Concept	0.86	0.32	13.5	40%	5.4	1.8	60%	1.1	1818	80%	1454
SLP-NB-F705a	02131105,Filter,No Concept	0.61	0.04	6.6	40%	2.6	1.2	60%	0.7	1237	80%	990
SLP-NB-F704a	02131105,Filter,No Concept	1.15	0.10	13.0	40%	5.2	2.3	60%	1.4	2340	80%	1872
SLP-NB-F703a	02131105,Filter,No Concept	1.85	0.07	19.4	40%	7.7	3.7	60%	2.2	3736	80%	2989
SLP-NB-F703b	02131105,Filter,No Concept	2.57	0.00	25.5	40%	10.2	5.1	60%	3.1	5173	80%	4139
SLP-NB-F705b	02131105,Filter,No Concept	0.17	0.00	1.8	40%	0.7	0.3	60%	0.2	344	80%	275
SLP-NB-F766c	02131105,Filter,No Concept	0.97	0.00	9.7	40%	3.9	1.9	60%	1.2	1958	80%	1567
SLP-NB-F720b	02131105,Filter,No Concept	0.67	0.00	6.7	40%	2.7	1.3	60%	0.8	1343	80%	1074
SLP-NB-F738a	02131105,Filter,No Concept	1.12	0.08	12.3	40%	4.9	2.3	60%	1.4	2278	80%	1822
SLP-NB-F733a	02131105,Filter,No Concept	2.98	0.15	32.0	40%	12.8	6.0	60%	3.6	6048	80%	4839
SLP-NB-F735a	02131105,Filter,No Concept	1.03	0.06	11.2	40%	4.5	2.1	60%	1.2	2093	80%	1675
SLP-NB-F734b	02131105,Filter,No Concept	1.45	0.05	15.3	40%	6.1	2.9	60%	1.7	2940	80%	2352
SLP-NB-F728a	02131105,Filter,No Concept	3.86	2.03	70.0	40%	28.0	8.3	60%	5.0	8353	80%	6683
SLP-NB-F718a	02131105,Filter,No Concept	2.87	0.64	38.5	40%	15.4	5.9	60%	3.5	5966	80%	4773
SLP-NB-F718b	02131105,Filter,No Concept	1.23	0.20	15.3	40%	6.1	2.5	60%	1.5	2530	80%	2024
SLP-NB-F713a	02131105,Filter,No Concept	2.80	1.12	45.4	40%	18.2	5.9	60%	3.5	5965	80%	4772
SLP-NB-F707a	02131105,Filter,No Concept	3.42	0.56	42.7	40%	17.1	7.0	60%	4.2	7041	80%	5633
SLP-NB-F736a	02131105,Filter,No Concept	1.65	0.56	25.1	40%	10.1	3.4	60%	2.1	3484	80%	2787
NLP-NB-F540A	02131105,Filter,No Concept	0.19	0.09	3.3	40%	1.3	0.4	60%	0.2	416	80%	333
NLP-NB-F540B	02131105,Filter,No Concept	0.69	0.88	20.5	40%	8.2	1.6	60%	1.0	1639	80%	1311
NLP-NB-F540C	02131105,Filter,No Concept	0.14	0.10	2.9	40%	1.1	0.3	60%	0.2	301	80%	241
NLP-NB-F530	02131105,Filter,No Concept	0.25	0.02	2.8	40%	1.1	0.5	60%	0.3	518	80%	414
NLP-NB-F526	02131105,Filter,No Concept	0.30	0.01	3.1	40%	1.3	0.6	60%	0.4	614	80%	491
NLP-NB-F523	02131105,Filter,No Concept	0.09	0.02	1.2	40%	0.5	0.2	60%	0.1	188	80%	151
DOR-NB-F943i	02131105,Filter,No Concept	0.35	0.05	4.3	40%	1.7	0.7	60%	0.4	722	80%	578

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DOR-NB-F943p	02131105,Filter,No Concept	0.58	0.00	5.7	40%	2.3	1.1	60%	0.7	1160	80%	928
DOR-NB-F943o	02131105,Filter,No Concept	0.58	0.01	5.8	40%	2.3	1.1	60%	0.7	1163	80%	930
DOR-NB-F943u	02131105,Filter,No Concept	0.61	0.01	6.2	40%	2.5	1.2	60%	0.7	1235	80%	988
DOR-NB-F943cc	02131105,Filter,No Concept	0.22	0.33	7.4	40%	3.0	0.5	60%	0.3	539	80%	431
DOR-NB-F943e	02131105,Filter,No Concept	0.48	0.05	5.5	40%	2.2	1.0	60%	0.6	972	80%	777
SLP-NB-F710a	02131105,Filter,No Concept	2.17	0.63	31.3	40%	12.5	4.5	60%	2.7	4545	80%	3636
SLP-NB-F761c	02131105,Filter,No Concept	2.66	0.37	32.2	40%	12.9	5.4	60%	3.2	5466	80%	4373
SLP-NB-F762b	02131105,Filter,No Concept	3.80	0.37	43.5	40%	17.4	7.7	60%	4.6	7762	80%	6210
SLP-NB-F762c	02131105,Filter,No Concept	2.04	0.21	23.5	40%	9.4	4.1	60%	2.5	4172	80%	3337
SLP-NB-F717a	02131105,Filter,No Concept	0.76	0.13	9.5	40%	3.8	1.5	60%	0.9	1562	80%	1249
SLP-NB-F717b	02131105,Filter,No Concept	0.77	0.37	13.5	40%	5.4	1.7	60%	1.0	1667	80%	1334
SLP-NB-F716a	02131105,Filter,No Concept	0.67	0.59	15.9	40%	6.3	1.5	60%	0.9	1511	80%	1209
SLP-NB-F719a	02131105,Filter,No Concept	1.63	0.18	19.0	40%	7.6	3.3	60%	2.0	3329	80%	2663
SLP-NB-F748b	02131105,Filter,No Concept	0.12	0.01	1.3	40%	0.5	0.2	60%	0.1	241	80%	193
SMP-NB-F308A	02131105,Filter,No Concept	1.24	0.25	16.2	40%	6.5	2.5	60%	1.5	2572	80%	2057
SMP-NB-F323D	02131105,Filter,No Concept	2.42	0.01	24.2	40%	9.7	4.8	60%	2.9	4884	80%	3907
SMP-NB-F323B	02131105,Filter,No Concept	3.19	1.25	51.3	40%	20.5	6.7	60%	4.0	6786	80%	5429
SMP-NB-F323C	02131105,Filter,No Concept	1.19	0.11	13.5	40%	5.4	2.4	60%	1.4	2432	80%	1946
SMP-NB-F323A	02131105,Filter,No Concept	4.13	0.59	50.2	40%	20.1	8.4	60%	5.0	8485	80%	6788
SMP-NB-F314C	02131105,Filter,No Concept	0.56	0.03	6.1	40%	2.4	1.1	60%	0.7	1129	80%	904
SMP-NB-F314B	02131105,Filter,No Concept	0.30	0.35	8.5	40%	3.4	0.7	60%	0.4	704	80%	563
SMP-NB-F314A	02131105,Filter,No Concept	1.54	1.17	33.5	40%	13.4	3.4	60%	2.0	3433	80%	2747
SMP-NB-F314D	02131105,Filter,No Concept	1.28	0.73	24.1	40%	9.6	2.8	60%	1.7	2791	80%	2233
SMP-NB-F309A	02131105,Filter,No Concept	0.23	0.00	2.3	40%	0.9	0.5	60%	0.3	460	80%	368
SMP-NB-F313C	02131105,Filter,No Concept	1.08	0.42	17.3	40%	6.9	2.3	60%	1.4	2299	80%	1839
SMP-NB-F313D	02131105,Filter,No Concept	1.25	0.16	14.9	40%	6.0	2.5	60%	1.5	2568	80%	2055
SMP-NB-F313B	02131105,Filter,No Concept	0.57	0.10	7.2	40%	2.9	1.2	60%	0.7	1167	80%	934
SMP-NB-F313A	02131105,Filter,No Concept	0.15	0.21	4.7	40%	1.9	0.4	60%	0.2	354	80%	283

