National Pollutant Discharge Elimination System
Phase I MS4 Permit No. 99-DP-3313 MD0068276

Permit Term October 2005 to October 2010

Second Annual Report
October 21, 2007

Submitted to:
Water Management Administration
Maryland Department of the Environment
1800 Washington Boulevard
Baltimore, MD 21230

Submitted by:
Highway Hydraulics Division
Maryland State Highway Administration
707 North Calvert Street, C-201
Baltimore, MD 21202

Martin O'Malley, *Governor*
Anthony Brown, *Lt. Governor*

SHA
State Highway Administration
Maryland Department of Transportation

John D. Porcari, *Secretary*
Neil J. Pedersen, *Administrator*

October 21, 2007

RE: Second Annual NPDES MS4 Phase I Report
Permit Term: 10/2005 to 10/2010
Permit No.: 99-DP-3313 MD0068276

Mr. Brian Clevenger
Sediment, Stormwater & Dam Safety Program,
Suite 440
Water Management Administration
Maryland Department of the Environment
1800 Washington Blvd.
Baltimore, MD 21230-1708

Dear Mr. Clevenger:

We are please to submit an annual report for the second year of the permit term for NPDES Phase I MS 4 permit. This work represents the work accomplished in past years and cumulatively so far under the phase I permit. SHA remains committed to environmental compliance and stewardship; and you will find that initiative and work that has contributed to the reach this stage is accomplished by many programs and efforts through out the organization. We trust that you will find this report and SHA in compliance with the permit conditions.

We look forward to a continuing partnership between our agencies. If you desire, we are willing to present the major accomplishments of the past two years in person. Should you have any questions or required additional information, please contact me at (410) 545-8390 or Karen Coffman at (410) 545-8407.

Sincerely,

Karuna Pujara, Chief
Highway Hydraulics Division

cc: Mr. Ray Bahr
Ms. Karen Coffman
Ms. Dana Havlik
Mr. Michael Stewart
Mr. Kirk McClelland.

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SHA State Highway Administration Driven to Excel
Maryland Department of Transportation

Executive Summary

The Maryland State Highway Administration (SHA) is submitting this second annual report for the NPDES Phase I Municipal Separate Storm Sewer System (MS4) permit that was issued in October 2005 by the Maryland Department of the Environment (MDE) Water Management Administration (WMA). This annual report covers the time period October 2006 to September 2007. A summary of the permit conditions and our work toward meeting them is provided below as a general overview of SHA permit activities for this report period.

Source Identification – Work on the last two Phase I counties, Carroll and Charles, continued this year with completion still being targeted for early 2008. With the completion of these counties, SHA will have fulfilled the Source Identification condition and we will have a complete GIS inventory of the nine Phase I NPDES counties. Updates to our existing GIS are also on-going with office research being completed in August for Prince George's and Anne Arundel Counties. Field verification and inspections are anticipated to begin in February 2008.

We have also devoted resources to developing our GIS tools for manipulating, displaying and reporting on our data. The SHA NPDES GIS viewer application is nearing completion for the first component, the BMP Viewer tool and completion of additional components will follow in quick succession.

Impervious accounting efforts continue also, with the development of impervious layers for three counties complete and a draft protocol for the accounting procedures submitted for review. We are well ahead of our deadline of October 2009 for impervious accounting in all nine NPDES counties.

Discharge Characterization – We continue to investigate and research topics in order to maximize water quality in our construction methods, permanent stormwater runoff controls, decisions in design and location of roadways and maintenance techniques. Available literature abounds and we are also continuing research efforts into thermal impacts of stormwater underground storage, pollutant removal effectiveness of grassed swales and literature search on BMP pollutant removal efficiencies in anticipation of future research on other BMP types and uses.

Management Program – Our program continues to expand to incorporate new thinking in Green Highways, watershed-based stormwater management and environmental site design techniques. While we also continue to improve our existing programs such as erosion and sediment control through quality assurance initiatives, tracking our effectiveness is an area of our program that we are seeing particularly fruitful results in basing decisions on supportable documentation and real experiences.

Construction on Towson Run Stream Stabilization was Completed in 2007

Watershed Assessment – Coordination with other NPDES jurisdictions and local watershed groups continued this year. Sites for water quality treatment within the Patuxent River watershed have been identified and documented. Project development is under way to design and construct new facilities to increase our treatment of stormwater runoff in this watershed. We also continue our efforts to develop a framework to implement watershed-based stormwater management for SHA roadway projects.

Watershed Restoration – Efforts to construct and fund stormwater retrofits increased this year with the award of Transportation Enhancement Funding (TEP) for the I-97 Stormwater Functional Upgrades. This adds to the thirty-nine restoration projects we currently have underway and increases our efforts to fifty-four significant watershed restoration projects being sponsored by SHA. We also work to encourage the use and award of TEP funds for other jurisdictions to fund projects targeted at mitigating pollutants due to roadway runoff.

Assessment of Controls – A year has passed and the Long Draught Branch stream restoration pre-construction monitoring has been in place, capturing data to allow us to evaluate the effectiveness of the project after construction. The design of the project has progressed and construction is anticipated to begin in the summer of 2008.

Program Funding – Our NPDES program remains a priority and is adequately funded. Consultant resources continue to avail progress in all areas of permit requirements.

Total Maximum Daily Loads – By remaining in compliance with this permit, we are controlling stormwater pollution to the maximum extend practicable. We look forward to working within watershed restoration action plans and tributary strategy implementation plans.

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PART ONE

Standard Permit Conditions and Responses

Introduction

The Maryland State Highway Administration (SHA) is committed to continuing our National Pollutant Discharge Elimination System (NPDES) Program efforts and is pleased to partner with the Maryland Department of the Environment (MDE), the Environmental Protection Agency (EPA) and other NPDES jurisdictions in order to achieve the program goals.

The original NPDES phase one permit guided SHA through establishing our NPDES program. (The permit, MS-SH-99-011, was issued on January 8, 1999 and expired in 2004.) The current permit (99-DP-3313, MD0068276, issued October 2005) focuses on improving water quality benefits and developing a watershed-based outlook for stormwater management and NPDES program elements. This shift in focus is seen in the conditions that have been added to this permit such as impervious accounting, highway maintenance activities including sweeping and deicing operations, environmental design practices, innovative watershed enhancements such as stream buffer plantings and extensive monitoring of an alternative BMP and watershed restoration effort.

This is the second annual report for the re-issued permit. Part One of the report lists the permit conditions and explains SHA activities over the last year in compliance with each condition. Wherever possible, future activities and schedules for completion are provided. In depth discussions for some of the major program components follow this section.

SWM Act of 2007

This past year saw the introduction of new stormwater management legislation in Maryland – the Stormwater Management Act of 2007. SHA looks forward to participating in focus groups that will facilitate the implementation of this law and development of associated regulations. As the intent of the regulations is to foster environmental site design, SHA has already shown a commitment to this philosophy in our stormwater site development criteria and stormwater management facility program. We are enthusiastic about looking to new ways to improve our commitment through this legislation.

Maryland Stormwater Management Act of 2007 Environmental Site Design
• Optimizing Conservation of Natural Features, such as Drainage Patterns, Soils and Vegetation
• Minimizing Use of Impervious Surfaces such as Paved Surfaces, Concrete Channels, Roofs and Pipes
• Slowing Down Runoff to Maintain Discharge Timing and Increase Infiltration and Evapo-transpiration
• Using Other Non-Structural Practices or Innovative Stormwater Management Technologies Approved by the Department

A Administration of Permit

Administration responsibilities of the NPDES MS4 permit for SHA is listed below and an organizational chart is attached as Figure 1-1.

Ms. Karen Coffman
SHA NPDES Coordinator
Highway Hydraulics Division
(410) 545-8407
kcoffman@sha.state.md.us

NPDES Industrial Permits and associated activities are coordinated by:

Ms. Sonal Sanghavi
Division Chief
Environmental Compliance Division
(410) 582-5585
ssanghavi@sha.state.md.us

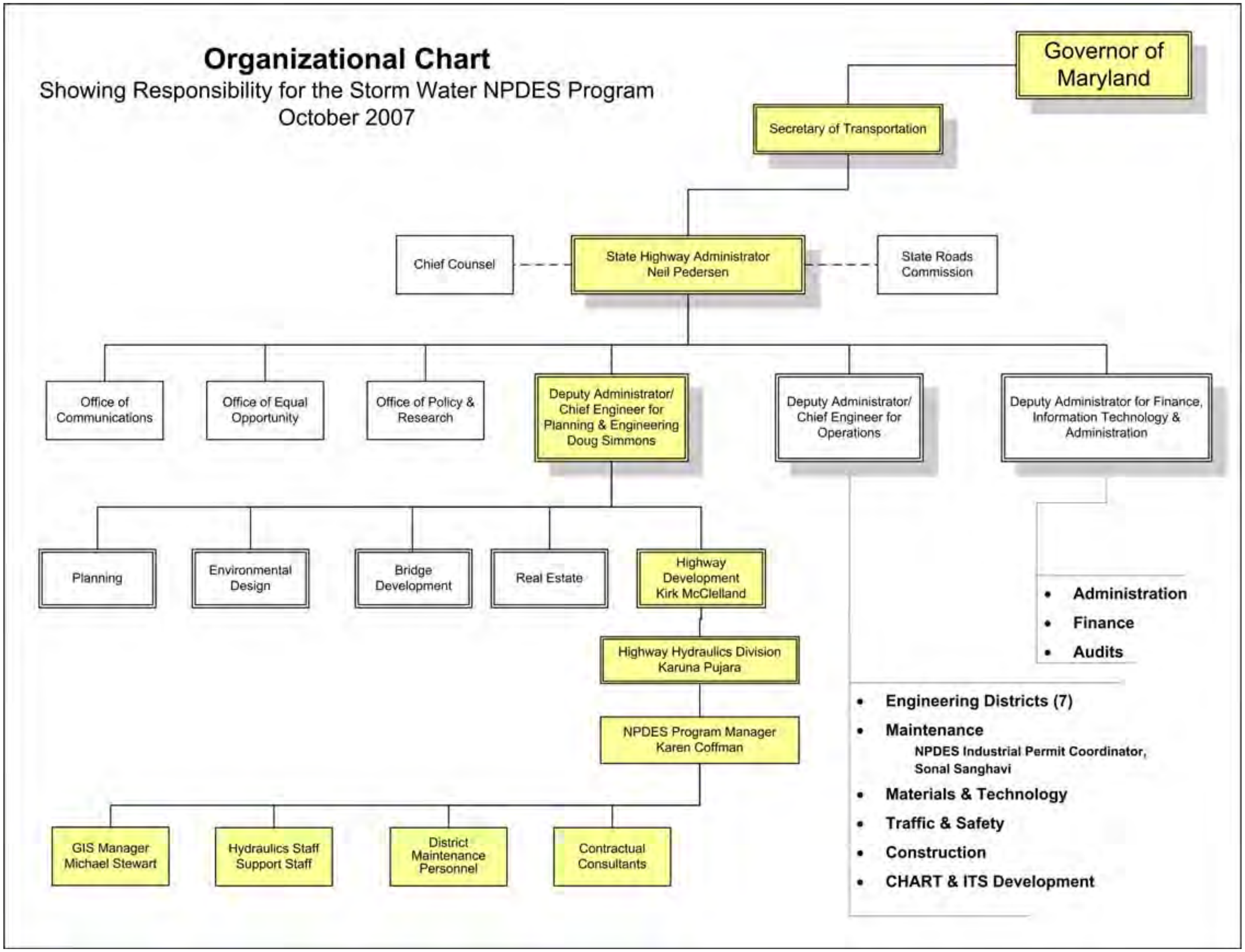


Figure 1-1 Organizational Chart for NPDES Permit Administration

B Legal Authority

A description of the legal authority maintained by SHA was restated in the first annual report dated October 21, 2006.

C Source Identification

For this permit term, MDE has defined the source identification effort as completing the description of the SHA storm drain and BMP system, submitting BMP data to MDE and creating an impervious surface account.

Source identification deals with identifying sources of pollutants and linking these sources to specific water quality impacts on a highway district basis. Source identification is also tied to impervious surfaces. From the perspective of land use and roadways, the functional classification of roadways and daily traffic volumes (both average and peak) provide a characterization of the intensity of use the roadway receives and the nature of the surrounding development (urban or rural). This can give us a relative understanding of the impact a particular roadway will have on the watershed pollutant loads. SHA also manages other land uses such as Park N Rides and visitor centers.

A description of the functional classification codes and other SHA land uses follows:

Rural Roadway Classifications

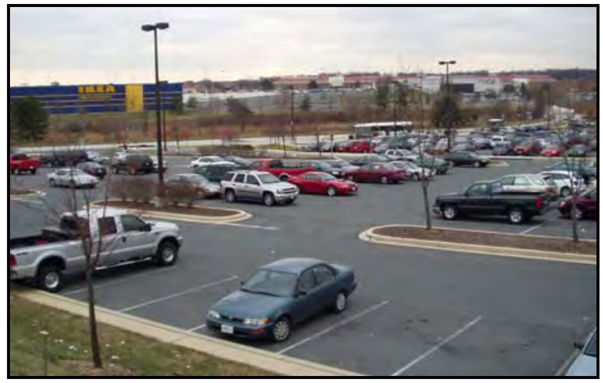
1. Interstate
2. Other Principal Arterial
6. Minor Arterial
7. Major Collector
8. Minor Collector
9. Local

Urban Roadway Classifications

11. Interstate
12. Other Freeways & Expressways
14. Other Principal Arterial
16. Minor Arterial
17. Collector
19. Local

Other SHA Land Uses

Park N Rides
Visitor Centers
Shops, Maintenance Faculties
Weigh Stations
Headquarters and District Offices