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SMP-NB-F312	02131105,Filter,No Concept	1.03	0.02	10.5	40%	4.2	2.0	60%	1.2	2073	80%	1659
SMP-NB-F311B	02131105,Filter,No Concept	1.42	0.39	20.2	40%	8.1	2.9	60%	1.8	2978	80%	2382
SMP-NB-F311A	02131105,Filter,No Concept	0.62	0.00	6.2	40%	2.5	1.2	60%	0.7	1258	80%	1006
SMP-NB-F324A	02131105,Filter,No Concept	0.22	0.08	3.4	40%	1.4	0.5	60%	0.3	458	80%	366
SMP-NB-F324D	02131105,Filter,No Concept	0.00	0.10	1.7	40%	0.7	0.0	60%	0.0	36	80%	28
NLP-NB-F507	02131105,Filter,No Concept	0.14	0.01	1.6	40%	0.6	0.3	60%	0.2	282	80%	226
NLP-NB-F502A	02131105,Filter,No Concept	0.31	0.06	4.0	40%	1.6	0.6	60%	0.4	633	80%	507
NLP-NB-F522C	02131105,Filter,No Concept	0.50	0.04	5.5	40%	2.2	1.0	60%	0.6	1009	80%	807
NLP-NB-F509	02131105,Filter,No Concept	0.22	0.02	2.4	40%	1.0	0.4	60%	0.3	444	80%	356
NLP-NB-F524	02131105,Filter,No Concept	0.13	0.11	3.0	40%	1.2	0.3	60%	0.2	296	80%	237
NLP-NB-D560	02131105,Filter,No Concept	1.26	0.24	16.4	40%	6.5	2.6	60%	1.6	2612	80%	2090
NLP-NB-F534	02131105,Filter,No Concept	0.58	0.01	5.9	40%	2.4	1.2	60%	0.7	1165	80%	932
DOR-NB-F939b	02131105,Filter,No Concept	0.17	0.03	2.0	40%	0.8	0.3	60%	0.2	342	80%	273
DOR-NB-F939c	02131105,Filter,No Concept	0.13	0.01	1.4	40%	0.6	0.3	60%	0.2	263	80%	211
DOR-NB-F939d	02131105,Filter,No Concept	0.21	0.01	2.3	40%	0.9	0.4	60%	0.3	429	80%	343
DOR-NB-F939e	02131105,Filter,No Concept	0.17	0.02	1.9	40%	0.8	0.3	60%	0.2	338	80%	270
DOR-NB-F939a	02131105,Filter,No Concept	0.17	0.01	1.9	40%	0.8	0.3	60%	0.2	346	80%	277
DOR-NB-F939f	02131105,Filter,No Concept	0.15	0.02	1.7	40%	0.7	0.3	60%	0.2	300	80%	240
DOR-NB-F915a	02131105,Filter,No Concept	1.09	0.04	11.5	40%	4.6	2.2	60%	1.3	2200	80%	1760
DOR-NB-F915b	02131105,Filter,No Concept	0.22	0.04	2.8	40%	1.1	0.4	60%	0.3	448	80%	358
DOR-NB-F913a	02131105,Filter,No Concept	0.18	0.06	2.8	40%	1.1	0.4	60%	0.2	388	80%	310
DOR-NB-F915d	02131105,Filter,No Concept	0.22	0.01	2.3	40%	0.9	0.4	60%	0.3	454	80%	363
DOR-NB-F915e	02131105,Filter,No Concept	1.29	0.02	13.2	40%	5.3	2.6	60%	1.5	2610	80%	2088
DOR-NB-F915g	02131105,Filter,No Concept	0.77	0.07	8.7	40%	3.5	1.5	60%	0.9	1562	80%	1250
DOR-NB-F915h	02131105,Filter,No Concept	0.73	0.07	8.3	40%	3.3	1.5	60%	0.9	1483	80%	1186
DOR-NB-F913b	02131105,Filter,No Concept	0.33	0.13	5.3	40%	2.1	0.7	60%	0.4	706	80%	565
DOR-NB-F914a	02131105,Filter,No Concept	2.51	0.08	26.2	40%	10.5	5.0	60%	3.0	5078	80%	4062
DOR-NB-F903d	02131105,Filter,No Concept	0.57	0.06	6.6	40%	2.7	1.2	60%	0.7	1164	80%	931

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DOR-NB-F903e	02131105,Filter,No Concept	0.51	0.06	6.0	40%	2.4	1.0	60%	0.6	1048	80%	838
DOR-NB-F903f	02131105,Filter,No Concept	0.10	0.05	1.7	40%	0.7	0.2	60%	0.1	206	80%	164
DOR-NB-F903g	02131105,Filter,No Concept	0.07	0.05	1.5	40%	0.6	0.2	60%	0.1	158	80%	126
DOR-NB-F903h	02131105,Filter,No Concept	0.55	0.05	6.2	40%	2.5	1.1	60%	0.7	1119	80%	895
DOR-NB-F903i	02131105,Filter,No Concept	0.74	0.10	8.9	40%	3.6	1.5	60%	0.9	1526	80%	1220
DOR-NB-F903k	02131105,Filter,No Concept	0.37	0.04	4.4	40%	1.7	0.8	60%	0.5	759	80%	607
DOR-NB-F942b	02131105,Filter,No Concept	0.09	0.02	1.2	40%	0.5	0.2	60%	0.1	186	80%	149
DOR-NB-F942c	02131105,Filter,No Concept	0.09	0.02	1.2	40%	0.5	0.2	60%	0.1	196	80%	157
DOR-NB-F942d	02131105,Filter,No Concept	0.18	0.01	2.0	40%	0.8	0.4	60%	0.2	368	80%	295
DOR-NB-F942e	02131105,Filter,No Concept	0.18	0.02	2.2	40%	0.9	0.4	60%	0.2	374	80%	299
DOR-NB-F942a	02131105,Filter,No Concept	0.19	0.08	3.1	40%	1.2	0.4	60%	0.2	402	80%	322
DOR-NB-F942g	02131105,Filter,No Concept	0.36	0.10	5.2	40%	2.1	0.8	60%	0.5	762	80%	610
DOR-NB-F941a	02131105,Filter,No Concept	0.22	0.01	2.4	40%	1.0	0.4	60%	0.3	445	80%	356
DOR-NB-F941d	02131105,Filter,No Concept	0.19	0.03	2.3	40%	0.9	0.4	60%	0.2	386	80%	309
DOR-NB-F941e	02131105,Filter,No Concept	0.22	0.04	2.8	40%	1.1	0.5	60%	0.3	457	80%	365
DOR-NB-F941f	02131105,Filter,No Concept	0.20	0.03	2.4	40%	1.0	0.4	60%	0.2	408	80%	326
DOR-NB-F925b	02131105,Filter,No Concept	0.71	0.03	7.5	40%	3.0	1.4	60%	0.9	1446	80%	1157
DOR-NB-F925c	02131105,Filter,No Concept	0.91	0.15	11.3	40%	4.5	1.8	60%	1.1	1865	80%	1492
DOR-NB-F925d	02131105,Filter,No Concept	0.44	0.04	4.9	40%	2.0	0.9	60%	0.5	889	80%	711
DOR-NB-F925e	02131105,Filter,No Concept	0.69	0.03	7.4	40%	3.0	1.4	60%	0.8	1407	80%	1126
DOR-NB-F925f	02131105,Filter,No Concept	1.36	0.18	16.3	40%	6.5	2.8	60%	1.7	2784	80%	2227
DOR-NB-F941i	02131105,Filter,No Concept	0.46	0.08	5.8	40%	2.3	0.9	60%	0.6	951	80%	761
DOR-NB-F903c	02131105,Filter,No Concept	0.54	0.08	6.7	40%	2.7	1.1	60%	0.7	1116	80%	893
DOR-NB-F903j	02131105,Filter,No Concept	0.48	0.11	6.5	40%	2.6	1.0	60%	0.6	1004	80%	804
DOR-NB-F903l	02131105,Filter,No Concept	0.57	0.09	7.0	40%	2.8	1.2	60%	0.7	1169	80%	935
DOR-NB-F903m	02131105,Filter,No Concept	0.67	0.12	8.4	40%	3.4	1.4	60%	0.8	1374	80%	1099
DOR-NB-F903n	02131105,Filter,No Concept	0.12	0.05	2.0	40%	0.8	0.3	60%	0.2	253	80%	203
DOR-NB-F903o	02131105,Filter,No Concept	0.04	0.02	0.7	40%	0.3	0.1	60%	0.1	87	80%	70

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DOR-NB-F942f	02131105,Filter,No Concept	0.13	0.04	1.8	40%	0.7	0.3	60%	0.2	267	80%	213
DOR-NB-F941b	02131105,Filter,No Concept	0.24	0.02	2.7	40%	1.1	0.5	60%	0.3	481	80%	385
DOR-NB-F941c	02131105,Filter,No Concept	0.20	0.02	2.3	40%	0.9	0.4	60%	0.2	407	80%	325
DOR-NB-F941g	02131105,Filter,No Concept	0.13	0.07	2.3	40%	0.9	0.3	60%	0.2	273	80%	219
DOR-NB-F941j	02131105,Filter,No Concept	0.43	0.08	5.5	40%	2.2	0.9	60%	0.5	897	80%	718
DOR-NB-F943b	02131105,Filter,No Concept	0.29	0.10	4.4	40%	1.8	0.6	60%	0.4	613	80%	490
DOR-NB-F943d	02131105,Filter,No Concept	0.32	0.00	3.1	40%	1.3	0.6	60%	0.4	637	80%	510
DOR-NB-F943f	02131105,Filter,No Concept	0.26	0.00	2.6	40%	1.0	0.5	60%	0.3	522	80%	417
DOR-NB-F943g	02131105,Filter,No Concept	0.33	0.00	3.3	40%	1.3	0.7	60%	0.4	673	80%	538
DOR-NB-F943h	02131105,Filter,No Concept	0.29	0.00	2.9	40%	1.1	0.6	60%	0.3	579	80%	464
DOR-NB-F943j	02131105,Filter,No Concept	0.38	0.03	4.3	40%	1.7	0.8	60%	0.5	779	80%	623
DOR-NB-F943k	02131105,Filter,No Concept	0.53	0.04	5.8	40%	2.3	1.1	60%	0.6	1073	80%	858
DOR-NB-F943m	02131105,Filter,No Concept	0.62	0.20	9.2	40%	3.7	1.3	60%	0.8	1301	80%	1041
DOR-NB-F943n	02131105,Filter,No Concept	0.83	0.24	12.0	40%	4.8	1.7	60%	1.0	1744	80%	1395
DOR-NB-F943q	02131105,Filter,No Concept	1.19	0.01	12.0	40%	4.8	2.4	60%	1.4	2402	80%	1921
DOR-NB-F943aa	02131105,Filter,No Concept	1.05	0.02	10.7	40%	4.3	2.1	60%	1.3	2115	80%	1692
DOR-NB-F943bb	02131105,Filter,No Concept	0.71	0.01	7.2	40%	2.9	1.4	60%	0.8	1428	80%	1143
dor-nb-f932a	02131105,Filter,No Concept	0.80	0.15	10.3	40%	4.1	1.6	60%	1.0	1648	80%	1318
dor-nb-f932b	02131105,Filter,No Concept	1.07	0.08	11.9	40%	4.8	2.2	60%	1.3	2182	80%	1746
dor-nb-f932c	02131105,Filter,No Concept	0.17	0.06	2.6	40%	1.0	0.4	60%	0.2	355	80%	284
dor-nb-f932e	02131105,Filter,No Concept	0.46	0.10	6.1	40%	2.5	0.9	60%	0.6	953	80%	762
dor-nb-f932f	02131105,Filter,No Concept	0.25	0.01	2.6	40%	1.0	0.5	60%	0.3	497	80%	397
dor-nb-f932g	02131105,Filter,No Concept	0.06	0.01	0.8	40%	0.3	0.1	60%	0.1	132	80%	106
DOR-NB-F927a	02131105,Filter,No Concept	0.24	0.06	3.3	40%	1.3	0.5	60%	0.3	494	80%	395
DOR-NB-F931a	02131105,Filter,No Concept	0.61	0.07	7.2	40%	2.9	1.2	60%	0.7	1250	80%	1000
DOR-NB-F931b	02131105,Filter,No Concept	1.31	0.08	14.3	40%	5.7	2.6	60%	1.6	2667	80%	2133
DOR-NB-F931c	02131105,Filter,No Concept	1.25	0.07	13.5	40%	5.4	2.5	60%	1.5	2529	80%	2023
DOR-NB-F931d	02131105,Filter,No Concept	0.88	0.04	9.4	40%	3.7	1.8	60%	1.1	1777	80%	1422

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				Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)	Load from DA (lbs/yr)	RE	Max Potential Load Reduction (lbs/yr)
DOR-NB-F931e	02131105,Filter,No Concept	0.72	0.03	7.6	40%	3.1	1.4	60%	0.9	1450	80%	1160
DOR-NB-F931f	02131105,Filter,No Concept	1.12	0.07	12.3	40%	4.9	2.3	60%	1.4	2281	80%	1824
DOR-NB-F931g	02131105,Filter,No Concept	0.67	0.06	7.6	40%	3.0	1.4	60%	0.8	1366	80%	1093
DOR-NB-F931h	02131105,Filter,No Concept	1.37	0.08	14.8	40%	5.9	2.7	60%	1.6	2777	80%	2221
DOR-NB-F931i	02131105,Filter,No Concept	1.37	0.13	15.6	40%	6.2	2.8	60%	1.7	2786	80%	2229
DOR-NB-F931j	02131105,Filter,No Concept	0.54	0.22	8.8	40%	3.5	1.1	60%	0.7	1143	80%	914
DOR-NB-F931l	02131105,Filter,No Concept	0.20	0.03	2.4	40%	1.0	0.4	60%	0.2	409	80%	327
DOR-NB-F931m	02131105,Filter,No Concept	0.11	0.01	1.2	40%	0.5	0.2	60%	0.1	215	80%	172
DOR-NB-F929b	02131105,Filter,No Concept	0.27	0.01	2.7	40%	1.1	0.5	60%	0.3	539	80%	431
DOR-NB-F925a	02131105,Filter,No Concept	0.73	0.07	8.3	40%	3.3	1.5	60%	0.9	1486	80%	1189
DOR-NB-F925i	02131105,Filter,No Concept	0.33	0.07	4.4	40%	1.8	0.7	60%	0.4	683	80%	546
DOR-NB-F925j	02131105,Filter,No Concept	0.70	0.08	8.3	40%	3.3	1.4	60%	0.9	1440	80%	1152
DOR-NB-F925k	02131105,Filter,No Concept	1.45	0.08	15.7	40%	6.3	2.9	60%	1.7	2949	80%	2359
DOR-NB-F926a	02131105,Filter,No Concept	1.03	0.14	12.4	40%	5.0	2.1	60%	1.3	2120	80%	1696
DOR-NB-F926b	02131105,Filter,No Concept	1.20	0.07	13.0	40%	5.2	2.4	60%	1.4	2434	80%	1948
DOR-NB-F926c	02131105,Filter,No Concept	1.21	0.07	13.1	40%	5.3	2.4	60%	1.5	2449	80%	1959
DOR-NB-F926d	02131105,Filter,No Concept	0.58	0.03	6.1	40%	2.5	1.2	60%	0.7	1172	80%	938
DOR-NB-F924b	02131105,Filter,No Concept	0.18	0.04	2.4	40%	1.0	0.4	60%	0.2	371	80%	297
DOR-NB-F930a	02131105,Filter,No Concept	0.59	0.06	6.8	40%	2.7	1.2	60%	0.7	1202	80%	961
DOR-NB-F930b	02131105,Filter,No Concept	0.28	0.09	4.2	40%	1.7	0.6	60%	0.4	592	80%	474
DOR-NB-F930c	02131105,Filter,No Concept	0.44	0.15	6.7	40%	2.7	0.9	60%	0.6	931	80%	745
DOR-NB-F930d	02131105,Filter,No Concept	0.64	0.41	12.9	40%	5.1	1.4	60%	0.8	1414	80%	1131
DOR-NB-F930e	02131105,Filter,No Concept	0.03	0.01	0.4	40%	0.2	0.1	60%	0.0	53	80%	42
DOR-NB-F901a	02131105,Filter,No Concept	1.07	0.12	12.5	40%	5.0	2.2	60%	1.3	2180	80%	1744
DOR-NB-F901b	02131105,Filter,No Concept	0.88	0.11	10.5	40%	4.2	1.8	60%	1.1	1796	80%	1437
DOR-NB-F901c	02131105,Filter,No Concept	0.84	0.09	9.7	40%	3.9	1.7	60%	1.0	1712	80%	1369
DOR-NB-F901d	02131105,Filter,No Concept	0.82	0.08	9.4	40%	3.8	1.7	60%	1.0	1676	80%	1341
DOR-NB-F901e	02131105,Filter,No Concept	0.07	0.01	0.9	40%	0.3	0.1	60%	0.1	138	80%	110