Park N Ride

Rural Interstate

Urban Interstate

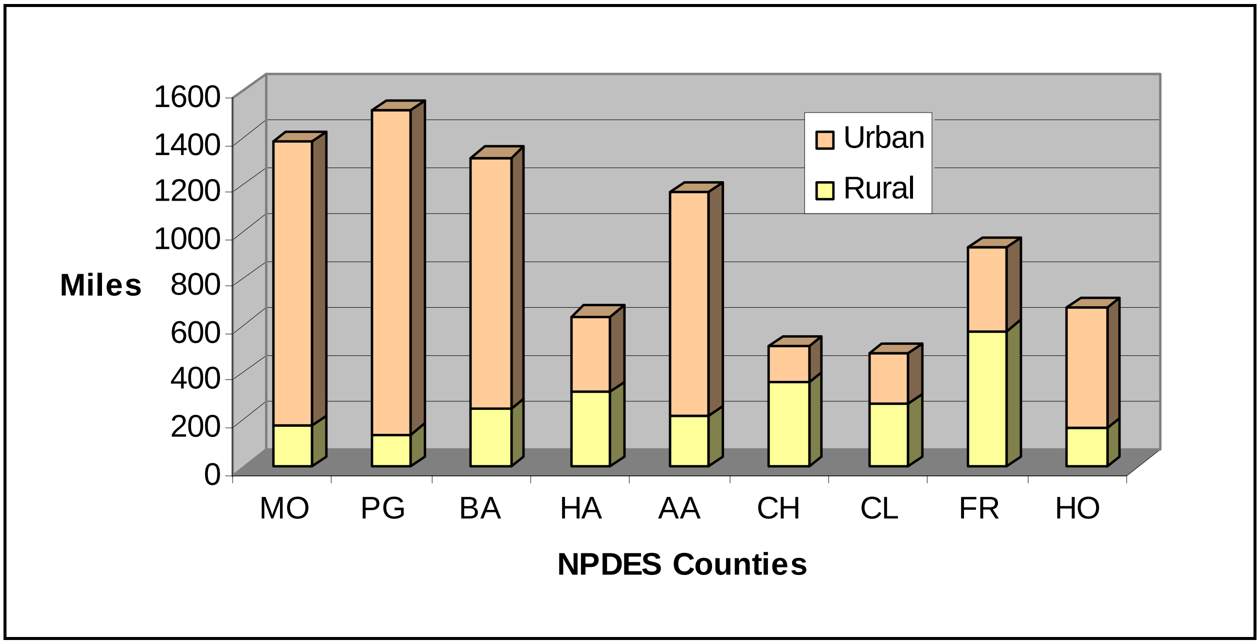


Figure 1-2 Roadway Functional Classifications by NPDES County

Table 1-1. SHA Lane Miles by Functional Classification within NPDES Counties

	SHA District 3		SHA District 4		SHA District 5		SHA District 7		
Functional Class	MO	PG	BA	HA	AA	CH	CL	FR	HO
Rural Classifications:									
1	17.02	7.87	58.61	0.00	50.40	0.00	0.00	91.55	55.94
2	0.00	39.63	24.32	40.57	19.08	106.66	23.61	128.50	19.58
6	61.84	14.29	50.58	105.39	73.39	51.44	130.14	95.64	33.15
7	80.41	71.83	116.22	119.93	38.14	122.34	67.66	218.11	47.96
8	9.16	0.00	0.00	47.20	28.00	30.70	8.56	16.54	7.12
9	8.26	4.75	0.20	7.98	7.73	47.57	37.14	30.21	3.24
Total Rural	176.69	138.37	321.07	1,329.23	216.74	358.71	267.11	580.55	166.99
District Totals	315.06		1,650.30		575.45		1,014.65		
Urban Classifications:									
11	299.25	347.45	366.69	0.00	130.54	0.00	9.66	102.94	141.56
12	46.18	225.47	117.31	45.88	235.56	0.00	0.00	63.72	193.36
14	685.06	565.23	361.86	163.92	257.21	125.87	153.52	65.06	75.06
16	159.57	196.36	200.58	98.59	222.00	25.59	24.35	73.15	78.06
17	7.35	23.94	20.36	8.40	55.57	4.98	2.43	27.80	11.69
19	9.51	17.18	1.68	3.33	51.10	0.00	23.85	22.54	11.99
Total Urban	1,206.92	1,375.63	1,068.48	320.12	951.98	156.44	213.81	355.21	511.72
District Totals	2,582.55		1,388.60		1,108.42		1,080.74		
Total County Lane Mileage	1,383.61	1,514.00	1,318.41	641.19	1,168.72	515.15	480.92	935.76	678.71
Total District Lane Mileage	2,897.61		1,959.60		1,683.87		2,095.39		

Mileage current to January 1, 2007

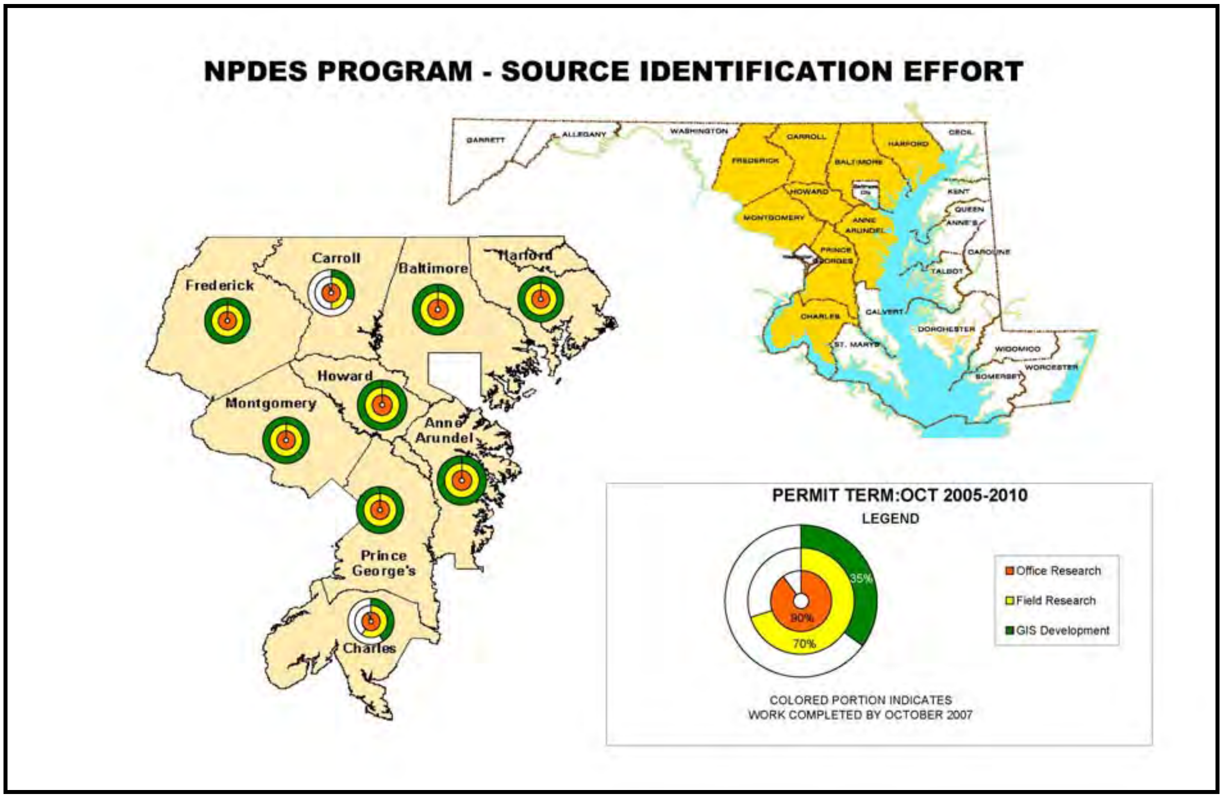


Figure 1-3 Source Identification and GIS Development Status

Table 1-1 lists the lane miles for each SHA district broken out by functional classifications and Figure 1-2 illustrates the breakdown between urban and rural classifications. While most of the Phase I counties are characterized by a majority of urban classified roadways, Charles, Carroll and Frederick counties are characterized by mostly rural roadways.

We will continue to pursue work to incorporate functional classifications, traffic volumes and other land uses into our NPDES program and GIS development.

C.1 Describe Storm Drain System

Requirements under this condition include:

a) *Complete Source identification requirements by October 21, 2009;*

b) *Address source identification data compatibility issues with each jurisdiction where data are collected. Data shall be organized and stored in formats compatible for use by all governmental entities involved;*

c) *Continually update its source identification data for new projects and from data gathered during routine inspection and repair of its municipal separate storm sewer system; and*

d) *Submit an example of source identification for each jurisdiction where source identification is being compiled.*

C.1.a Complete Source Identification

SHA is well on our way to completing the identification and GIS development for our storm drain systems and stormwater management facilities. We anticipate completing this requirement by the end of 2008, a year prior to the deadline of October 2009.

Figure 1-3 summarizes the status of the source identification effort by SHA. Specific information for Carroll and Charles county efforts is included below. Information on source

ID updates in for the remaining counties is included under section C.1.c, Update Source ID Data.

Of the nine NPDES Phase 1 MS4 counties, SHA has completed source identification for seven and is working to develop the information for the two remaining counties. Currently, counties with completed source identification databases include (in order of completion):

1. Howard
2. Montgomery
3. Anne Arundel,
4. Prince George's
5. Baltimore
6. Harford
7. Frederick

We have completed office identification work and assigned the last two phase one counties for field location, inspection and GIS development. These final counties are:

8. Carroll
9. Charles

Carroll County – The initial office as-built inventory was completed and the field location, inspection and database development task was assigned for this county in August 2006. All available as-built construction drawings were researched and will be field verified. The number of post-construction stormwater facilities identified during the as-built inventory is 47. The database and GIS model for drainage features will be completed in January 2008.

Phase of Source ID	% Complete
Office Research	95
Field Research	50
GIS Development	30

Charles County – The initial office as-built inventory was completed and the field location, inspection and database development task was assigned for this county in September 2006. All available as-built construction drawings were researched and will be field verified. The number of post-construction stormwater facilities identified during the as-built inventory is 107. The database and GIS model for drainage features will be completed in January 2008.

Phase of Source ID	% Complete
Office Research	95
Field Research	60
GIS Development	41

C.1.b Data Compatibility

SHA continues to provide data to the other NPDES jurisdictions as well as acquire data from them. This data sharing is proving effective in generating the most up-to-date GIS and database information. The NPDES data generated by SHA is in standard ESRI Geodatabase format and is either natively compatible with other jurisdictions, or can be exported to ESRI shape file format.

The only disadvantage of the shape file format is that the relationship classes that have been developed in the geodatabase model do not transfer. However, all of the spatial (point, line, polygon) and attribute data can easily be exported to shape files.

Geospatial Database Development

SHA has developed a geospatial database for the source identification data and this database will be expanded to include other components of the program as they are brought together and as we update our standard procedures and inspection manuals. Utilizing the ESRI Geodatabase data format, SHA is working towards implementing an enterprise ArcSDE Environment to store all of the source identification data.

Currently our data for Montgomery, Frederick, Anne Arundel, Prince George's and Harford counties have been migrated to geodatabase format. Efforts to migrate the existing databases and GIS information to the geodatabase will be completed as counties are assigned for source identification updates.

NPDES GIS Viewer Application

A GIS viewer application tool is being developed to utilize the power of the enterprise GIS server and allow SHA to manage these assets effectively. It will consist of a number of modules and is being developed, a module at a time, according to the list below:

- **GIS Viewer** – web-based application that allows SHA personnel, NPDES jurisdictions and other users to access our data. The viewer application will allow SHA staff to view, analyze, and query the storm drain, cross culvert and stormwater facility GIS data as well as manage updates.
- **Stormwater Facility Program Module** – facilitates the management of the BMP inspections, maintenance, remediation or enhancement.
- **IDDE Module** – allows tracking of NPDES outfall screening, illicit discharges, reporting and elimination efforts.
- **Impervious Accounting Module** – tracks the impervious accounting by SHA district and 6-digit watersheds and facilitates updating impervious layers as new projects and stormwater management facilities are built.
- **Outfall & Storm Drain Inspection & Remediation (SOIRP) Program Module** – facilitates the management of the storm drain and outfall inspection data, maintenance, remediation or enhancements.

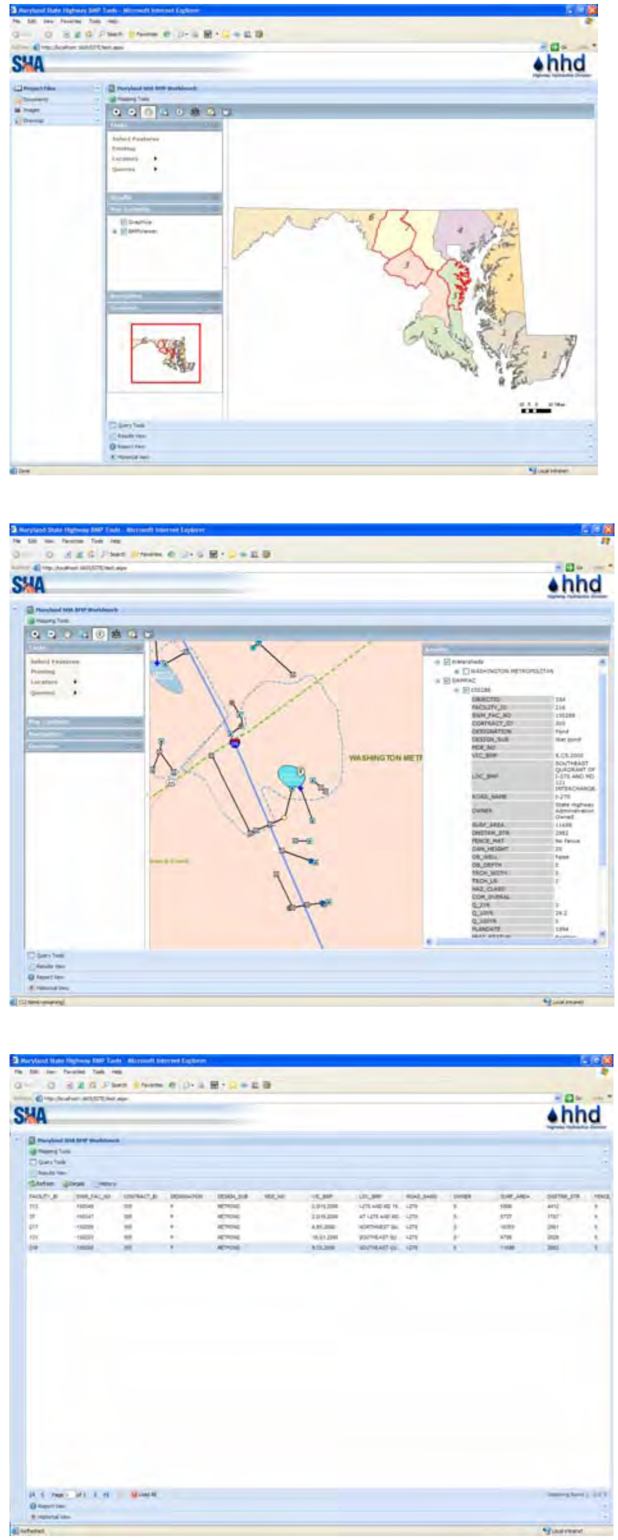


Figure 1-4 GIS Viewer Application Navigation Screens

Standard Procedures Manual and Workshops

We are continuing to develop our standard procedures which document data collection, inspection and data management standards for our source identification, stormwater management facility inspections and remediation program, illicit discharge, detection and elimination and storm drain outfall inspections. The focus over the last year was to completely update the stormwater management inspection procedures and the updated documentation, which is Chapter 3 of the procedures manual, is included in Appendix A.

Updates to the BMP inspection manual include:

- Updated to include geodatabase formatting,
- Added site development criteria which includes sustainability, safety, environmental and visual quality,
- Integrated SHA access permit process and joint use stormwater management,
- Integrated impervious surface accounting.

Along with the standard procedures manual we are developing a set of workshops that will train our GIS developers and inspectors on SHA standards and our NPDES permit conditions. This will ensure that they fully understand the commitment and tasks to be performed in order to meet the goals of the NPDES program. We performed two workshops over the last year and are in the process of updating and improving the training materials. Future training workshops will be held annually and will include several modules that can be put together in any combination depending upon our training needs. The modules include:

- Source ID procedures
- IDDE Field training
- Outfall stability inspection
- BMP Inspections
- GIS Data Management and Geodatabase.

Table 1-2. Source ID Update Schedule

County	Source ID Complete	1st Update	2nd Update
Howard	**01/2001-C**	**01/2005-C**	*8/2008*
Montgomery	**01/2001-C**	**09/2006-C**	*09/2009*
Anne Arundel	**08/2003-C**	**6/2007-I**	
Prince George's	**03/2003-C**	**6/2007-I**	
Baltimore	**03/2004-C**	*8/2008*	
Harford	**08/2005-C**	*08/2008*	
Frederick	**09/2006-C**	*09/2009*	
Carroll	**08/2006-I**		
Charles	**09/2006-I**		

Note: **Bold text** is actual completion dates (**-C**) or actual initiation dates (**-I**).
Italicized text is projected initiation dates.

C.1.c Update Source Identification Data

As source identification is completed for all the counties, the permit activity for this condition will become solely updating the source data. Source identification updates are performed on completed counties every three years or once the maintenance and remediation efforts are complete. Additional roadway mileage, storm drain infrastructure and BMPs are identified and added to the databases. Future updates will be performed according to Table 1-2. The following county database updates were assigned since the last annual report:

- Prince George's,
- Anne Arundel.

Information for each county is listed below in the order in which the original source identification efforts were completed:

<u>Howard County</u> - The initial inventory, database and GIS model of drainage features were completed in January 2001. Updates to the database and GIS model were completed in January 2005. The current number of post-construction BMPs identified for this county is 247.

<u>Montgomery County</u> - The initial inventory, database and GIS model of drainage features were completed in January 2001. Updates for the database and GIS model were completed in September 2006. The current number of post-construction stormwater BMPs identified for this county is 267.

<u>Anne Arundel County</u> - The initial inventory, database and GIS model of drainage features were completed in August 2003. Source identification efforts to update our GIS information have begun for this county. All available as-built construction drawings were researched and will be field verified.

An additional 189 stormwater management facilities have been identified as being constructed in the county since August 2003 bringing our current estimate of BMPs to 613.

Phase of GIS Updates	% Complete
Office Research	85
Field Research	0
GIS Development	0

Updates of our GIS data, field verification and inspections will begin this winter, 2007.

<u>Prince George's County</u> – The inventory, database and GIS model of drainage features were completed in March 2003. Source identification efforts to update our GIS information have begun for this county. All available as-built construction drawings were researched and will be field verified.

An additional 82 stormwater management facilities have been identified as being constructed in the county since March 2003 bringing our current estimate of BMPs to 263.

Phase of GIS Updates	% Complete
Office Research	85
Field Research	0
GIS Development	0

Updates of our GIS data, field verification and inspections will begin this winter, 2007.

Baltimore County – The inventory, database and GIS model of drainage features were completed in March 2004. The current number of post-construction BMPs identified for this county is 167.

Harford County – The inventory, database and GIS model of drainage were completed in August 2005. The current number of post-construction stormwater BMPs identified for this county 109.

Frederick County – The inventory, database and GIS model of drainage features were completed in August 2006. The current number of post-construction stormwater BMPs identified is 75.

C.1.d Submit Source Identification Data

Examples of the source identification data for Charles and Carroll counties are included in Appendix B. The source identification effort continues in these counties and is anticipated to be completed spring 2008.

C.2 Submit BMP Data

Data is included on the enclosed CD for the Urban BMP database (Table B) according to Part IV and Attachment A of the permit.

C.3 Create Impervious Surface Account

This condition requires that SHA provide a detailed account of impervious surfaces owned by SHA and an account of those acres of impervious surface controlled by stormwater management, broken out by SHA engineering district. This account will be used to assess current stormwater status and to identify potential areas for implementing restoration activities.

We have focused our efforts over the last year on developing the impervious surface layers and determining the issues involved in putting together an accounting strategy. Table 1-3, below, provides an updated schedule for the completion of the impervious accounting effort.

Table 1-3. Impervious Accounting Schedule

Activity	Impervious Surface Layer	Treatment Accounting
Charles	**9//2007-C**	*5/2008*
Howard	**9/2007-C**	**10/2007-C**
Harford	**9/2007-C**	**10/2007-C**
Baltimore	**9/2007-C**	**10/2007-C**
Frederick	**6/2007-I**	*6/2008*
Anne Arundel	**7/2007-I**	*5/2009*
Carroll	*11/2007*	*3/2008*
Montgomery	*12/2007*	*4/2008*
Prince George's	*2/2008*	*5/2009*

Note: **Bold text** is actual completion dates (-**C**) or actual initiation dates (-**I**).
Italicized text is projected initiation dates.

Work Plan

The approach we have taken in meeting this requirement is detailed below:

1. **Pilot Studies –** Completed. See last year's report for more information on these studies.
2. **Impervious Layer Methodology Selection –** Completed. See last year's report for more information on the feature analyst process.
3. **Impervious Accounting Protocol –** Under development. See discussion below.
4. **Fiscal Tracking –** Under development.

5. **Schedule –** Completed. See Table 1-3 above.
6. **Implementation –** Impervious surface layers are currently being developed. See discussion below.
7. **Annual Reporting –** We have provided information here to track our progress.

Figure 1-5 Impervious Surface Layer Generated with Feature Analyst Process

Impervious Layers

We have developed four of the nine impervious surface layers: Charles, Howard, Harford, and Baltimore. Maps of the layers are included in Appendix C. We have also determined the amount of impervious being treated by stormwater management structural facilities for Howard, Harford and Baltimore Counties. Pavement being treated by grass swales or other non-structural measures are not accounted for at this time.

Although the impervious surface layer for Charles County has been completed, the BMP drainage areas are not available for this county because it is currently undergoing source identification and GIS development.

Figure 1-5 shows an example of the surface layer. Because this layer is generated through a process that reads the photogrammetry, there are minor inaccuracies. But as a general quantity representing the amount SHA owns within an entire county, we feel it is a good estimate.

Figure 1-6, below illustrates the relationship between SHA impervious surfaces that have been identified in the three counties along with the amount that is being treated by stormwater BMPs. Table 1-4 lists the actual numbers associated with each county.

The challenge is to keep the impervious layers and BMP treatment accounting updated as new impervious areas and stormwater management facilities are built.

Impervious Accounting Protocol

The impervious accounting protocol is the methodology for developing impervious surface layers and then accounting for the stormwater treatment of the various categories of impervious surfaces that SHA deals with. A draft protocol has been developed and is included in Appendix D.

A procedure for importing new impervious surface information from Microstation CADD files is under development and will require that SHA CADD Standards be adhered for any project that adds impervious surfaces to SHA ownership (see Figure 1-7). This will allow us to track our progress in treating stormwater runoff from impervious surfaces without having to rerun the Feature Analyst models repeatedly. Models for this procedure are included in the draft protocol in Appendix D.

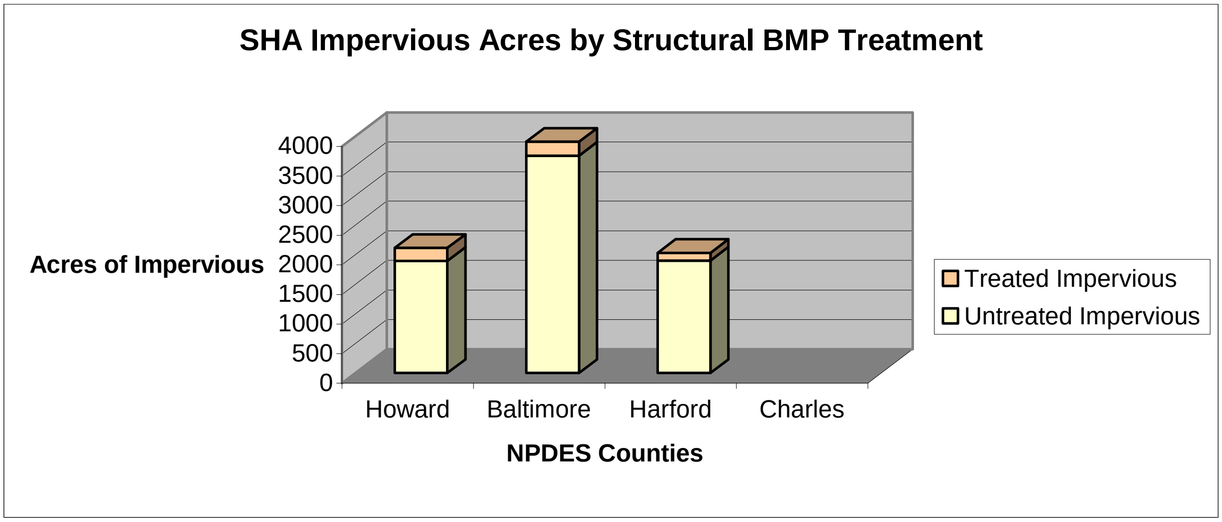


Figure 1-6 SHA-Owned Impervious Surface Treatment in 3 NPDES Counties

Table 1-4. SHA Impervious Accounting

County	Untreated SHA Impervious (AC)	Treated SHA Impervious (AC)	Total SHA Impervious in County (AC)	Percent SHA Impervious Treated
Charles	-	-	2,218.42	-
Howard	1,894.43	220.21	2,224.65	10.4%
Harford	1,900.79	129.05	2,029.84	6.40%
Baltimore	3,673.18	235.37	3,908.55	6.00%
Frederick	-	-	-	-
Anne Arundel	-	-	-	-
Carroll	-	-	-	-
Montgomery	-	-	-	-
Prince George's	-	-	-	-

Note: Numbers current to 10/2007. Treatment is by structural BMPs.

SHA-Owned Impervious — Treated impervious (right)

Figure 1-7 Impervious Accounting

The final protocol will address these remaining issues:

- **Define 'Stormwater Treatment' –** This issue seeks to tie down what is meant by stormwater treatment and the types of BMPs that are recognized as providing treatment. Specifically the questions of structural versus non-structural BMPs and water quality versus quantity will be addressed.

  Because SHA often enters into agreements with adjacent developers to share stormwater facilities, impervious surfaces not owned by SHA are often treated by SHA stormwater BMPs. Also, SHA impervious may drain to facilities owned by others without any agreements. For this reason, we have added two additional categories of impervious surfaces to be considered in our impervious accounting: non-SHA impervious treated by SHA and SHA impervious treated by others.

  Categories of impervious treatment include:

  1. SHA Impervious Not Treated,

  2. SHA Impervious Treated
     a. Structural BMP Treatment
     b. Non-structural Treatment (Not shown on Figure 1-6 or Table 1-4.)

  7. Non-SHA Impervious Treated by SHA BMP. (Not shown on Figure 1-6 or Table 1-4.)
     a. SHA Structural BMP Treatment
     b. SHA Non-Structural Treatment

  8. SHA Impervious Treated by Others (Not shown on Figure 1-6 or Table 1-4.)
     a. Other Structural BMP Treatment
     b. Other Non-structural BMP Treatment

- **Integrate into Water Quality Bank –** Impervious accounting will be integrated with tools developed to track the current SHA/MDE water quality banking agreement and process.

Figure 1-8 CADD Drawing Converted and Clipped into GIS Impervious Layer

- **Standard Accounting Procedures –** This entails anticipating all contingencies and identifying methods to address them. An example of a contingency that falls outside the defined standard condition is acres of non-SHA owned impervious area treated by SHA BMPs and whether credit is allowed to offset SHA impervious that is not treated. Another would be SHA impervious that is treated by a facility owned by another entity.

- **Quality Assurance –** Develop quality assurance mechanisms.

- **User Documentation –** Develop process, database and GIS user documentation.

D Discharge Characterization

This current permit term looks at scrutinizing the available MDE dataset compiled from eleven NPDES jurisdictions and other research performed nationally to improve stormwater management programs and develop watershed restoration projects. We have continued our efforts to understand stormwater runoff associated with highways by reviewing available literature and studies on the subject and by conducting studies to further our understanding.

The following studies are currently under progress by the University of Maryland, Department of Civil Engineering, and progress reports are contained in the appendices as noted:

- *Grassed Swale Pollutant Removal Efficiency Studies – Part III.* Progress report is provided as Appendix E and the objective from that study is provided below.

  "Several studies have demonstrated grass swales as an effective LID technology by comparing water quality enhancements through pollutant removal efficiency. The focus of this study is to investigate the effectiveness of vegetated check dams on swale performance. This project has three objectives. The first is to study the overall efficiency of grass swales with native check dams on roadway runoff pollutant removal. Second, is to examine the effect of shallow sloped grass pre-treatment area adjacent to the grass swale (i.e., pavement-to-buffer ratio). Third, is to compare the results of the water quality parameters with the previous study by Stagge (2006) (grass swales without check dams)."

  Because this portion of the study was commenced earlier this year, the data is preliminary. Additional information will be provided in the subsequent annual reports.

- *Literature Review: BMP Efficiencies for Highway and Urban Stormwater Runoff.* A progress report is provided as Appendix F. This literature search looks at current available resources for evaluating the effectiveness of stormwater management technologies in removing pollutants and methodologies for evaluating this effectiveness. The current report including information on reporting parameters of BMPs, grass swale, bioretention, basins, vegetated buffer strips, sand filters and wetlands. This research will continue to broaden our understanding of what has been accomplished in the field of stormwater BMP efficiencies.

Native Grass Check Dam at SHA Swale

Signs at Grass Swale Study

The following studies have been completed by SHA and were included in last year's report:

- *Low Impact Development Implementation Studies at Mt. Rainier, MD,* October 2006.
- *Grass Swale Study – Part II,* October 2006.

The following studies were completed by SHA during the previous permit term:

- *Annual Report: Pindell School Road Storm Sampling*, KCI, March 7, 2000;
- *National Highway Runoff Study: Comparison to MSHA Sampling Results,* KCI, December 2001;

- *Dulaney Valley Road I-695 Interchange Stream Monitoring at the Tributary to Hampton Branch*, KCI, Annual Reports dating 2000 to 2003.

Additional resources have been acquired for SHA research purposes and include:

Highway Runoff Discharge Characterization

- *The National Runoff Data and Methodology Synthesis, Publication No FHWA-EP-03-054 -055, -056, 2003*.

Stormwater Best Management Practices

- *Evaluation of Best Management Practices for Highway Runoff Control*, NCHRP Report 565.
- *Controlling Urban Runoff: Practical Manual for Planning and Designing Urban BMPs,* Metropolitan Washington Council of Governments, 1987.

Deicing Materials

- *Guidelines for Selection of Snow and Ice Control Materials to Mitigate Environmental Impacts*, NCHRP Report 577.
- *Assessing the Role of Road Salt Run-off on the Critical Ecological interactions that Regulate Carbon Processing in Small, Headwter Streams in the Chesapeake Bay Watershed,* Chris Swann, MWRRC, 2006.
- *Pollutant Mass Flushing Characterization of Highway Stormwater Runoff from an Ultra-Urban Area,* Flint and Davis, June 2007.
- *Choosing Appropriate Vegetation for Salt-Impacted Roadways,* Center for Watershed Protection Technical Note # 56.
- *Rating Deicing Agents: Road Salt Stands Firm,* Center for Watershed Protection Technical Note # 55.
- *Increased Salinization of Fresh Water in the Northeastern United States,* Kaushal, Groffman, Likens, Belt, Stack, Kelly, Band and Fisher, August 2005.