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DOR-NB-F901f	02131105,Filter,No Concept	0.44	0.13	6.5	40%	2.6	0.9	60%	0.6	926	80%	741
DOR-NB-F901g	02131105,Filter,No Concept	0.59	0.10	7.4	40%	3.0	1.2	60%	0.7	1213	80%	971
DOR-NB-F901h	02131105,Filter,No Concept	0.51	0.07	6.2	40%	2.5	1.0	60%	0.6	1046	80%	837
DOR-NB-F901i	02131105,Filter,No Concept	0.11	0.05	1.9	40%	0.8	0.2	60%	0.1	243	80%	195
DOR-NB-F901j	02131105,Filter,No Concept	0.64	0.11	8.1	40%	3.2	1.3	60%	0.8	1326	80%	1060
DOR-NB-F901k	02131105,Filter,No Concept	0.52	0.08	6.5	40%	2.6	1.1	60%	0.6	1078	80%	862
DOR-NB-F901l	02131105,Filter,No Concept	0.82	0.08	9.5	40%	3.8	1.7	60%	1.0	1679	80%	1343
DOR-NB-F901m	02131105,Filter,No Concept	0.40	0.02	4.3	40%	1.7	0.8	60%	0.5	816	80%	653
DOR-NB-F904a	02131105,Filter,No Concept	0.28	0.64	12.8	40%	5.1	0.7	60%	0.4	746	80%	597
DOR-NB-F904b	02131105,Filter,No Concept	0.07	1.09	17.7	40%	7.1	0.5	60%	0.3	459	80%	367
DOR-NB-F910b	02131105,Filter,No Concept	2.31	0.10	24.4	40%	9.8	4.6	60%	2.8	4673	80%	3739
DOR-NB-F910c	02131105,Filter,No Concept	0.71	0.73	18.4	40%	7.4	1.6	60%	1.0	1639	80%	1311
DOR-NB-F917b	02131105,Filter,No Concept	0.56	0.23	9.2	40%	3.7	1.2	60%	0.7	1197	80%	957
dor-nb-f932d	02131105,Filter,No Concept	0.28	0.01	2.9	40%	1.2	0.6	60%	0.3	573	80%	458
SLP-NB-F768b	02131105,Infiltration,No Concept	1.69	0.13	18.8	80%	15.1	3.4	85%	2.9	3439	95%	3268
SLP-NB-F772a	02131105,Infiltration,No Concept	1.53	0.65	25.3	80%	20.3	3.2	85%	2.7	3263	95%	3100
SLP-NB-F756a	02131105,Infiltration,No Concept	1.15	0.27	15.6	80%	12.5	2.4	85%	2.0	2394	95%	2274
NLP-NB-F513	02131105,Infiltration,No Concept	0.97	1.35	30.7	80%	24.6	2.3	85%	2.0	2334	95%	2218
NLP-NB-F544	02131105,Infiltration,No Concept	0.11	0.04	1.7	80%	1.4	0.2	85%	0.2	225	95%	214
dor-nb-f933a	02131105,Infiltration,No Concept	0.00	0.06	1.0	80%	0.8	0.0	85%	0.0	18	95%	17
dor-nb-f933b	02131105,Infiltration,No Concept	0.12	0.10	2.7	80%	2.1	0.3	85%	0.2	266	95%	253
DOR-NB-F920b	02131105,Infiltration,No Concept	2.02	0.16	22.6	80%	18.1	4.1	85%	3.5	4120	95%	3914
DOR-NB-F917a	02131105,Infiltration,No Concept	0.72	0.80	19.7	80%	15.8	1.7	85%	1.4	1680	95%	1596
SLP-NB-F776b	02131105,PermPavNoSVNoUD,No Concept	0.41	0.25	7.9	75%	5.9	0.9	80%	0.7	902	85%	766
SLP-NB-F748a	02131105,PermPavNoSVNoUD,No Concept	0.90	0.07	10.0	75%	7.5	1.8	80%	1.4	1824	85%	1551
SLP-NB-F752b	02131105,PermPavNoSVNoUD,No Concept	0.35	0.05	4.3	75%	3.2	0.7	80%	0.6	711	85%	605
SLP-NB-F742b	02131105,PermPavNoSVNoUD,No Concept	0.13	0.03	1.7	75%	1.3	0.3	80%	0.2	271	85%	230
SLP-NB-F743b	02131105,PermPavNoSVNoUD,No Concept	0.24	0.03	2.8	75%	2.1	0.5	80%	0.4	485	85%	413

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SLP-NB-F769a	02131105,PermPavNoSVNoUD,No Concept	0.24	0.01	2.5	75%	1.9	0.5	80%	0.4	484	85%	412
SLP-NB-F757c	02131105,PermPavNoSVNoUD,No Concept	0.48	0.07	5.8	75%	4.4	1.0	80%	0.8	985	85%	837
SLP-NB-F737b	02131105,PermPavNoSVNoUD,No Concept	0.49	0.12	6.8	75%	5.1	1.0	80%	0.8	1025	85%	871
SLP-NB-F741c	02131105,PermPavNoSVNoUD,No Concept	0.30	0.00	3.1	75%	2.3	0.6	80%	0.5	605	85%	514
SLP-NB-F727a	02131105,PermPavNoSVNoUD,No Concept	1.66	0.39	22.6	75%	17.0	3.4	80%	2.7	3459	85%	2940
SLP-NB-F730a	02131105,PermPavNoSVNoUD,No Concept	2.04	0.44	27.1	75%	20.4	4.2	80%	3.4	4234	85%	3599
SLP-NB-F706a	02131105,PermPavNoSVNoUD,No Concept	1.89	0.10	20.4	75%	15.3	3.8	80%	3.0	3831	85%	3256
SLP-NB-F701b	02131105,PermPavNoSVNoUD,No Concept	0.31	0.03	3.5	75%	2.6	0.6	80%	0.5	624	85%	531
SLP-NB-F739a	02131105,PermPavNoSVNoUD,No Concept	3.56	0.02	35.6	75%	26.7	7.1	80%	5.7	7173	85%	6097
SLP-NB-F715c	02131105,PermPavNoSVNoUD,No Concept	0.57	0.07	6.8	75%	5.1	1.2	80%	0.9	1176	85%	999
SLP-NB-F726b	02131105,PermPavNoSVNoUD,No Concept	0.30	0.02	3.3	75%	2.4	0.6	80%	0.5	602	85%	511
SLP-NB-F724c	02131105,PermPavNoSVNoUD,No Concept	0.33	0.04	3.9	75%	2.9	0.7	80%	0.5	684	85%	581
SLP-NB-F722a	02131105,PermPavNoSVNoUD,No Concept	1.23	0.10	13.8	75%	10.3	2.5	80%	2.0	2507	85%	2131
SLP-NB-F760a	02131105,PermPavNoSVNoUD,No Concept	0.49	0.03	5.3	75%	4.0	1.0	80%	0.8	993	85%	844
SLP-NB-F762d	02131105,PermPavNoSVNoUD,No Concept	1.18	0.10	13.2	75%	9.9	2.4	80%	1.9	2400	85%	2040
SLP-NB-F712d	02131105,PermPavNoSVNoUD,No Concept	1.29	0.06	13.7	75%	10.3	2.6	80%	2.1	2612	85%	2220
SLP-NB-F744c	02131105,PermPavNoSVNoUD,No Concept	1.24	0.26	16.4	75%	12.3	2.5	80%	2.0	2575	85%	2189
NLP-NB-F547A	02131105,PermPavNoSVNoUD,No Concept	0.39	0.09	5.3	75%	4.0	0.8	80%	0.6	814	85%	692
NLP-NB-F547B	02131105,PermPavNoSVNoUD,No Concept	1.01	0.11	11.7	75%	8.8	2.0	80%	1.6	2066	85%	1756
NLP-NB-D558	02131105,WetPondWetland ,No Concept	1.56	6.03	109.6	20%	21.9	4.9	45%	2.2	4862	60%	2917
DOR-NB-F938a	02131105,WetPondWetland ,No Concept	4.25	0.12	44.0	20%	8.8	8.5	45%	3.8	8599	60%	5159
DOR-NB-F911a	02131105,WetPondWetland ,No Concept	1.81	1.02	34.0	20%	6.8	3.9	45%	1.8	3934	60%	2361
DOR-NB-F911b	02131105,WetPondWetland ,No Concept	2.25	0.88	36.1	20%	7.2	4.7	45%	2.1	4787	60%	2872
DOR-NB-F928a	02131105,WetPondWetland ,No Concept	1.96	0.60	28.7	20%	5.7	4.1	45%	1.8	4108	60%	2465
DOR-NB-F925h	02131105,WetPondWetland ,No Concept	0.13	0.02	1.7	20%	0.3	0.3	45%	0.1	275	60%	165

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DOR-NB-F924a	02131105,WetPondWetland ,No Concept	0.74	0.06	8.3	20%	1.7	1.5	45%	0.7	1509	60%	905
DOR-NB-F920c	02131105,WetPondWetland ,No Concept	12	0	119.6	20%	23.9	24.0	45%	10.8	24226	60%	14536
	Total	316.2	91.6	4568.6		1865.2	656.1		385.1	662882		488342

Appendix L

Grass Swale Process Addendum

GRASS SWALE PROCESS ADDENDUM

MARYLAND DEPARTMENT OF TRANSPORTATION™

STATE HIGHWAY ADMINISTRATION

October 2017

Table of Contents

Introduction 2
Enhancement #1: Site Specific Hydraulic Analysis of Grass Channels 2
Enhancement #2: Shortening the Swale 2
Case Study – Site Specific Hydraulic Analysis of Grass Channels 3
Example 1 3
Example 2 3
Case Study – Shortening the Swale 4
Example 3 4

Attachments

Attachment A – Case Study Example 1 Calculations
Attachment B – Case Study Example 2 Calculations
Attachment C – Case Study Example 3 Calculations

Grass Swale Process Addendum

Introduction

MDOT SHA made two key enhancements to the *Existing Water Quality Grass Swale Identification Protocol* (dated April 13, 2016 and approved by MDE on July 12, 2016) by further analyzing existing grass channels that were field measured but failed the Grass Channel Analysis (Step 3 in the *Protocol*). These channels were designated "XX" swales and were not approved 2A grass swales. The enhancements build from the extensive field-collected channel cross-section geometry gathered during the field verification process from the original *Protocol* and applies a more refined hydraulic analysis to the data. This additional analysis was used to determine if there are XX swales that meet MDE's grass swale design criteria and can be categorized as a viable 2A grass swale with associated baseline credit.