Total Maximum Daily Loads

- *Maryland's 2006 TMDL Implementation Guidance for Local Governments,* Maryland Department of the Environment, 2006.
- *Maryland's Chesapeake Bay Tributary Strategy Statewide Implementation Plan*, Watershed Services Center, Maryland Department of Natural Resources, August 2, 2007.

Illicit Discharges

- *Methods for Detection of Inappropriate Discharges to Storm Drainage Systems*, Robert Pitt, University of Alabama, November 2001.
- *Illicit Discharge, Detection and Elimination: A Guidance Manual for Program Development and Technical Assessments*, Center for Watershed Protection, October 2004.

Watershed-Based Strategies

- *A User's Guide to Watershed Planning in Maryland*, Center for Watershed Protection, December 2005.
- *Watershed-Based National Pollutant Discharge Elimination System (NPDES) Permitting Implementation Guidance*, Environmental Protection Agency, December 2003.

Using the literature and research documented above, we are pursuing further understanding of the pollutant removal capabilities of the various BMPs discussed in the *2000 Maryland Stormwater Design Manual* as well as other innovative stormwater management techniques. We are also pursuing understanding of pollutants and their transport and uptake mechanisms, watershed based emphasis to stormwater and the efforts by Maryland to achieve watershed level restoration.

E Management Program

A management program is required to limit the discharge of stormwater pollutants to the maximum extent practicable. The idea is to eliminate pollutants before they enter the waterways. This program includes provisions for environmental design, erosion and sediment control, stormwater management, industrial facility maintenance, illicit connection detection and elimination, and personnel and citizen education concerning stormwater and pollutant minimization.

E.1 Environmental Design Practices

The Maryland State Highway Administration has a strong environmental commitment that will only increase as the new Stormwater Management Act of 2007 is implemented. Through this legislation, emphasis will be placed on the use of environmental site design (ESD) techniques. This includes optimizing conservation of natural features, such as drainage patterns, soils and vegetation; minimizing use of impervious surfaces such as paved surfaces, concrete channels, roofs and pipes; slowing down runoff to maintain discharge timing and increase infiltration and evapotranspiration; and using other non-structural practices or innovative stormwater management technologies.

We are actively participating in focus groups organized to develop regulations and guidelines for implementing this law.

SHA also continues to adhere to processes that ensure that environmental and cultural resources are evaluated in the planning, design, construction and maintenance of our roadway network. This includes providing opportunity for public involvement and incorporating context sensitive design and solution principles. We also ensure that all environmental permitting requirements are met by providing training to our personnel (see E.6.b below) and creating and utilizing software to track permitting needs on projects as they move through the design, advertisement and construction processes.

NEPA/MEPA Process

Our National Environmental Policy Act/ Maryland Environmental Policy Act (NEPA/MEPA) design and planning process, includes environmental assessments for any project proposed within SHA right-of-way or utilizing state or federal funding. This includes projects granted Transportation Enhancement Program funds that are carried out by other jurisdictions. The environmental assessments determine the direction environmental documentation must take, whether Categorical Exclusion (CE), Finding of No Significant Impact (FONSI) or Environmental Impact Statement (EIS). Environmental assessments include landuse considerations, water use considerations, air use considerations, plants and animals, socio-economic, and other considerations.

Effort is made to avoid or minimize environmental impacts. If impacts are unavoidable, however, mitigation is provided and monitored per regulatory requirements.

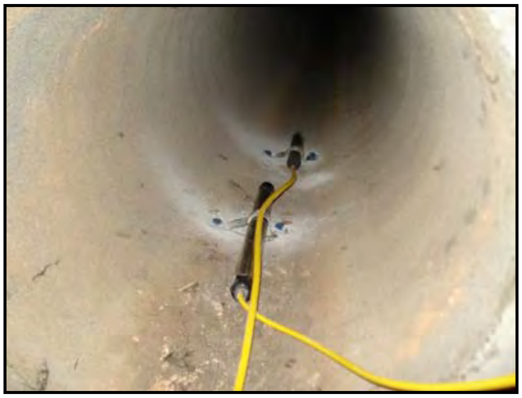
Environmental Research

In addition to the research studies mentioned above in Section D, Discharge Characterization, that target the pollutant removal characteristics of certain BMPs, SHA is also pursuing research and development studies to improve our understanding of the impacts certain BMPs have on the environment. Studies completed or under way include:

- **Mosquito Surveillance/Control Program** – This three-year study conducted by Millersville University for Maryland was concluded and the final report and conclusions were included in last year's annual report.

  In this study, SHA investigated the connection between West Nile Virus (WNV) transmission and stormwater management facilities. West Nile viral encephalitis is a zoonosis in which people and horses are incidentally infected by mosquitoes that feed on both bird and mammalian hosts. In 2002, there were thirty-one human WNV cases identified from nine counties in Maryland.

SHA is currently working to determine an appropriate follow-up study to ascertain our best course of action given the conclusions of the report.



Instrumentation at I-83 Underground Storage Facility Sites

- **Thermal Impact of Underground Stormwater Management Storage Facilities on Highway Stormwater Runoff** – The goal of the study is to identify and document the thermal reduction effects on stormwater in underground storage facilities. Three sites have been identified and monitoring equipment has been installed at two of the sites along I-83 in Baltimore County. Instrumentation has been installed to measure temperature at the inflow and outflow. Development of a predictive model will be investigated. Additional information for this study will be provided as it progresses.

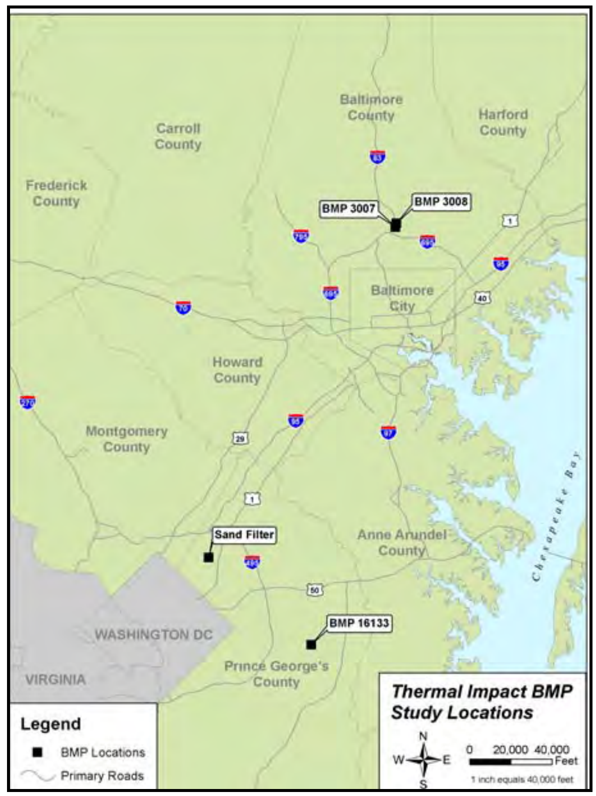


Figure 1-9 Thermal Impact Study Locations

- **Prediction of Temperature at the Outlet of Stormwater Sand Filters –** This study was begun in 2003 and the intent was to create a computer model or a sand filter BMP that will allow prediction of outlet temperature as a function of time. The approach is physics based, depending on energy and mass balances, and heat and mass transfer predictions.

The most significant finding in this study was that the predicted uniform flow that the model was based on was not the actual behavior of water in actual conditions. Rather than uniform flow, water tends to flow in channels or fingers through sand and other soils and this flow type is called preferential flow. This preferential flow resulted in less contact with sand particles and less transference of heat from the water to the sand. No further work on this predictive model is planned at this time.

E.2 Erosion and Sediment Control

Requirements under this condition include:

a) *Use MDE's 1994 Standards and Specifications for Soil Erosion and Sediment Control, or any subsequent revisions, evaluate new products for erosion and sediment control, and assist MDE in developing new standards; and*

b) *Perform responsible personnel ("green card") certification classes to educate highway construction contractors regarding erosion and sediment control requirements. Program activity shall be recorded on MDE's "green card" database and submitted as required in Part IV of this permit.*

E.2.a MDE ESC Standards

SHA continues to comply with Maryland State and Federal laws and regulations for erosion and sediment control (ESC) as well as MDE requirements for permitting. This includes implementing the *1994 Standards and Specifications for Soil Erosion* for all projects. We also comply with Federal NPDES construction ESC requirements by continuing to submit Notification of Intent forms to MDE for all projects that disturb over one acre and by posting the resulting NPDES Construction Permits at construction sites.

SHA ESC Quality Assurance Ratings

SHA continues to use our improved Quality Assurance rating system for ESC on all roadway projects. This effort improves field implementation of ESC measures by including an incentive payment to the contractor for excellent ESC performance or imposes liquidated damages on the contractor for poor ESC performance.

Quality Assurance Inspections Ensure Properly Installed and Maintained Erosion and Sediment Controls

SHA tracks QA inspections and ratings for reporting to our business plan (see Figures 1-10 and 1-11). In the first half of 2007, 99% of active construction projects were in compliance with ESC standards. Increased numbers of inspections and better documentation have improved the overall performance of our ESC program. In the first half of 2007, 1,105 inspections were conducted and documented for 110 active construction projects. That is about 10 inspections on average per construction site.

Incentive payments are made when the contractor receives an ESC rating score of 85 or greater. This incentive payment can be made quarterly on a project (every 3 months) for quarters that the project continues to receive 85 or greater ratings.

Liquidated damages are imposed on the contractor if the project receives a 'D' or 'F' rating. If two ratings of 'F' are received on a project, the ESC certification issued by SHA will be revoked from the contractor's project superintendent and the ESC manager for a period of 6 months and until they complete and pass the certification training. This system of rewarding good performance and penalizing poor performance is expected to greatly improve contractor responsibility for ESC practices and improve water quality associated with construction activities.

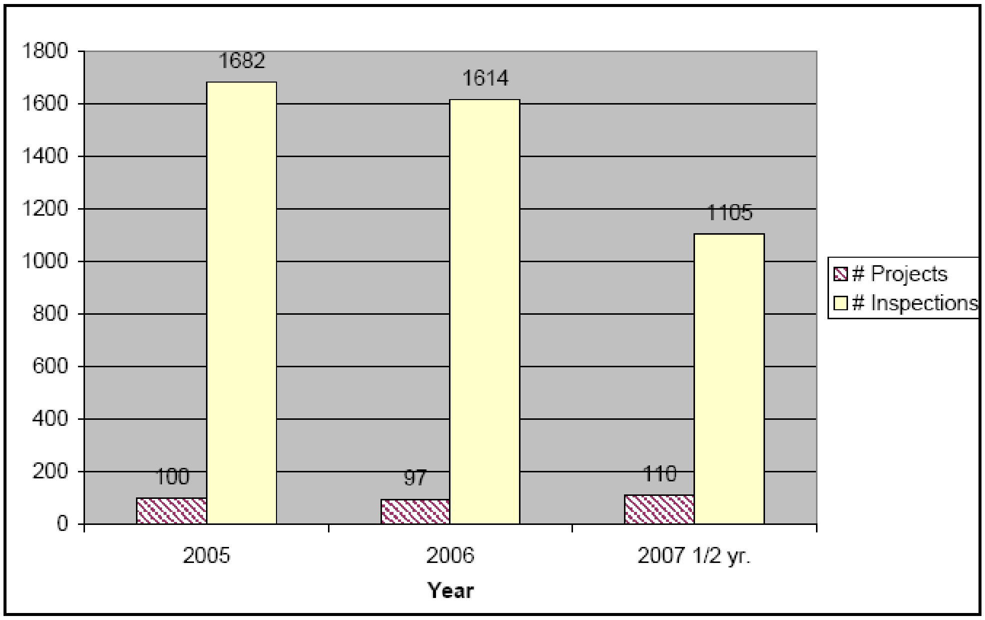


Figure 1-10 Number of SHA ESC Quality Assurance Inspections Compared to Number of Active Construction Projects

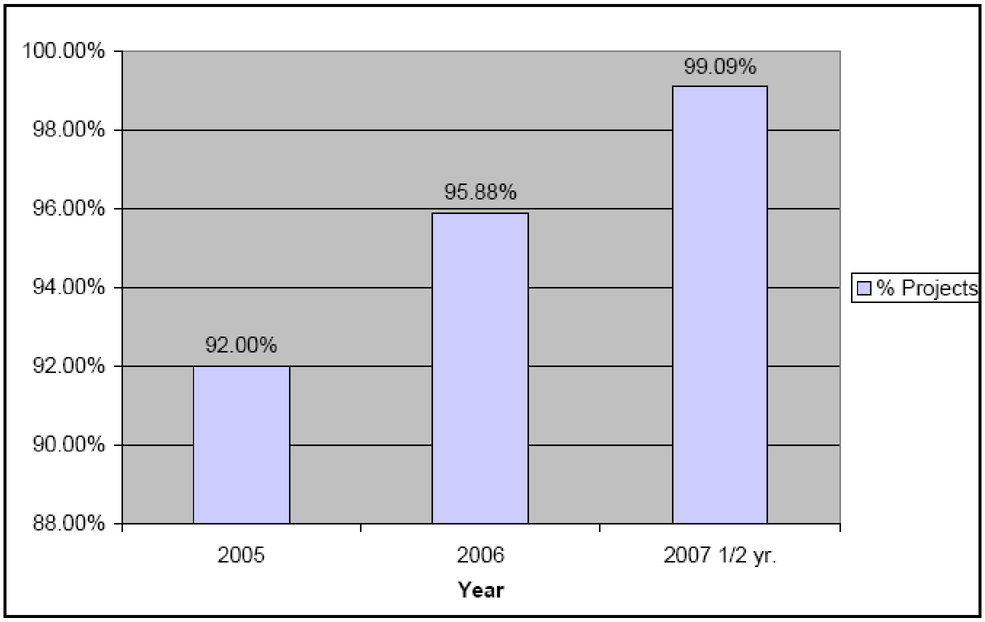


Figure 1-11 Percent of SHA Construction Projects in Compliance with SHA Quality Assurance Standard

Another improvement to our ESC efforts is that we are now requiring designers to provide offsets and stationing on the limit of disturbance (LOD) on ESC design plans. This will give the construction contractor information in order to accurately stake out and place the LOD in the field. Ultimately, this will provide better control of project disturbance.

Turf Acceptance Standard

In order to ensure that quality turf is established along SHA rights-of-way and thereby reduce erosion and improve slope stability, the SHA Landscape Operations Division (LOD) has developed a turf inspection and acceptance process. This process requires contractors to meet minimum turf coverage percentages in order to secure final release of the project for maintenance and final payment to the contractor

Poor Turf Establishment Increases Erosion

Quality Turf Improves Soil Retention

At the time of semi-final inspection the turf on the construction project is evaluated according to the criteria below.

- Areas flatter than 4:1 should exhibit:
    - 95% coverage of Permanent Seed Mix or *Sericea lespedeza* or Special Purpose Seed Mix; and
    - Dark green color
- Areas 4:1 and steeper (tracked with a bulldozer) should exhibit:
    - 95% coverage of vegetation with 50% coverage of Permanent Seed Mix or *Sericea lespedeza* or Special Purpose Seed Mix; and
    - Dark green color

SHA ESC Field Guide

The SHA Field Guide to Erosion and Sediment Control was completed and is being distributed to construction engineers, certified ESC managers and inspectors, and ESC designers. This field guide provides essential information in a manner that is easy to access and carry.

E.2.b Responsible Personnel Certification Classes (Green Card Training)

SHA continues to sponsore and perform training for ESC Responsible Personnel Certification Classes over the past year. This training is conducted by SHA for SHA personnel, consultants and contractors.

A copy of the database of trained personnel (MDE Table H, Responsible Personnel Certification Information) is included on the CD included as an attachment.

SHA Basic Erosion and Sediment Control Training (BEST)

In addition to Green Card Training classes, SHA developed and implemented its own ESC Certification Program at two levels. Level I is known as BEST (Basic Erosion and Sediment Control Training). This day and a half training is aimed at contractors and field personnel and focuses on in-depth discussions of ESC design, construction and permitting requirements. This is also a prerequisite for Level II training.

The Level II training is intended for ESC design professionals and course material has been developed. The Level II training began in June 2007.

Table 1-5 ESC Training Held by SHA (10/2006 to 9/2007)

Type of Training	No. of Participants
Responsible Personnel (Green Card)	900
BEST Level 1 (Yellow Card)	652
BEST Level 2 (Designer's Training)	39

E.3 Stormwater Management

The continuance of an effective stormwater management program is 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 and COMAR;*

b) *Implement a BMP inspection and maintenance program to inspect all stormwater management facilities at least once every three years and perform all routine maintenance (e.g., mowing, trash removal, tarring risers, etc.) within one year of the inspection; and*

c) *Document BMPs in need of significant maintenance work and prioritize these facilities for repair. The SHA shall provide in its annual reports detailed schedules for performing all significant BMP repair work.*

E.3.a Implement SWM Design Manual and Regulations

SHA continues to comply with Maryland State and Federal laws and regulations for stormwater management (SWM) as well as MDE requirements for permitting. We also continue to implement the practices found in the *2000 Maryland Stormwater Design Manual* and *Maryland Stormwater Management Guidelines for State and Federal Projects, July 2001* for all projects. Permitting needs are tracked for projects statewide through our Permit Tracker software tool.

E.3.b Implement BMP Inspection & Maintenance Program

Our continuing Stormwater Facility Program (managed by Ms. Dana Havlik) inspects, evaluates, maintains, remediates and enhances SHA BMP assets to maintain and improve water quality and protect sensitive water resources. Inspections are conducted every three years as part of the NPDES source identification and update effort (see Section C, above). Maintenance and remediation efforts are accomplished after the inspection data has been evaluated and ranked according to SHA rating criteria.

Details of the Stormwater Facility Program are included as Part 3 of this document. Discussion of inspection results and maintenance, remediation, retrofit and enhancement efforts undertaken over the past year is included in that section.

BMP Inspection Workshop held in 2007

As-Built Certification Process

SHA continues with our SWM Facility As-Built Certification Process. This process requires the design engineer to coordinate with MDE on the completion of as-built checklists and tabulations. The contractor is then required to inspect and certify the facility construction according to the approved design plans. Additional requirements are imposed upon the contractor by SHA that go above and beyond the certification required by MDE. This includes certification of facility plantings and permanent turf establishment. SHA has made the delivery of this certification a separate pay item. A copy of the revised As-Built Certification special provision was included in last year's report.

Copies of the final approved as-built certifications are retained by SHA and integrated into the storm drain and BMP GIS/database. This information is then used as source identification updates are planned and assigned.

E.3.c Document Significant BMP Maintenance

See Part 3 for SWM Facility Program updates on major maintenance, remediation and retrofits.

E.4 Highway Maintenance

Requirements under this condition include:

- *a) Clean inlets and sweep streets;*
- *b) Reduce the use of pesticides, herbicides, and fertilizers through the use of integrated pest management (IPM);*
- *c) Manage winter weather deicing operations trough continual improvement of materials and effective decision making;*
- *d) Ensure that all SHA facilities identified by the Clean Water Act (CWA) as being industrial activities have NPDES industrial general permit coverage; and*
- *e) Develop a "Statewide Shop Improvement Plan" for SHA vehicle maintenance facilities to address pollution prevention and treatment requirements.*

E.4.a Inlet Cleaning and Street Sweeping

Mechanical sweeping of the roadway is essential in the collection and disposal of loose material, debris and litter into approved landfills. This material, such as dirt and sand, collects along curbs and gutters, bridge parapets/curbs, inlets and outlet pipes. Sweeping prevents buildup along sections of roadway and allows for the free flow of water from the highway, to enter into the highway drainage system.

SHA sweeping standard is to ensure 95% of the traveled roadway is clear of loose material, with less than 1 inch in depth along curb and gutter of closed sections of roadways. In addition, our standard is also to ensure 90% of buildup of lose material along open sections of roadways does not exceed 1 ½ inches in depth along the shoulder.

In addition to street sweeping, SHA owns and operates four vacuum pump trucks that 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. This practice ensures safer roadways through ensuring proper drainage and improves water quality in Maryland's streams.

Vacuum Pump Truck

E.4.b Reduction of Pesticides, Herbicides and Fertilizers

SHA has standards for maintaining the highway system. One of these standards is the *SHA Integrated Vegetation Management Manual for Maryland Highways, October 2003* (IVMM). This manual incorporates the major 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.

Herbicide Application

Herbicides are selected based upon their safety to the environment and personnel, as well as for economical performance. In order to ensure that herbicides are applied safely to roadside target species, herbicide supervisory and application personnel are thoroughly trained, registered and/or certified by at least one of the following:

- University of Maryland
- Maryland Department of Agriculture
- SHA.

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 need for Nutrient Management Plans (NMP) is determined by SHA for all roadway projects according to State law (COMAR 15.20.04-08 – Nutrient Management Regulations). NMPs are developed by the Landscape Operations Division (LOD), Technical Resources Team (TRT) and the need for a NMP is at the discretion of the TRT.

The application of fertilizer is performed based upon soil sampling and testing for major plant nutrients such as phosphorus and potash. Once these plant nutrient levels are determined, a NMP is developed for both construction and maintenance. Certain major fertilizer nutrients are reduced due to adequate soil levels.

Mowing Reduction/Native Meadows

A major initiative at the SHA is to reduce the extent of mowed areas within our right-of-way. Along with this initiative, several pilot projects have been completed to install and maintain native meadow areas. Ultimately this practice will further reduce the need for fertilizer and herbicide application.

Before Meadow Establishment

After Meadow Establishment

E.4.c Winter Deicing Operations

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 at the conclusion of storm events, thus lessening the overall usage of deicers.

In addition, SHA has expanded 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.

Understanding Impacts of Deicing Chemicals

We are also pursuing research to understand the impact deicing chemicals have on surrounding ecosystems and organisms. See Section D, Discharge Characterization, for a list or resources we are studying.

Table 1-6. Winter Materials used by SHA

Material	Characteristics
Sodium Chloride (Rock and Solar Salt)	The principle winter material used by SHA. Effective down to 20° F and is relatively inexpensive.
Abrasives	These include sand and crushed stone and are used to increase traction for motorists during storms. Abrasives have no snow melting capability.
Calcium Chloride	A solid (flake) winter material used during extremely cold winter storms. SHA uses limited amounts of calcium chloride.
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.
Magnesium Chloride (Mag)	One of the primary liquid winter materials used by SHA for deicing operations. Freeze point of -26° F and proven cost-effective in the colder regions (northern and western counties).
Caliber M-100	Magnesium chloride based deicer with a corrosion inhibiting additive.
Potassium Acetate	A costly, environmentally friendly, liquid material used at SHAs two automated bridge anti-icing system sites in Allegany County.

E.4.d NPDES Industrial Permit Coverage

As discussed in the previous Annual Report, SHA has initiated the development and implementation of a Compliance Focused Environmental Management System (CFEMS). The CFEMS will utilize a structured, phased approach to support ongoing environmental compliance activities at SHA facilities as well as those conducted during routine operations. This effort will ultimately provide a uniform, SHA-wide system of procedures for decision-making and management of environmental compliance issues, including those related to Industrial NPDES at maintenance facilities.

The CFEMS will be developed and implemented in a phased approach over a five-year period. The initial phase of environmental assessments at SHA's primary maintenance facilities is complete. SHA has identified the primary maintenance facilities that qualify as industrial and obtained all NPDES industrial permit coverage where necessary. Subsequent phases will expand the CFEMS to other SHA facilities and operations. These facilities will be assessed for stormwater permitting needs at this time. Additional capital improvements that relate to stormwater pollution prevention will likely emerge from the CFEMS development efforts described above.

E.4.e Statewide Shop Improvement Plans

SHA continues to maintain an effective Industrial Stormwater NPDES Program to insure pollution prevention and permit requirements are being met at SHA maintenance facilities. As stated in the previous annual report, SHA performed detailed site assessments at maintenance facilities covered under an Industrial Discharge Permit in 2001 and 2005. Information gathered during these site assessments was used to prepare (2001) and update (2005) Stormwater Pollution Prevention Plans (SWPPP) and Spill Prevention, Control, and Countermeasure Plans (SPCCP) (2005).

The information from the detailed site assessments was also used to identify pollution prevention Best Management Practices (BMPs). See Appendix I for a summary of the BMPs for each maintenance facility. Pollution prevention training was also conducted in 2001 and 2005.

SHA initiated work in 2006 to upgrade both the SWPPPs and SPCCPs; pilot assessments and plans were development for two primary maintenance facilities. SHA has also initiated the creation of a document that will serve as the "Statewide Shop Improvement Plan". This strategic document will be incorporated into SHA's CFEMS and may reference documents and systems that are currently under development.

SHA continued to develop BMPs by designing and implementing capital improvements. Figure 1-6 summarizes the statewide status of the Industrial NPDES elements by District. The following details maintenance facility improvements since the last annual report.

Completed Projects:

- Environmental compliance assessments completed at all primary maintenance facilities as part of SHA's CFEMS.
- Washbay retrofit construction completed at Prince Frederick maintenance facility.
- Washbay treatment system upgrade advertised for Leonardtown maintenance facility.
- SWPPP and SPCCP upgrades at pilot sites complete (Frederick and Dayton).

Table 1-7 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
	Millington	General
3	Fairland	General
	Gaithersburg	General
	Kensington	General
	Laurel	General
	Marlboro	General
	Metro/Landover	General
4	Churchville	Individual – SW
	Golden Ring	General
	Hereford	Individual – SW
	Owings Mills	General
5	Annapolis	General
	Glen Burnie	General
	La Plata	General
	Leonardtown	Individual – SW
	Prince Frederick	General
6	Frostburg	General
	Hagerstown	General
	Hancock	General
	Keyser’s Ridge	Individual – GW
	Laval	General
	Oakland	General
7	Dayton	Individual – SW
	Frederick	General
	Thurmont	General
	Westminster	General
Offices / Other Facilities	Brooklandville Complex	General
	Hanover Complex	Individual – SW

Note: SW = Surface Water, GW = Groundwater

- Re-vegetation test plots constructed as the initial phase of salt contamination remediation for Stevensville maintenance facility.
- Stormwater management retrofit design complete for the Glen Burnie maintenance facility.
- UST inspection / inventory completed for maintenance facilities with vehicle fueling stations.

On-Going Projects:

- Statewide oil-water separator maintenance program.
- Statewide discharge sampling and reporting program for facilities with Individual Discharge Permits.

Initiated Projects:

- Stormwater management BMP re-inspections underway for maintenance facilities
- Battery Storage / Spill Kit procurement underway at maintenance facilities.
- 3rd round of SWPPP updates / Statewide Shop Improvement Plan under development.
- Washbay treatment system upgrade desing underway at Hereford maintenance facility.
- Erosion control design for eroded area at Annapolis maintenance facility.
- Grit Chamber assessment and upgrade design at Prince Frederick and Marlboro maintenance facilities.

Table 1-8 Capital Expenditures for Pollution Prevention BMPs

Fiscal Year	Expenditure
2005	$ 613,210 - actual
2006	$ 592,873 - actual
2007	$ 450,608 - actual
2008	$ 500,000 - anticipated

Table 1-8 shows SHA's capital expenditures towards industrial pollution prevention BMPs from the current and past two fiscal years. A list and schedule of the capital improvements identified at maintenance facilities is included as Appendix I.

E.5 Illicit Discharge Detection and Elimination

Requirements under this condition include:

a) Conduct visual inspections of stormwater outfalls as part of its source identification and BMP inspection protocols

b) Document each outfall's structural, environmental and functional attributes;

c) Investigate outfalls suspected of having illicit connections by using storm drain maps, chemical screening, dye testing, and other viable means;

d) Use appropriate enforcement procedures for eliminating illicit connections or refer violators to MDE for enforcement and permitting.

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

f) Annually report illicit discharge detection and elimination activities as specified in Part IV of this permit. Annual reports shall include any requests and accompanying justifications for proposed modifications to the detection and elimination program.

E.5.a Visual Inspections of Outfalls

Our previous efforts to address storm drain and outfall stability resulted in our developing the Storm Drain and Outfall Inspection and Remediation Program (SOIRP), headed by Mr. Brandon Scott, and associated protocol. At that time we placed the Illicit Discharge Detection and Elimination (IDDE) inspections into the same protocol. Based on feedback and observed confusion in our source identification and inspection workshops, we now believe that the SOIRP program should be a separate entity from the IDDE inspections.