Enhancement #1: Site Specific Hydraulic Analysis of Grass Channels

Step 3 of the *Protocol* outlines the Grass Channel Analysis procedure to determine if an existing grass channel qualifies as a water quality grass swale per MDE's *Stormwater Design Manual* Chapter 5 criteria. One of the foundations of Step 3 is the use of Grass Swale Charts, which use the inputs of (1) swale longitudinal slope [0.1%, 1%, 2%, 3%, and 4%], (2) swale flat bottom width [2' to 8'], and (3) percent impervious to estimate a maximum drainage area in acres, above which the resultant water quality flow depth would exceed 4". One of the assumptions of these charts, however, is that the existing channel side slopes are 3H:1V. Based on results of the field verification process, very few of the existing grass channels had side slopes as steep as 3H:1V, and most times were much flatter. Therefore, the Grass Swale Charts underestimate the maximum drainage area for most existing grass channels.

Rather than use charts to determine whether the flow depth will exceed 4", the actual flow depth was calculated using Manning's equation and the existing grass channel cross-section geometry collected during the field verification process. This results in a true calculation of flow depth and velocity for each channel based on actual drainage area and no longer underestimates the maximum drainage area by using a blanket 3H:1V side slope assumption. This enhancement results in a greater number of grass channels meeting MDE's grass swale design criteria that are viable 2A swales.

To be consistent with methodology, the calculations refined under Enhancement #1 were applied to all previously approved 2A swales, and an Existing Water Quality Grass Swale calculation sheet was produced for each 2A swale, confirming each swale meets MDE's criteria.

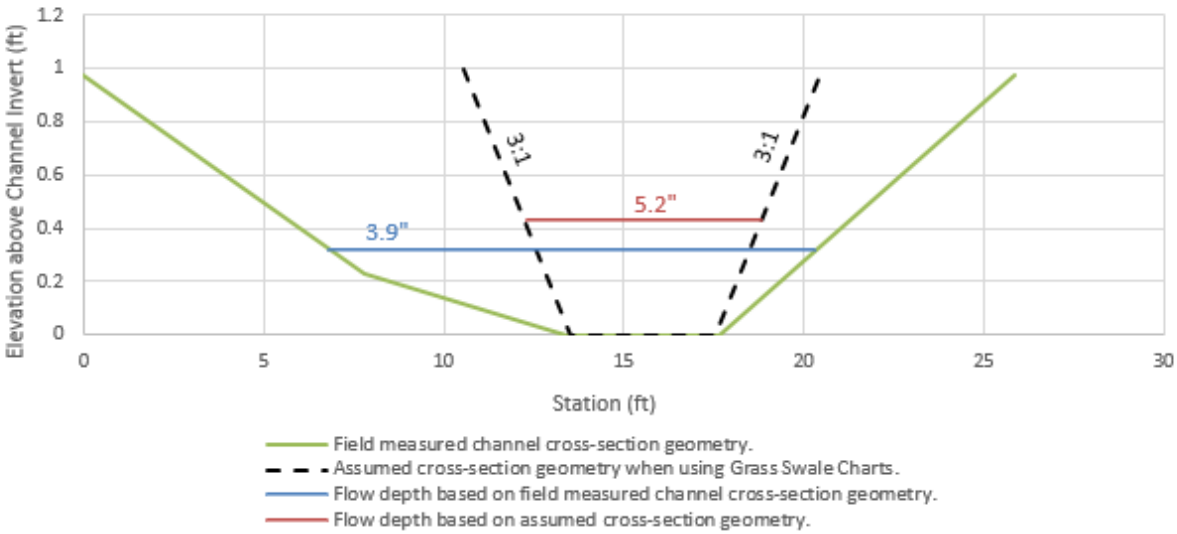
Enhancement #2: Shortening the Swale

For those XX swales that have flow depths that still exceed 4" after applying Enhancement #1, the swale was further evaluated to determine if shortening the swale, thus reducing the drainage area and flows to the swale, will result in a viable 2A swale. For example, an XX swale that is 800' long may pass all criteria except the flow depth, but shortening the swale (moving the Point of Investigation upstream) to 500' would result in a reduction in contributing drainage area and flow, reduce the flow depth to less than 4", and produce a viable 2A swale.

Case Study – Site Specific Hydraulic Analysis of Grass Channels

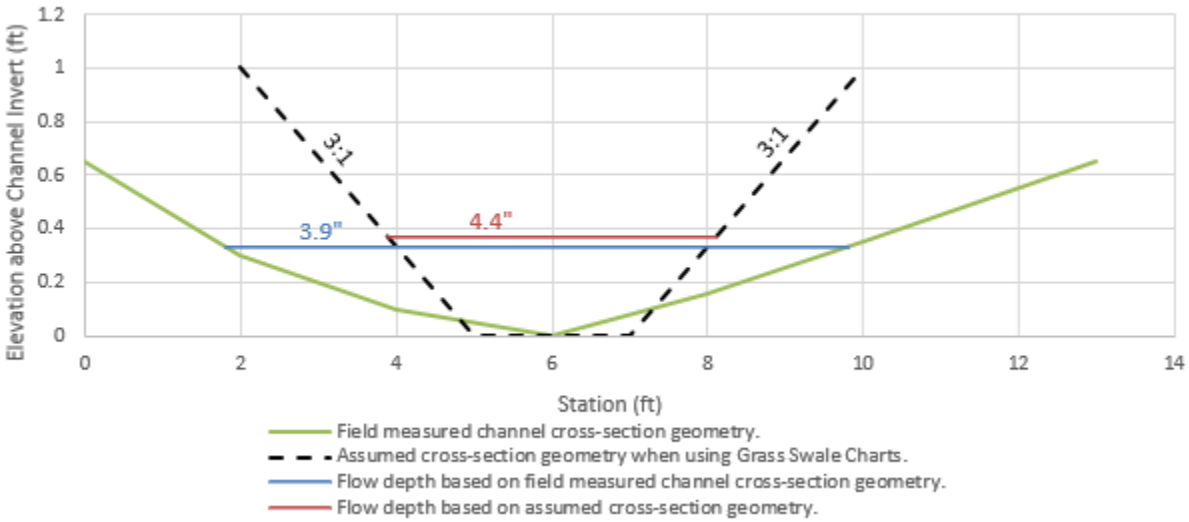
Example 1

Swale Category_XX_631_Ind24_10 in Frederick County was de-categorized due to the existing drainage area (1.98 acres) exceeded the maximum allowed drainage area (1.24 acres) per the Protocol's Final Analysis Spreadsheet. The field measurements indicated that this swale has a flat bottom with a width of 4.3'. The XX swale was re-analyzed using Manning's equation to determine that the water quality flow depth was 3.9", with a velocity of 0.5 fps. All other criteria are satisfied. The chart below illustrates the assumptions when using the Grass Swale Charts (resulting in a flow depth of 5.2") versus the true flow depth based on the field measured channel cross-section geometry. This is a viable 2A swale, and should be re-categorized as such, resulting in an impervious area credit of 1.00 acres.