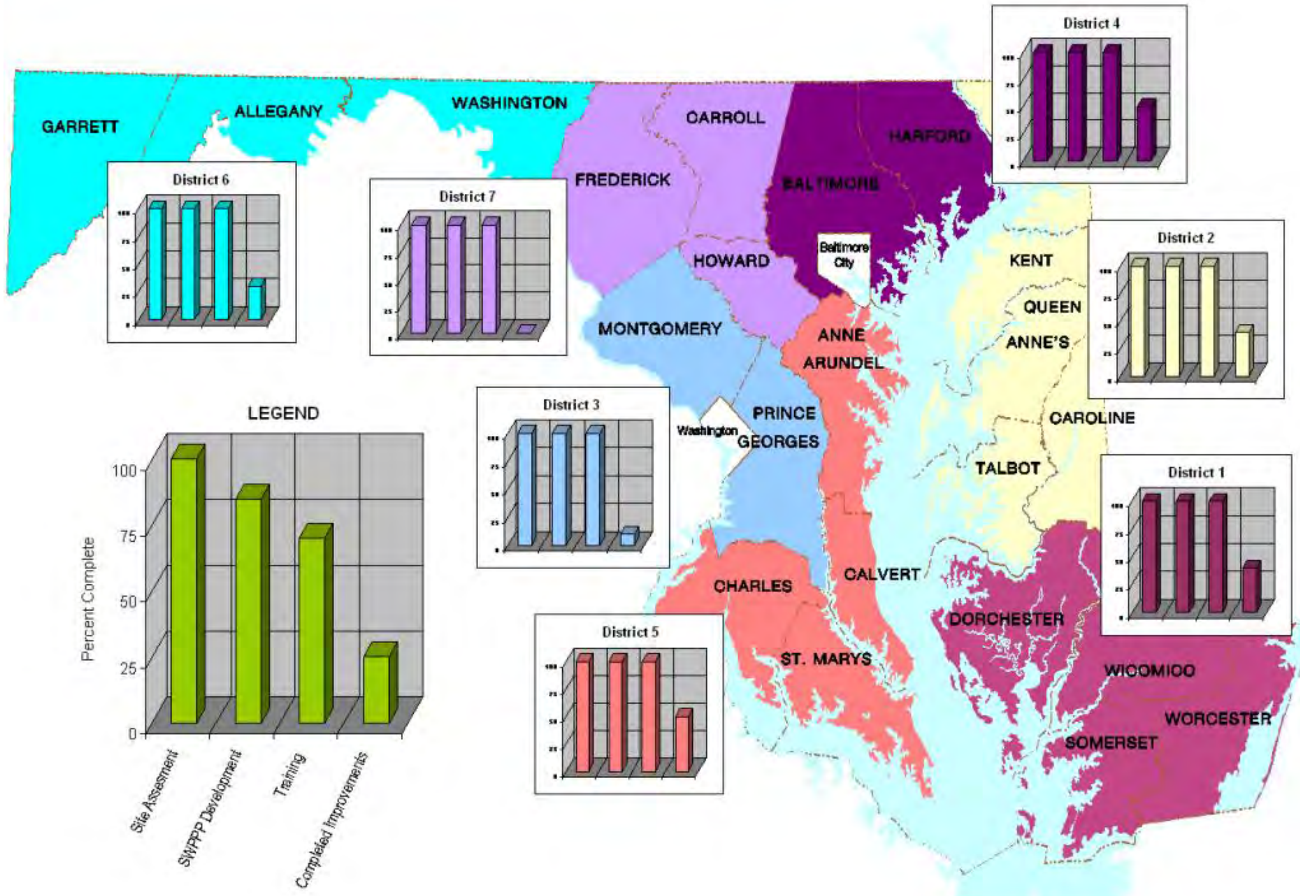


Figure 1-12 Industrial Stormwater NPDES Program Status – 2007

As part of the source identification training and workshops (see Section C.1.b, Data Compatibility) we are updating our standard procedures to provide for separate chapters for the IDDE and the SOIRP inspections. We will also develop distinct training modules for each of these programs.

The results of the SOIRP and IDDE inspections will facilitate separate types of actions and follow-up. The IDDE entails developing illicit discharge reports and delivering them to the local NPDES jurisdiction IDDE personnel. The IDDE activities would then involve following up with both the local jurisdiction and MDE on the disconnection of these illicit discharges.

The inspections for the SOIRP program will result in developing strategies for maintaining, repairing or otherwise remediating storm drain and outfall stabilization projects. The resulting remediation actions can be constructed through our open-end construction contracts, transportation enhancement fund projects or advertised projects.

The inspection form for the IDDE inspection will be developed using guidance in the IDDE Guidance Manual (October 2003) put out by the Center for Watershed Protection and the Outfall Reconnaissance Inventory (ORI) that is discussed in that manual.

Information from the EPA Webcast Series on IDDE is also useful for preparing our training material for the IDDE program. We have even acquired the video clips from IDDE 201 for use in our training. The revised training material should be completed in spring 2008.

EPA Video Clip for IDDE Inspections will be used in SHA IDDE Training

Table 1-9 Outfall Inspection Ratings

	Outfall Inspection Ratings							
County	No Rating	1	2	3	4	5	Total Inspected	Number of Pipes
Montgomery	354	558	7	17	22	4	962	15,429
Frederick	974	2,542	330	151	126	9	4,132	12,156
Baltimore	669	1,650	38	23	23	3	2,406	14,306
Harford	109	285	297	130	47	5	873	4,161
Howard	377	288	138	119	14	1	937	2,127
Charles[3]	74	49	19	4	1	1	74	4,029
Carroll[3]	129	1,162	124	99	62	19	1,595	5,538
Totals	**2,686**	**6,534**	**953**	**543**	**295**	**42**	**10,979**	**57,746**

Notes:
1. The outfall inspection program began halfway through the Baltimore Co. MS4 inventory and inspections. Therefore, approximately 50% of the pipes and outfalls were inspected for Baltimore Co.
2. Outfall inspections performed on pipes in Montgomery Co. addressed updates only, not all possible pipes.
3. Numbers for Charles and Carroll Counties not final. GIS development is on-going for these counties.

E.5.b Document each Outfall's Attributes

SOIRP outfall inspections are being conducted on the outfalls in Carroll and Charles Counties currently. Also, Anne Arundel and Prince George's County updates will begin this winter and this will include outfall inspection and documentation.

Inspections using the SHA SOIRP Program outfall inspection protocol were previously conducted on the five counties listed in Table 1-9, Montgomery, Baltimore, Frederick, Harford and Howard. Based on the needs determined from the inspections, SHA is currently in the design phase for Baltimore County and the evaluation phase for Harford County. Maps of the 20 sites in Baltimore County and 52 sites in Harford County that are being targeted along with a list of the sites are included in Appendix J. The current plan is for SHA to construct any repairs in Baltimore County using open-ended construction contracts. Once the Harford County sites are assessed, the feasibility of obtaining federal aid for any major repairs will be determined.

E.5.c Illicit Connection Investigations

During the last reporting period, there were a number of illicit discharge reports that needed followed-up. We had Greenman Pedersen, Inc. and Chesapeake Environmental Management, Inc. re-inspect the outfalls and illicit connections and develop updated reports for Frederick, Montgomery and Howard Counties. These reports are attached as Appendix K.

An Illicit Connection at MD 79 in Frederick County

E.5.d Use Appropriate Enforcement Procedures

We followed up with the findings by sending the Frederick County report to Frederick County NPDES contact, Shannon Moore, who agreed to follow up with the connections. We will also send the Montgomery and Howard County reports to the respective NPDES coordinators.

An updated summary of any actions taken and the ultimate resolution of the illicit connections will be included in subsequent annual reports.

Table 1-10 Illicit Discharge Screenings

County	Outfalls Screened	Outfalls w/ Flow Observed	Illicit Discharge Reports
Frederick	39	46	16
Harford	53	16	1
Howard	209	172	2
Montgomery	217	26	3
Charles[1]	74	27	0
Carroll[1]	145	167	10
Totals	**737**	**454**	**32**

Notes: 1. Information for Charles and Carroll Counties is not final. GIS Development is on-going in these counties.

E.5.f Annual Report Illicit Discharge Detection and Elimination Activities

A summary of illicit discharge detection and elimination activities for this report term is provided above. The MDE database Table G for Illicit Discharge Detection and Elimination is included on the attached CD.

E.6 Environmental Stewardship

Requirements under this condition include:

a) *Environmental Stewardship by Motorists*

   i. *Provide stream, river, lake, and estuary name signs and environmental stewardship messages where appropriate and safe,* *ii. Create opportunities for volunteer roadside litter control and native tree plantings; and*

iii. Promote combined vehicle trips, ozone alerts, fueling after dark, mass transit and other pollution reduction actions for motorist participation.

b) Environmental Stewardship by Employees

i. Provide classes regarding stormwater management and erosion and sediment control;

ii. Participate in field trips that demonstrate links between highway runoff and stream, river, and Chesapeake Bay health;

iii. Provide an environmental awareness training module for all areas of SHA;

iv. Provide pollution prevention training for vehicle maintenance shop personnel;

v. Ensure IPM instruction and certification by the Maryland Department of Agriculture for personnel responsible for roadside vegetation maintenance; and

vi. Promote pollution prevention by SHA employees by encouraging combined vehicle trips, carpooling, mass transit, and compressed work weeks.

E.6.a Environmental Stewardship by Motorists

SHA has implemented many initiatives that encourage or target public involvement and participation in water quality programs. These initiatives cover the areas of litter control, watershed partnerships, community planting efforts and public education.

SHA public involvement and participation initiatives for the past year include:

- **Annual Earth Day Celebration** – The SHA Earth Day Team sponsored the Fifth Annual Earth Day Celebration on Tuesday, April 24, 2007 at the SHA headquarters complex. The SHA NPDES program participated by preparing an educational exhibit and manning the booth to answer questions. This annual event organized by the SHA Office of Environmental Design brings many groups and environmental organizations together to highlight accomplishments and initiatives being undertaken by SHA and others. Programs such as Tree-mendous Maryland and the USFWS Bayscapes Program are included in the celebration.

  Distributing environmental literature and brochures at this event is a key method of disseminating information to the public. This year's Earth Day celebration was also accompanied by a clean up day on Wednesday, April 25th to remove litter and manage vegetation at the Bush River. During the Earth Day celebration volunteers were encouraged to help with the clean up.

- **Adopt-a-Highway Program –** This program encourages volunteer groups (family, business, school or civic organizations) to pick up litter along 1-3 mile stretches of non-interstate roadways four times a year for a two year period as a community service.

Table 1-11 Adopt-a-Highway Program

County	No. Groups Participated	Miles Adopted
Prince George's	38	26
Harford	47	97
Baltimore	130	136
Anne Arundel	16	21
Charles	23	529
Howard	23	23
Frederick	55	63
Carroll	56	89
Totals	388	984

- **Sponsor-a-Highway Program** – SHA has launched a two-year pilot program that allows corporate sponsors to sponsor one-mile sections of Maryland roadways. The Sponsor enters into an agreement with a Maintenance Provider for litter and debris removal from the sponsored segment.

Table 1-12 Sponsor-a-Highway Program

County	Miles Sponsored
Prince George's	92
Baltimore	80
Anne Arundel	95
Howard	35
Totals	302

- **Partnership Planting Program** – SHA develops partnerships with local governments, community organizations and garden clubs for the purpose of beautifying highways and improving the environment. Community gateway plantings, reforestation plantings, streetscapes and highway beautification plantings are examples of the types of projects that have been completed within the Partnership Planting Program. In 2006, 13 groups participated in community planting projects. In 2007, 11 groups participated in community planting projects. They planted a total of 323 trees and 230 shrubs.

- **Transportation Enhancement Program** – SHA Administers the Federal Highway Transportation Enhancement Program (TEP) for the State of Maryland. In this capacity, SHA looks for opportunities to share the potential benefits of applying for funding under this program with projects that fall under the eligible funding categories. There were thirteen projects in 2007, including four projects sponsored by SHA.

  The SHA sponsored project for 2007 within Phase I limits under the 'Mitigation of Water Pollution due to Highway Runoff" category includes:

  - I-97 Functional Upgrades to Sixteen Stormwater Management Facilities in Anne Arundel County (AA5355174)

  For potential projects that fall under the funding category 'Mitigation of Water Pollution due to Highway Runoff', SHA Highway Hydraulics Division takes the initiative with watershed groups, local municipalities, community groups and counties to encourage their participation in this program. SHA provides assistance to potential project sponsors by advising on proposal content, reviewing drafts and then providing guidance on Federal Aid requirements for construction document preparation and advertisement process.

- **Roadside Debris/Safety Campaign TEP Project** – The SHA Office of Communications is pursuing a highway safety and outreach initiative to educate the motoring public about the dangers and environmental consequences of roadside debris. Such debris along state highways can not only serve as the catalyst for crashes across Maryland but it is also harmful to the environment.

Billy Ripken Recorded Public Service Announcements for Debris Campaign

This effort has:

- Printed 25,000 anti-liter/roadside debris brochures for distribution at community events (i.e. Maryland State Fair, Maryland Municipal League, seatbelt safety checks and community fairs), with language translations in Spanish.
- Paid for media placement throughout the State, providing safety tips and environmental information. This included thirty to sixty second pubic service announcements which aired between April and September during various times and

targeting licensed drivers. Ads were also aired during sports events, such as Orioles baseball games, and outdoor community activities. Bill Ripken, previously of the orioles, recorded the public service announcements promoting this program.

  - Constructed an Anti-litter Interactive Display/Kiosk, designed for ages two to fifteen that demonstrates the perils of litter and debris and how it may impact the environment. The interactive display will be used by the Adopt-A-Highway program coordinators at local/ community events, shopping malls and schools.
  - Printed 500,000 bumper and window stickers for Maryland vehicles to be distributed at area restaurants with anti-litter messaging.

- **The 2007 Maryland Bay Game** – SHA participated as a contributor.

E.6.b Environmental Stewardship by Employees

SHA continues to provide environmental awareness training to its personnel and is committed to continuing these efforts in the future. We have provided updated statistics for these efforts through the following training programs below:

- **Graduate Engineers Training Program (GETP)** – This program provides training to all new SHA engineers and includes training concerning the MEPA/NEPA, Environmental Permitting, Stormwater Management, and Erosion & Sediment Control. In 2007, 78 individuals attended these modules including 29 who graduated on August 14, 2007.

- **OHD University** – This is an internal training program for the Office of Highway Development that provides detailed information on SWM, E&S and environmental permitting issues, including NPDES concerns. It is an annual program that targets new engineers in the office. In 2007, 53 individuals participated.

- **Statewide Vegetation Management Training (2007)** – This training provides annual vegetation management updates and 24 out of 28 shops participated in the training (one session per shop) with 147 people attending.

- **Annual Vegetation Management Conference (2007) –** This annual conference is sponsored by the Office of Environmental Design and the Maryland SHA Statewide Vegetation Management Team, and provides a forum for disseminating current information on topics such as invasive species eradication, nutrient management, stormwater management facility vegetation management, turf establishment, forest conservation, native meadow establishment, and herbicide application. Each SHA maintenance shop sends people to these conferences and in 2006, 69 people attended. The 2007 conference is scheduled for October 24 and numbers of attendees will be provided in the next annual report.

- **Environmental Awareness Training (Chesapeake Bay Field Trips)** – This training is provided to all new employees. These field trips demonstrate the link between highway runoff and its impact on streams, rivers and on the health of the Chesapeake Bay. In 2007, 76 individuals attended theses trips.

- **Maryland Department of Transportation (MDOT) Water Quality Policies and Water Quality Clearing House Web Page** – This is a continuing effort that provides information on department-wide water quality policies and other regulations applicable to transportation projects. This webpage is periodically updated with regulatory/policy changes and can be accessed at www.mdot.state.md.us and clicking on the Water Quality Clearinghouse link toward the bottom of the page. A copy of the MDOT water quality policy and brochure was attached to the Phase II NOI application that was submitted on January 14, 2005. We can provide additional copies upon request.

- **Environmental Permitting Training Tour** – Biennially the SHA headquarters environmental offices including Environmental

Planning, Highway Hydraulics Division, Environmental Programs Division, Landscape Architecture Division, Landscape Operations Division, and Cultural Resources Group, provide training on all environmental permitting requirements. This training is given to all levels of district office personnel including maintenance, construction inspection and special projects design. The training is also given to headquarters' personnel including construction, right-of-way, design divisions, access permits and project planning. It has also been added as a module in the Office of Highway Development University (OHDU) series of training classes and has been presented twice this year as part of that effort.