Example 2

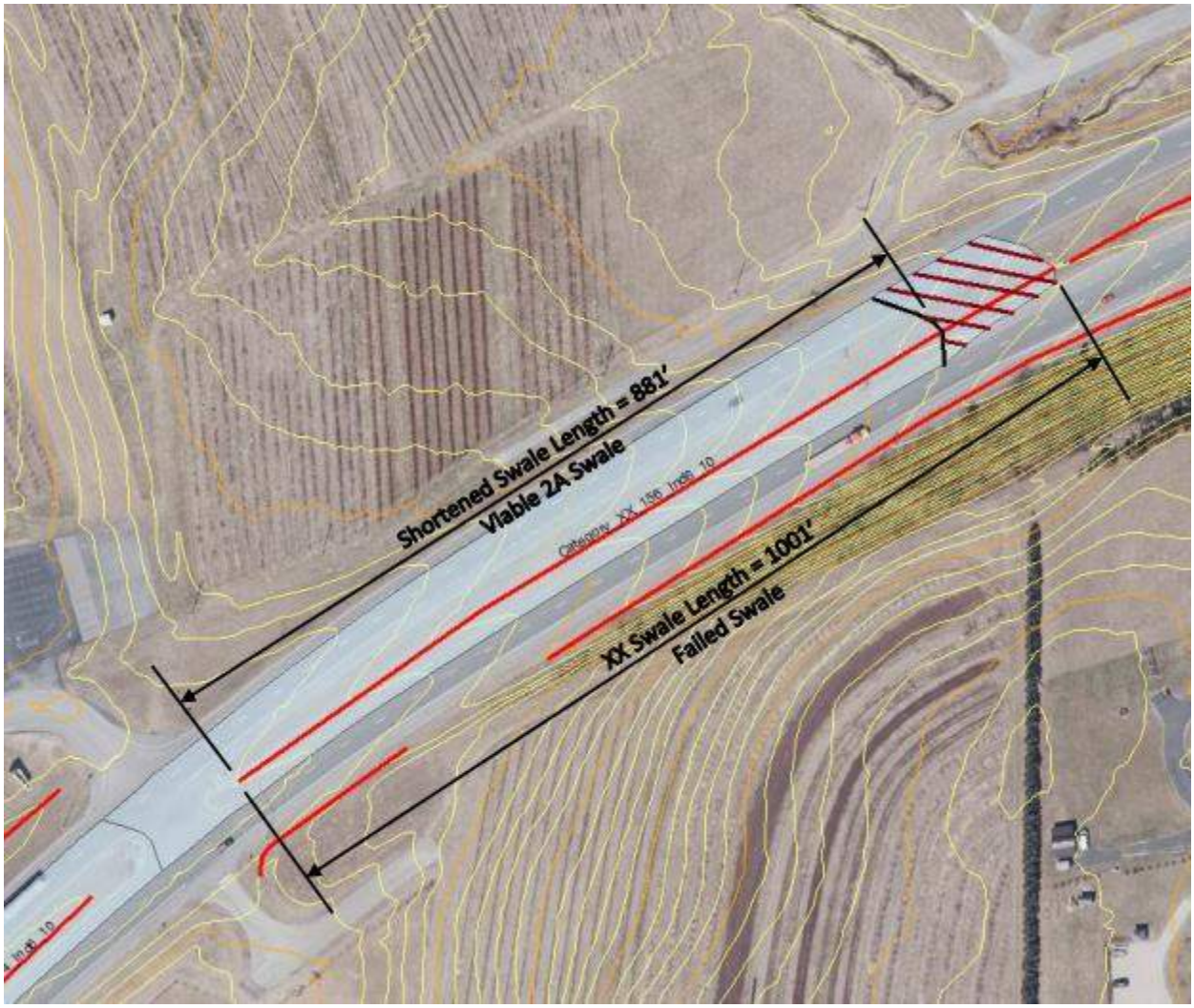
Swale Category_XX_IndC7_103_02 in Anne Arundel County was de-categorized due to the existing drainage area (1.58 acres) exceeded the maximum allowed drainage area (0.91 acres) per the Protocol's Final Analysis Spreadsheet. The bottom width of the swale was estimated to be 2' in the field, but field measurements indicate that this swale has a parabolic shape. The XX swale was re-analyzed using Manning's equation to determine that the water quality flow depth was 3.9", with a velocity of 0.6 fps. All other criteria are satisfied. The chart below illustrates the assumptions when using the Grass Swale Charts (resulting in a flow depth of 4.4") versus the true flow depth based on the field measured channel cross-section geometry. This is a viable 2A swale, and should be re-categorized as such, resulting in an impervious area credit of 0.58 acres.



Case Study – Shortening the Swale

Example 3

Swale Category_XX_156_Ind6_10 in Frederick County was de-categorized due to the existing drainage area (1.89 acres) exceeded the maximum allowed drainage area (1.20 acres) per the Protocol's Final Analysis Spreadsheet. The XX swale was re-analyzed using Manning's equation to determine that the water quality flow depth was 4.2", which exceeds the maximum allowable flow depth of 4". The downstream end of the swale was moved upstream, thus shortening the swale approximately 120 ft. The drainage area was reduced from 1.89 acres to 1.67 acres, and the XX swale was re-analyzed using the reduced drainage area, resulting in a water quality flow depth of 4.0". The shortened swale is a viable 2A swale, and should be re-categorized as such, resulting in an impervious area credit of 0.89 acres. The image below illustrates the above example of shortening the swale to meet MDE's water quality grass swale design criteria.



Attached to this process addendum are computation sheets for these three examples. These computation sheets provide the detailed analysis that will accompany each re-categorized 2A swale.

Attachment A

Case Study Example 1 Calculations

MARYLAND DEPARTMENT OF TRANSPORTATION™

STATE HIGHWAY ADMINISTRATION

Existing Water Quality Grass Swale

M-8 Grassed Channel - Equivalent Flat Bottom

Swale ID: Category_XX_631_Ind24_10

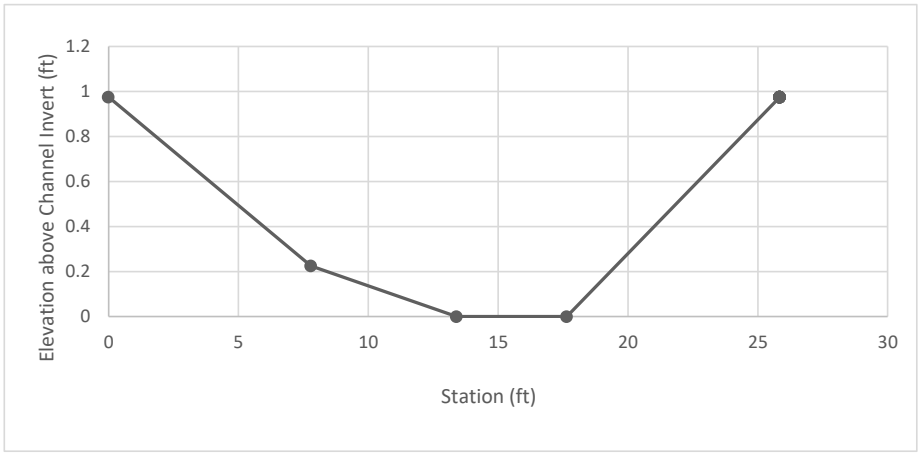
BMP ID:

Version 2017-03-30

Grass Channel Characteristics:

County	Frederick		
Drainage Area (A), ac	1.98		
Impervious Area (IA), ac	1.00		
Time of Concentration (T_c), hr	0.1	(Min. 0.1; Max. 10.0)	
Impervious Cover I, % =	50.5%	= (IA/A) x 100	= (1/1.98) x 100
R_v =	0.505	= 0.05 + 0.009 x I	= 0.05 + 0.009 x 0.51
Design Swale Length (L), ft	1106		
Swale Slope, %	2.0%		**Channel Slope ≤ 4%, OK**
Design P_E, in	1.00		

Channel Geometry (field measured): 7/6/2016



Station (ft)	Elevation (ft)
0.00	0.97
7.80	0.22
13.40	0.00
17.65	0.00
25.85	0.97

Design Flow

Runoff Depth Q_a, in	0.505	=P_E x R_v	= 1 x 0.505
ESD_V, ac-ft	0.083	=P_E/12 x R x A	= 1/12 x 0.505 x 1.98
ESD_V, cf	3,624	=P_E/12 x R x A x 43560	= 1/12 x 0.505 x 1.98 x 43560
Adjusted Curve Number (CN)	94	$CN = \frac{1000}{[10+5P_E+10Q_a-10(Qa^2+1.25Q_aP_E)^{\frac{1}{2}}]}$	$S = \left(\frac{1000}{CN}\right) - 10$ S= 0.638
Initial Abstraction, I_a	0.128	I_a = 0.2 x S	
I_a/P_E	0.128	Used for interpolating coefficients in Table F-1, TR-55	
Unit Peak Discharge (q_u), csm/in	999	$\log(q_u) = C_0 + C1 \times \log(T_c) + C_2 \times \{\log(T_c)\}^2$	
		=2.54107 + -0.61615x log(0.1) + -0.15747 x {log(0.1)}^2	
C_0	2.54107	interpolated from table F-1, TR-55.	
C_1	-0.61615	interpolated from table F-1, TR-55.	
C_2	-0.15747	interpolated from table F-1, TR-55.	
Design Peak Flow (Q_p), cfs	**1.56**	$Q_p = q_u \times A \times Q_a$	= 999 x 1.98 x 0.505

Grass Channel Analysis:

Manning's N value	0.15		
Flow Depth (d), in	3.86	by solving Manning's Equation	**Depth<4 in, OK**
Cross Sectional Flow Area (Ax), sf	3.03	by solving Manning's Equation	
Wetted Perimeter (P_W), ft	13.59	by solving Manning's Equation	
Flow Velocity (V), fps	0.51	$V = Q_p/Ax$	**Velocity<1 fps, OK**

Existing Flat Bottom Channel

Bottom Width (EW), ft	4.3	Measured in field		**Width ≥ 2 ft, OK**
Bottom Surface Area (SA), sf	4701	S_A = EW x L	S_A / A = 5.5%	**Ratio ≥ 2%, OK**
Treated (P_E), in	**1.00**			***All Checks: OK***