The goal of the training is to provide all SHA personnel with an understanding of environmental resources and requirements for avoiding and minimizing impacts, mitigating and obtaining permits. The training also details procedures and provides contacts for answering questions and assisting in processing information. Specific topics covered by the training are:

- NEPA/MEPA Processes;
- Cultural Resources;
- Environmental Justice;
- Wetlands, Waterways, FEMA and other water resources;
- NPDES Construction Permit, MS4 Phase I and Phase II Permits, Industrial Permits;
- SWM & ESC;
- Forest Conservation, Reforestation and Roadside Tree Law;
- Scenic Highways Initiative;
- Environmental Compliance for SHA-owned Facilities.

The training is scheduled to begin in the spring of 2008.

- **Employee Commuter Reduction Incentives** – 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 include flexible work hours allowing employees to work compressed workweeks reducing the total number of commuting days and miles.

Telecommuting, a recently implemented initiative, allows employees to work from a remote location (presumably at or close to home) and also reduces the number of commuting days and miles per week.

Car-pooling has been encouraged at SHA for many years and reduces the number of commuters on the road. SHA car-pooling incentives include prioritizing parking space allocation to those in a designated car pool and Administration assistance in locating a carpool within the employee's residential area through parking database.

Finally, employee ID badges allow free access to MTA mass transit including the Baltimore area subway, light rail and buses. This encourages the use of mass transit by SHA employees who live within the Baltimore area.

F Watershed Assessment

The watershed assessment effort described by the permit includes continuing to provide available geographic information system (GIS) highway data to permitted NPDES municipalities and MDE; completing the impervious surface accounting by the fourth annual report; retrofitting impervious areas with poor or no control infrastructure; and working with NPDES municipalities to maximize water quality improvements in areas of local concern.

F.1 GIS Highway Data to NPDES Jurisdictions and MDE

SHA continues to make all GIS highway data available to NPDES jurisdictions and MDE.

F.2 Complete Impervious Accounting by Fourth Annual Report

SHA will complete the Impervious Accounting by the fourth annual report, October 2009. See the work plan and schedule included in the discussion in Section C.3, Impervious Surface Account, above.

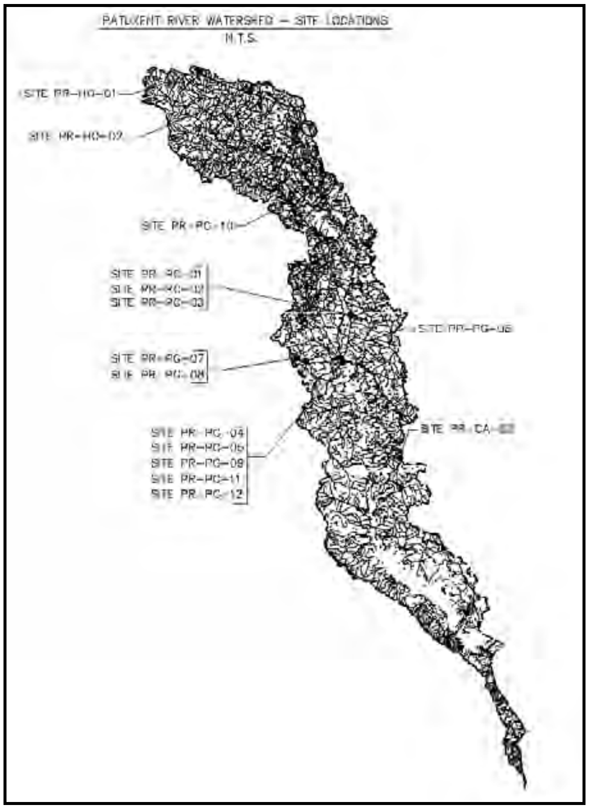


Figure 1-13 Potential Water Quality Sites in the Patuxent River Watershed

F.3 Impervious Area Retrofits

As we progress in the impervious area accounting process described in Section C.3, we will be identifying sites that prove suitable for developing as stormwater facilities to treat additional impervious surfaces in these counties. These efforts will be coordinated within a watershed, tributary strategy and TMDL perspective.

Additionally, as part of our Water Quality Banking Agreement with the MDE Sediment and Stormwater Division, SHA is actively pursing locating water quality retrofit sites in areas with poor or no runoff control infrastructure. A site search has been completed for the Patuxent River Area (02-13-11) and fourteen sites in Howard and Prince George's Counties have been identified. We are in the process of selecting sites to place into a design project with an anticipated advertisement date of spring 2009.

F.4 Maximize Water Quality Improvements in Areas of Local Concern

Because SHA is not a land planning and zoning entity, we do not have the authority or ability to generate and carry out priorities for individual watersheds. As part of this permit condition, MDE is requiring that we not only implement restoration efforts, but that we plug into the watershed restoration goals and priorities established by local NPDES jurisdictions. SHA proposed to pursue two specific activities over the last year in order to address this condition: begin a study for watershed-based decision process and document watershed goals and priorities.

EPA Green Highways Grant – Framework for Watershed Based SWM

During the last year, SHA continued work on the grant from EPA to develop a framework to implement a watershed-based approach to stormwater management as part of the Green Highways Partnership. The Green Highways Partnership connects diverse partners from all aspects of the infrastructure life cycle, from the design, construction, and maintenance to the governmental regulation and community outreach, and includes the EPA, SHA, and FHWA as key partners.

In the watershed-approach study, SHA will examine ways to implement a watershed decision-making process within SHA, local jurisdictions, and regulatory agencies. The primary focus of the study is from a transportation-centric view, however it is possible that the framework developed may have a wider range of applicability as the basis of the study is viewing the watershed holistically when planning and implementing stormwater management. The study emphasizes watershed restoration and preservation above-and-beyond minimum regulatory and NPDES requirements and promotes elements of green infrastructure.

For the first year of the study, SHA has completed a literature and data review and has compiled summaries of each document. The literature review was performed to determine how other frameworks have been developed as well as to determine if any previous work with watershed management has been performed, to what degree, and to what success level. A draft flow-chart has also been developed, demonstrating the task flow necessary to allow watershed-based stormwater management plans to work within the context of SHA's present process. This has allowed SHA to examine items that may already be in place to implement the framework as well as areas in which SHA must modify internal policy to adopt the framework.

Photo Courtesy of the Green Highways Partnership

Example from Green Highways Website Showing Green Components for Roadways

During the first year of the study, SHA also began an examination of four case studies. These case studies involve partnerships between SHA, local governments, and regulatory agencies to develop watershed-based management plans for several major highway projects. The case studies will be further examined to determine the effectiveness of the trials and incorporate appropriate steps or methods beneficial to the framework in development.

Two years remain of this three-year study and the end product will be a guideline document to implementing the watershed-approach framework and will include recommendations for future further studies, as well as a complete explanation on how the guidelines were developed.

Document Watershed Goals and Priorities

SHA as well as MDOT has been participating with other counties and jurisdictions in watershed efforts. During this past year SHA has contacted Montgomery County and met with them to discuss their NPDES program and watershed priorities.

Also, in applying for TEP funds (see Section E.6.a) for 'mitigation of water pollution due to highway runoff', SHA pursues support for the project from local jurisdictions. For the I-97 stormwater functional enhancements project we coordinated with Anne Arundel County and received a letter of support explaining how this project fits into their watershed planning efforts. Information concerning their watershed priorities including targeted watersheds for restoration, impacted sub-watersheds, Severn River stream assessment inventory and overall classification of sub-watersheds for restoration was included in the application for the funding.

G Watershed Restoration

Requirements for this permit condition include developing and implementing twenty-five significant stormwater management retrofit projects, contributing to local watershed restoration activities by constructing or funding retrofits within locally targeted watersheds, and submit annual report on watershed activities that contain proposals, costs, schedules, implementation status and impervious acres proposed for management.

G.1 Implement 25 Significant SWM Retrofit Projects

SHA currently has fifty-four enhancement projects in various stages of planning, design and construction. Documentation on these projects is included on the attached CD and includes contract drawings and bid tabulations (for projects that have successfully advertised and been awarded). Below is an abbreviated list of the proposed projects by watershed.

The new TEP project, I-97 Functional Upgrades, contains fourteen sites and these were added to the Patapsco River (02-13-09) and West Chesapeake (02-13-10) watersheds. The database for Table D, Watershed Restoration Project Locations, in the format required in Attachment A of the permit will be provided for these and future projects in subsequent annual reports.

Lower Susquehanna River – 02-12-02

1 BMP 12076, VEQ-S Enhancement

Bush River Area – 02-13-07

2 BMP 12069 – VEQ-S Enhancement
3 BMP 12072 – VEQ-S Enhancement
4 BMP 12073 – VEQ-S Enhancement
5 BMP 12075 – VEQ-S Enhancement
6 BMP 12081 – VEQ-S Enhancement
7 BMP 12082 – VEQ-S Enhancement

Gunpowder River – 02-13-08

8 Outfall Stabilization of Tributaries to Gunpowder Falls – Bioengineered outfall stabilization

Patapsco River – 02-13-09

9 BMP 2120 – Functional Enhancement
10 BMP 2121 – Functional Enhancement
11 BMP 2122 – Functional Enhancement
12 BMP 2150 – Functional Enhancement
13 BMP 3281 – VEQ-S Enhancement
14 MD 139 Tributary to Towson Run Stabilization – bioengineered stream stabilization
15 BMP 2111 – Functional Enhancement
16 BMP 2112 – Functional Enhancement
17 BMP 2098 – Functional Enhancement*
18 BMP 2099 – Functional Enhancement*
19 BMP 2476 – Functional Enhancement*
20 BMP 2477 – Functional Enhancement*
*New Projects Added

West Chesapeake Bay – 02-13-10

21 BMP 2019 – Functional Enhancement
22 BMP 2022 – Functional Enhancement
23 BMP 2027 – Functional Enhancement
24 BMP 2029 – Functional Enhancement
25 BMP 2031 – Functional Enhancement
26 BMP 2088 – Functional Enhancement
27 BMP 2481 – Functional Enhancement
28 BMP 2522 – Functional Enhancement
29 BMP 2273 – Functional Enhancement
30 BMP 2491 – Functional Enhancement
31 BMP 2185 – Functional Enhancement*
32 BMP 2198 – Functional Enhancement*
33 BMP 2201 – Functional Enhancement*
34 BMP 2203 – Functional Enhancement*
35 BMP 2204 – Functional Enhancement*
36 BMP 2205 – Functional Enhancement*
37 BMP 2206 – Functional Enhancement*
38 BMP 2208 – Functional Enhancement*
39 BMP 2210 – Functional Enhancement*
40 BMP 2211 – Functional Enhancement*
41 BMP 2220 – Functional Enhancement*
* New Projects Added

Patuxent River – 02-13-11

42 BMP 16059 – Functional Enhancement
43 BMP 16202 – Functional Enhancement
44 BMP 2488 – Functional Enhancement
45 BMP 16217 – Functional Enhancement
46 BMP 16219 – Functional Enhancement
47 BMP 16380 – Functional Enhancement
48 Unnamed Tributary to Rocky Gorge Reservoir adjacent US 29 – Stream Stabilization

Lower Potomac River – 02-14-01

49 BMP 16456 - Functional Enhancement

Washington Metropolitan – 02-14-02

50 16607 – Functional Enhancements
51 16609 – Functional Enhancements
52 16653 – Functional Enhancements
53 Long Draught Branch Restoration/ Stabilization – Stream stabilization

Middle Potomac River – 02-14-03

54 Tributary to Tuscarora Creek Stabilization at US 340 and US 50 – Stream Stabilization

G.2 Contribute to Local NPDES Watershed Restoration Activities

SHA often participates in and supports watershed interest groups and local jurisdictions in their activities. In addition, SHA has participated directly or indirectly in developing watershed plans as well as providing funding. The Maryland Department of Transportation's State Highway Administration oversees the federal Transportation Enhancement Program (TEP), which has awarded more than $173 million for 244 projects in Maryland since the TEP began in 1991

The following is a summary of such efforts undertaken during the report period:

- **Laurel Lakes Task Force – PG County**.The SHA project I-95/Contee Road Project (PG419A21) lies within the Bear Branch watershed and SHA participates on this Task Force. The goal of the group is to address sedimentation issues within the watershed.

  A field meeting was held July 30, 2007 to assess SHA's involvement in the watershed restoration efforts. SHA has agreed to provide monitoring equipment at the downstream side of I-95 culvert at Bear Branch in order to assess the effect our roadway project has on the watershed. We will also continue to attend task force meeting and update the group on the project as it progresses and provide input on the overall watershed restoration efforts.

  As a member of the task force, SHA will be coordinating our stormwater design efforts with the other members including PG county and the City of Laurel.

- **Weems Creek Watershed – AA County.** The previously SHA funded watershed assessment study for Weems Creek is currently being used as a case study in the EPA grant to develop a framework to implement a watershed-based approach to stormwater management (discussed in Section F.4). The Navy-Marine Corps Memorial Stadium project, a TEP project the SHA recommended for award (for construction of ponds and bioretention facilities) was completed construction in 2006. The Porter Drive outfall stabilization in Annapolis, a TEP project the SHA recommended for award, was completed in 2005.

- **South River Federation – AA County.** The BMP upgrade projects mentioned in the last annual report were delayed to address in-stream issues.

- **Whitehall Creek Watershed – AA County.** SHA worked with the county to prepare a watershed assessment study and actively participated in a multi-agency effort to address watershed water quality concerns in this watershed. SHA is supporting this project through the TEP review process for construction of various stream segments at the head of the watershed as well as significant stabilization from the US 50 interchange at MD 279 up to the point of tidal influence. Currently, the project is under design by the county. SHA has previous recommended this project for TEP funding award.

- **Cowhide Branch Stream Restoration and Fish Passage Project – AA County.** This project, located near US 50 and Best Gate Road involves removing a fish passage barrier, reducing in-stream velocities and abating erosion within the Cowhide Branch stream channel. It also involves the replacement of an eroded outfall associated with a SHA stormwater pond. SHA assisted in the TEP application process, provided technical review, will assist the county in our access permit review process. We recommended this project for funding award in 2007.

- **MD 213 Stormwater Retrofit for Gravel Run South – (Corsica River, not Phase 1)** Although not a phase I jurisdiction, the Corsica watershed is a special initiative by the Governor to implement tributary strategies and a Watershed Restoration Action Strategy (WRAS). SHA supported this project and recommended it for TEP funding award in 2007.