Attachment B

Case Study Example 2 Calculations

MARYLAND DEPARTMENT OF TRANSPORTATION™

STATE HIGHWAY ADMINISTRATION

Existing Water Quality Grass Swale

M-8 Grassed Channel - Equivalent Flat Bottom

Swale ID: Category_XX_IndC7_103_02

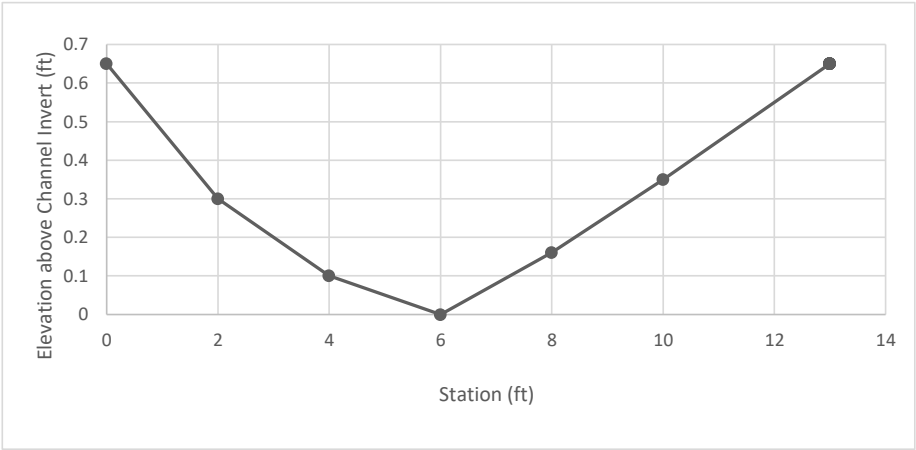
BMP ID:

Version 2017-03-30

Grass Channel Characteristics:

County	Anne Arundel		
Drainage Area (A), ac	1.58		
Impervious Area (IA), ac	0.58		
Time of Concentration (T_c), hr	0.1	(Min. 0.1; Max. 10.0)	
Impervious Cover I, % =	37.1%	= (IA/A) x 100	= (0.58/1.58) x 100
R_v =	0.384	= 0.05 + 0.009 x I	= 0.05 + 0.009 x 0.37
Design Swale Length (L), ft	751		
Swale Slope, %	4.0%		**Channel Slope ≤ 4%, OK**
Design P_E, in	1.00		

Channel Geometry (field measured): 11/30/2015



Station (ft)	Elevation (ft)
0.00	0.65
2.00	0.30
4.00	0.10
6.00	0.00
8.00	0.16
10.00	0.35
13.00	0.65

Design Flow

Runoff Depth Q_a, in	0.384	=P_E x R_v	= 1 x 0.384
ESD_V, ac-ft	0.050	=P_E/12 x R x A	= 1/12 x 0.384 x 1.58
ESD_V, cf	2,196	=P_E/12 x R x A x 43560	= 1/12 x 0.384 x 1.58 x 43560
Adjusted Curve Number (CN)	92	$CN = \frac{1000}{[10+5P_E+10Q_a-10(Qa^2+1.25Q_aP_E)^{\frac{1}{2}}]}$	$S = \left(\frac{1000}{CN}\right) - 10$ S= 0.870
Initial Abstraction, I_a	0.174	I_a = 0.2 x S	
I_a/P_E	0.174	Used for interpolating coefficients in Table F-1, TR-55	
Unit Peak Discharge (q_u), csm/in	982	$\log(q_u) = C_0 + C1 \times \log(T_c) + C_2 \times \{\log(T_c)\}^2$	
		=2.52074 + -0.61787x log(0.1) + -0.14649 x {log(0.1)}^2	
C_0	2.52074	interpolated from table F-1, TR-55.	
C_1	-0.61787	interpolated from table F-1, TR-55.	
C_2	-0.14649	interpolated from table F-1, TR-55.	
Design Peak Flow (Q_p), cfs	**0.93**	$Q_p = q_u \times A \times Q_a$	= 982 x 1.58 x 0.384

Grass Channel Analysis:

Manning's N value	0.15		
Flow Depth (d), in	3.93	by solving Manning's Equation	**Depth<4 in, OK**
Cross Sectional Flow Area (Ax), sf	1.45	by solving Manning's Equation	
Wetted Perimeter (P_W), ft	7.95	by solving Manning's Equation	
Flow Velocity (V), fps	0.64	V = Q_p/Ax	**Velocity<1 fps, OK**

Equivalent Flat Bottom Channel (assuming 3:1 side slopes and flow = Qp)

Equivalent Bottom Width (EW), ft	6.0	by solving Manning's Equation		**Width ≥ 2 ft, OK**
Equivalent Wetted Perimeter (PW), ft	7.34	by solving Manning's Equation		
Equivalent Bottom Surface Area (SA), sf	4504	S_A = EW x L	S_A / A = 6.6%	**Ratio ≥ 2%, OK**
Treated (P_E), in	**1.00**			***All Checks: OK***

Attachment C

Case Study Example 3 Calculations

MARYLAND DEPARTMENT OF TRANSPORTATION™

STATE HIGHWAY ADMINISTRATION

Existing Water Quality Grass Swale

M-8 Grassed Channel - Equivalent Flat Bottom

Swale ID: Category_XX_156_Ind6_10

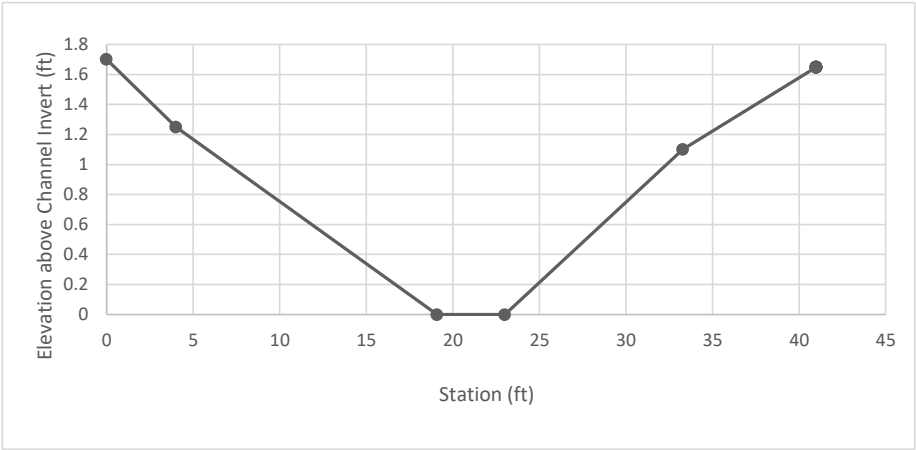
BMP ID:

Version 2017-03-30

Grass Channel Characteristics:

County	Frederick		
Drainage Area (A), ac	1.67		
Impervious Area (IA), ac	0.89		
Time of Concentration (T_c), hr	0.1	(Min. 0.1; Max. 10.0)	
Impervious Cover I, % =	53.5%	= (IA/A) x 100	= (0.89/1.67) x 100
R_v =	0.532	= 0.05 + 0.009 x I	= 0.05 + 0.009 x 0.54
Design Swale Length (L), ft	881		
Swale Slope, %	2.3%		**Channel Slope ≤ 4%, OK**
Design P_E, in	1.00		

Channel Geometry (field measured): 6/29/2016



Station (ft)	Elevation (ft)
0.00	1.70
4.00	1.25
19.10	0.00
23.00	0.00
33.30	1.10
41.00	1.65

Design Flow

Runoff Depth Q_a, in	0.532	=P_E x R_v	= 1 x 0.532
ESD_V, ac-ft	0.074	=P_E/12 x R x A	= 1/12 x 0.532 x 1.67
ESD_V, cf	3,224	=P_E/12 x R x A x 43560	= 1/12 x 0.532 x 1.67 x 43560
Adjusted Curve Number (CN)	94	$CN = \frac{1000}{[10+5P_E+10Q_a-10(Qa^2+1.25Q_aP_E)^{\frac{1}{2}}]}$	$S = \left(\frac{1000}{CN}\right) - 10$ S= 0.638
Initial Abstraction, I_a	0.128	I_a = 0.2 x S	
I_a/P_E	0.128	Used for interpolating coefficients in Table F-1, TR-55	
Unit Peak Discharge (q_u), csm/in	999	$\log(q_u) = C_0 + C1 \times \log(T_c) + C_2 \times \{\log(T_c)\}^2$	
		=2.54107 + -0.61615x log(0.1) + -0.15747 x {log(0.1)}^2	
C_0	2.54107	interpolated from table F-1, TR-55.	
C_1	-0.61615	interpolated from table F-1, TR-55.	
C_2	-0.15747	interpolated from table F-1, TR-55.	
Design Peak Flow (Q_p), cfs	**1.39**	$Q_p = q_u \times A \times Q_a$	= 999 x 1.67 x 0.532

Grass Channel Analysis:

Manning's N value	0.15		
Flow Depth (d), in	3.96	by solving Manning's Equation	**Depth<4 in, OK**
Cross Sectional Flow Area (Ax), sf	2.46	by solving Manning's Equation	
Wetted Perimeter (P_W), ft	11.01	by solving Manning's Equation	
Flow Velocity (V), fps	0.56	V = Q_p/Ax	**Velocity<1 fps, OK**

Existing Flat Bottom Channel

Bottom Width (EW), ft	3.9	Measured in field		**Width ≥ 2 ft, OK**
Bottom Surface Area (SA), sf	3437	S_A = EW x L	S_A / A = 4.7%	**Ratio ≥ 2%, OK**
Treated (P_E), in	**1.00**			***All Checks: OK***

Appendix M

Geospatial Database and Data Dictionary

Appendix M
SHA Annual Report GIS Database Submittal Data Dictionary

A Introduction

The NPDES Annual Report database submittal includes two ESRI geodatabases. SHA has provided the following geodatabases for submittal with the 2017 NPDES Annual Report:

Table M-1: SHA Geodatabases

Filename	Description	Specifications
MDOT_SHA_MDE_2017geodatabase.mdb	MDE geodatabase for the 2016 NPDES Annual Report (personal geodatabase)	Detailed *National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4), Geodatabase Design and User's Guide*, Version 1.1 published in April 2015
MDOT_SHA_NPDES_2017geodatabase.gdb	SWM Infrastructure and Impervious Accounting datasets (file geodatabase)	Detailed in the *SHA's National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Discharge Permit, Part IV.C*, which was provided to SHA on October 9, 2015

This database dictionary for the submittal incorporates a summary of modifications to the 2017 MDE geodatabase framework as well as a description of entities and attributes for the MDOT SHA NPDES 2017 geodatabase. Supplemental information for each layer is provided, as necessary, to detail the lineage of the datasets.

B File Formats

The 2017 Annual Report submittal geodatabases are exported from the enterprise SDE geodatabase environment into an ESRI geodatabase compatible with ArcGIS 10.0+.

C Contents

Within the "Databases" folder on the CD deliverable, the following ESRI geodatabases may be found:

- **MDOT_SHA_NPDES_2017geodatabase.gdb**
- **MDOT_SHA_MDE_2017geodatabase.mdb**
- **MDOT_SHA_Supplemental_2017geodatabase.gdb**

D Data Projection

These geodatabase submittals have been re-projected from SHA's standard projection into the required projection for MDE, specifically NAD_1983_StatePlane_Maryland _FIPS_1900_Meters. The data within the submittal geodatabases are developed in the following original spatial projection: NAD_1983_StatePlane_Maryland _FIPS_1900_Feet.

E 2017 SHA NPDES Geodatabase (MDOT_SHA_NPDES_2017geodatabase.gdb)

The geodatabase contains two core feature classes containing the spatial data relating to stormwater structures and conveyances. Each feature class is related through defined relationship classes to a set of tables that further describe the structure or conveyance. Additionally, the impervious surface layer is provided here as a feature class. The contents of the MDOT_SHA_NPDES_2017geodatabase.gdb are detailed below in Table M-2.

Table M-2: MDOT SHA NPDES Geodatabase Contents

DATABASE SPATIAL LAYERS	TYPE	DESCRIPTION
STRUCTURES	Feature Class	Point feature class that stores the spatial representation and tabular information pertaining to storm water structures (i.e., inlets, manholes, outfalls, control structures). Information includes structure type, feature status, major outfall (T/F), and other overlay attributes such as watershed.
CONVEYANCE	Feature Class	Line feature class that stores the spatial representation and tabular information pertaining to storm water conveyance (i.e., pipe and ditch). Information includes conveyance type, feature status, invert elevations, and other overlay attributes such as watershed.
DATABASE TABLES	**TYPE**	**DESCRIPTION**
END_HEADWALL	Table	Contains the outfall and open upstream structures for a storm drain system, such as endsections, projection pipes, headwall, and endwalls. Information includes the type and material of the end structure.
INLET	Table	Contains the inlet features within the storm drain systems. Information includes the type and material of the inlet, the top of grate, and the length for COG and COS type inlets.
MANHOLE_CONN	Table	Contains the manhole and other connection features within the storm drain system. Information includes the material and top of manhole lid, when applicable.
PUMPSTN	Table	Contains the pump stations within the storm drain system. Information includes the station name, install date, number of pumps, and maximum capacity for the station.
SWMRISER	Table	Contains the storm water BMP control structure, such as box risers and pipe barrel risers. Information includes the material, if a trash rack exists, riser type, and the stage storage elevation.
WEIR	Table	Contains the weirs and emergency spillways related to storm water BMP storage controls. Information includes the material, if a trash rack exists, and the stage storage elevation.

Table M-2: MDOT SHA NPDES Geodatabase Contents

DATABASE TABLES	TYPE	DESCRIPTION
DITCH	Table	Contains the ditch features within the storm drain conveyance. Information included includes ditch material and dimensions.
PIPES	Table	Contains the pipe features within the storm drain conveyance. Information includes the type, length, and dimension of the pipe.

F 2017 MDOT SHA Supplemental Geodatabase (MDOT_SHA_Supplemental_2017geodatabase.gdb)

The geodatabase contains three core feature classes containing the supplemental data provided to MDE, as follows:

Right_of_Way
The MDOT SHA right of way layer used throughout the impervious accounting processes.

Impervious_Surfaces
The MDOT SHA impervious surfaces layer mapped to the baseline year.

MDOT_SHA_FY17_Commercial_Industrial
The MDOT SHA commercial and industrial layer

G BMP / Structure System Numbering Convention

The BMP system numbering methodology applies a unique seven-digit identification number to each asset. The first two (2) digits indicate the county where the system is located. Table M-3 lists the county code numbers for Maryland. For county codes that begin with a zero (ex. Baltimore County 03), the leading zero is not dropped from any naming convention. The remaining five (5) digits represent the unique system number. For example, 130140 is system 140 located in Howard County (County Code 13).

Table M-3: Maryland County Codes

Code	Abbreviation	County Name	Code	Abbreviation	County Name
01	AL	Allegany	13	HO	Howard
02	AA	Anne Arundel	14	KE	Kent
03	BA	Baltimore	15	MO	Montgomery
04	CA	Calvert	16	PG	Prince Georges
05	CO	Caroline	17	QA	Queen Anne's
06	CL	Carroll	18	SM	St. Mary's
07	CE	Cecil	19	SO	Somerset
08	CH	Charles	20	TA	Talbot
09	DO	Dorchester	21	WA	Washington

Table M-3: Maryland County Codes

Code	Abbreviation	County Name	Code	Abbreviation	County Name
10	FR	Frederick	22	WI	Wicomico
11	GA	Garrett	23	WO	Worcester
12	HA	Harford	24	BC	Baltimore City
			99	SW	Statewide

The individual drainage structures located within a system receive a unique three (3) digit identification number. For example, 1300140.007 is the seventh (.007) structure in the 140th drainage system in Howard County.

Numbering begins with the most downstream structure, usually the outfall, which is assigned the structure number of .001. Structures are then numbered as the system is traced upstream. For initial data collection or adding new systems, the most downstream structure in any system should be numbered .001. This is convention only, and structures may be numbered out of sequence in the existing geodatabase. Each system that flows into a BMP is a separate system. The control structure and outfall for a stormwater BMP also starts a new system. Figures M-1 and M-2 (on the following page) show examples of system, structure, and BMP numbering.

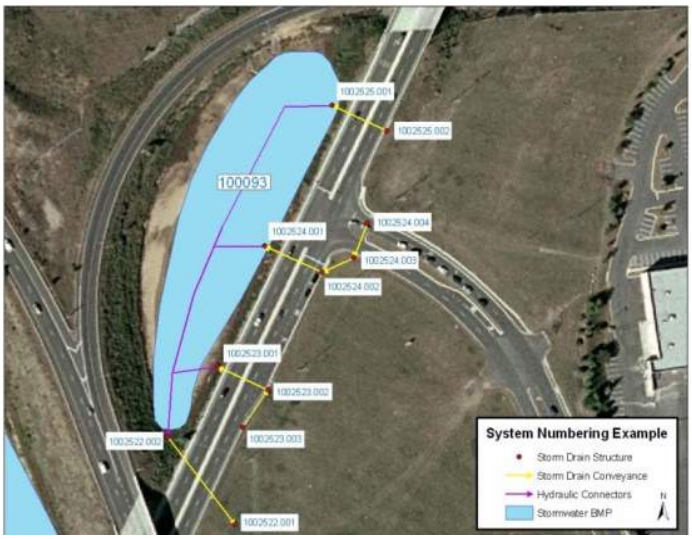


Figure M-1: System No. Ex. 1

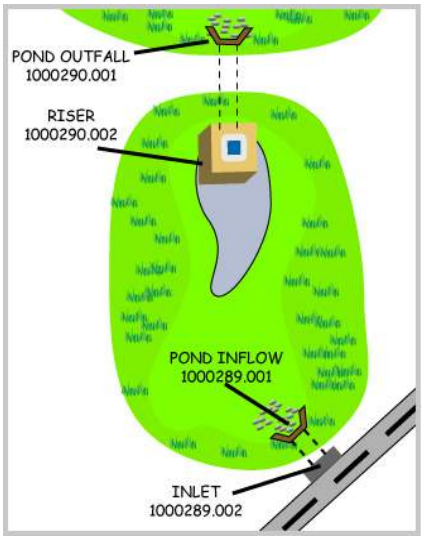


Figure M-2: System No. Ex. 2

MARYLAND DEPARTMENT OF TRANSPORTATION™

STATE HIGHWAY ADMINISTRATION