Table 1-13 SHA Funding or Other Support for Watershed Restoration Projects

Project	Watershed	SHA Funded	Federal TEP Funded	Other SHA Support
Navy-Marine Stadium SWM Facilities	Weems Creek		$590,665	• TEP Process Support • Recommended for Award
Porter Hall Outfall	Weems Creek		$202,000	• TEP Process Support • Recommended for Award
Stream Stabilization	Whitehall Creek		$619,000	• TEP Process Support • Recommended for Award
Cowhide Branch Stream Restoration and Fish Passage	Cowhide Branch	Waived R/W Fee	$1,000,000	• TEP Process Support • Access Permit Review • Technical Review • Recommended for Award
MD 213 Stormwater Retrofit for Gravel Run South	Corsica River		$133,050	• Access Permit • Technical Review and Comment • Recommended for Award
I-95 Stream Monitoring at Laurel Lakes	Bear Branch/ Patuxent River	$343,708		• Participating Member of Laurel Lakes Task Force • Funding & supplying monitoring at I-95 & Bear Branch
SHA Sponsored Watershed Restoration TEP Projects:				
Stony Run at US 40 Fish Passage Project	Bush River	$90,957	$90,957	Funded 2007
Trib. to Rocky Gorge Reservoir (US 29)	Patuxent River	$262,158	$262,158	Funded 2006
Stony Run Fish Passage and Stream Enhancement	Bush River	$710,851	$710,851	Funded 2005
Trib. to Tuscarora Creek (MD 340)	Middle Potomac	$289,812	$289,812	Funded 2005
Gunpowder Falls Tributaries – Stream Stabilization	Gunpowder River	$475,000	$475,000	Funded 2005
Trib. to Towson Run (MD 139)	Patapsco River	$452,485	$452,485	Funded 2004

G.3 Report and Submit Annually

SHA will submit information on our watershed restoration activities including retrofit proposals, costs, schedules, implementation status and impervious acres proposed for management. This information will be included in subsequent reports.

H Assessment of Controls

This condition requires that SHA develop a proposal and receive approval for a watershed restoration project by October 21,2006, develop and receive approval for a monitoring plan that should include chemical, biological and physical monitoring according to specified in the permit, and submit date annually.

H.1 Restoration Site Approved by October 21, 2006

The Long Draught Branch Restoration Project is our approved watershed restoration site. We have coordinated with both the City of Gaithersburg and Montgomery County in the development of this project. We included a detailed description of the project and watershed in our last report and we will provide a summary of progress in this report.

Progress Update

Long Draught Branch Restoration Project is on schedule for Final design submission and distribution in mid-September. A second submission to MDE Sediment and Stormwater Plan Review for erosion and sediment control is also planned for the same time frame. Three weeks of review are anticipated with a late November/early December Plans, Specifications and Estimate (PS&E) submission.

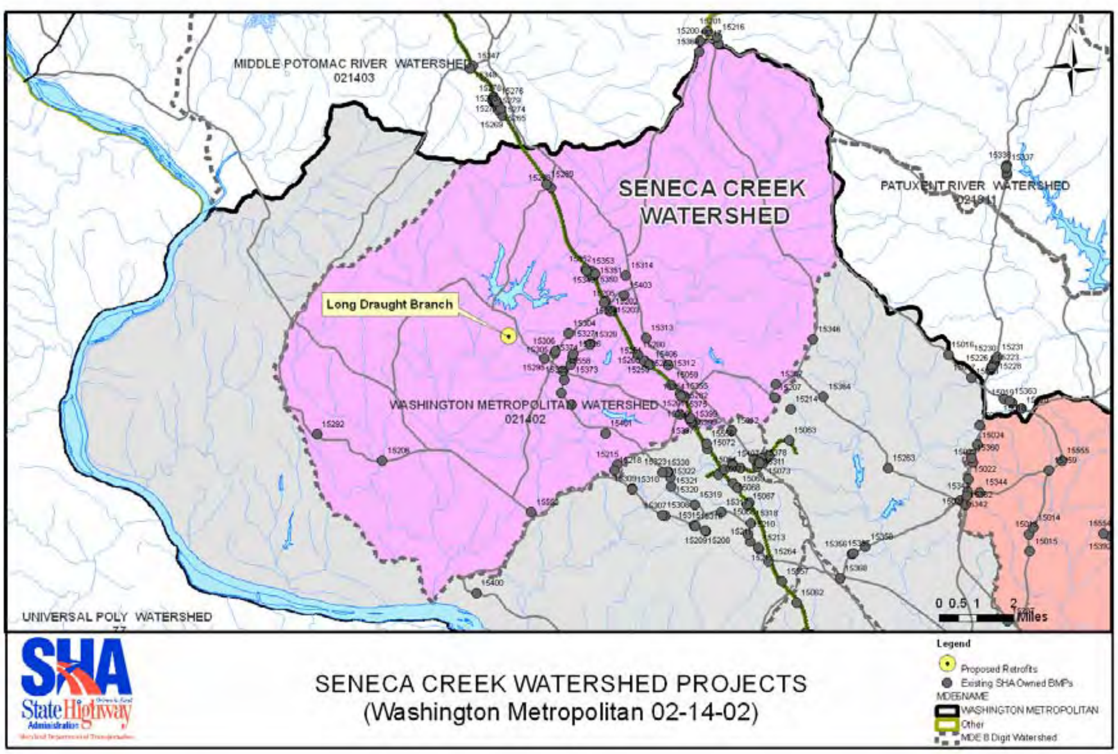


Figure 1-14 Long Draught Branch Project and SHA Owned BMPs within Seneca Creek Segment

Upon completion of the PS&E review, the bid documents will be compiled for construction advertisement in January, 2008. With the stream closure period from March to June, actual construction will not begin until mid-June, 2008. Construction will be ongoing through the summer with final plantings to be completed through the fall and into the winter months.

H.2 Monitoring Plan

SHA has included the results of the chemical monitoring in Appendix K. This monitoring period contained only nine total events; of those, three were storm events.

While it is difficult to draw conclusions based on so few sampling events, differences in concentrations for several constituents varied significantly when comparing base flow (dry weather) samples and storm samples. Concentrations of BOD, Phosphorous, and TSS were significantly higher during storm events.

Pollutant concentrations also varied between upstream and downstream chemical monitoring sites for Phosphorous, Lead, TSS, and Ammonia, with elevated concentrations at the downstream location. Since the chemical monitoring location near Rabbit Road is downstream of the end of the reach, and with the Gaithersburg Maintenance Facility in close proximity to that monitoring location, it is recommended that an additional chemical monitoring site be added at the downstream end of the stream reach.

Physical monitoring has not been performed to date. All three stations will be evaluated this fall during leaf-off and as close to the construction commencement as possible. A Rosgen Level I & II will be performed to characterize existing conditions of the project reach.

The annual monitoring report for the Long Draught Branch project is included in Appendix L.

H.3 Annual Data Submittal

Monitoring data has been included in the formats requested as Table E and F in Attachment A of the Phase I permit. These are included on the attached CD.

I Program Funding

This condition requires that a fiscal analysis of capital, operation and maintenance expenditures necessary to comply with the conditions of this permit be submitted, and that adequate program funding be made available to ensure compliance.

Available Funding

SHA has procured open-end consultant contracts in the amount of $9 million in order to accomplish both the current Phase I and Phase II NPDES permits. We have also programmed about $6 million annually through funds managed by the Highway Hydraulics Division for NPDES compliance and commitments. This annual allotment includes $2.4 million for NPDES programmatic activities such as illicit discharge detection and elimination, stormwater Best Management Practices (BMP) and storm-drain inspection, impervious area accounting, geodatabase development and program management. An additional $774,000 is allocated annually for routine BMP maintenance and $3.4 million is allocated annually for outfall, watershed and BMP retrofits. This funding and contract work has set the stage for the next four years of NPDES commitments.

In addition to the funding commitment from this office we also use State Planning and Research funds, Transportation Enhancement Program funds and SHA Operations and Maintenance funds in completing NPDES requirements.

Table 1-14 Capital Expenditures for NPDES at SHA

Fiscal Year	Expenditure (Millions)
2005	$ 3.4
2006	$ 7.26
2007	$ 5.74

Required Fiscal Analysis Data

Currently, SHA tracks spending for the entire NPDES program and breaks out a few items such as NPDES Stormwater Facility Program and industrial activities. We do not currently track many of the requested areas such as street sweeping, inlet cleaning or database maintenance as separate expenditures.

According to our current records, the total spent from State Fund 74 for MS4 NPDES and BMP Programs plus Industrial NPDES are listed in Table 1-14, above.

J Total Maximum Daily Loads

The permit states that MDE has determined that owners of storm drain systems that implement the requirements of this permit will be controlling stormwater pollution to the maximum extent practicable. Therefore, satisfying the conditions of this permit will meet waste load allocations specified in Total Maximum Daily Loads (TMDL) developed for impaired water bodies.

SHA is working closely with MDE on TMDL efforts with guidance from Mr. Brian Clevenger, head of the NPDES Program and Mr. James George, head of the Water Quality Restoration and Protection Program. Also SHA recently, met with Mr. Richard Eskin, Director of the Science Services Administration, and discussed implementation efforts by MDE and how they relate to SHA, viewed his presentation on TMDL and obtained contacts and other reference material to increase our knowledge and understanding of how future TMDL implementation and strategies will happen on the watershed level. We also discussed Tier II streams and the anti-degradation policy contained in COMAR 26.08.02.04.

One issue we are struggling are a few discrepancies between the Maryland Chesapeake Bay watershed divisions used in the MDE TMDL development effort and tributary strategies efforts (10 basins) and the watershed divisions used by the MDE Sediment and Stormwater Plan Review department for water quality banking (16 basins). This is of concern because we desire to integrate our water quality banking and impervious accounting with any watershed TMDL strategies implemented in the future and with current tributary strategies from the Bay Program.

Table 1-15 Maryland Chesapeake Bay Watersheds

10 Tributary Basins (TMDL)	16 Watershed Basins (WQ Banking)
Choptank	Choptank 02-13-04 (part)
Lower Eastern Shore	Choptank 02-13-04 (part)
	Nanticoke 02-13-03
	Pocomoke 02-13-02
Lower Potomac	Lower Potomac 02-14-01
Lower Western Shore	West Chesapeake 02-13-10
Middle Potomac	Wash Metro 02-14-02
Patapsco Back	Patapsco 02-13-09
Patuxent	Patuxent 02-13-11
Upper Eastern Shore	Elk 02-13-06
	Chester 02-13-05
Upper Potomac	Middle Potomac 02-14-03
	Upper Potomac 02-14-05
	North Branch Potomac 02-14-10
Upper Western Shore	Gunpowder 02-13-09
	Bush 02-13-07
	Lower Susquehanna 02-12-02

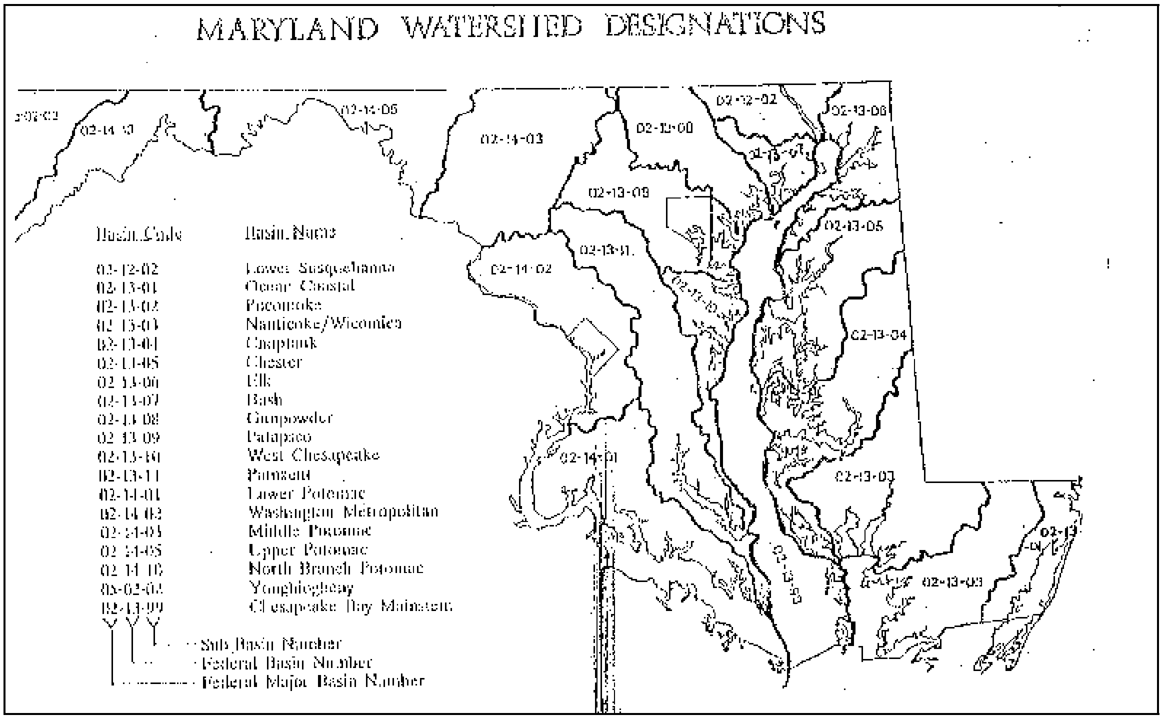


Figure 1-15 Maryland Watershed Designations from MDE Water Management Administration

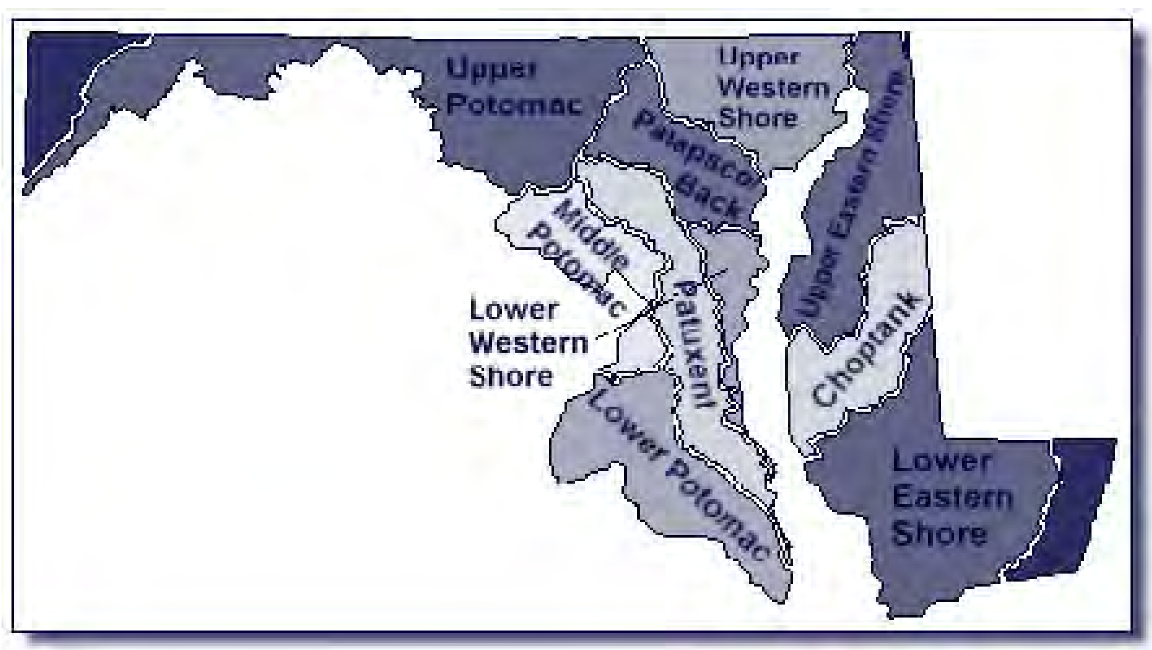


Figure 1-16 Tributary Team Basin Designations from Chesapeake Bay Tributary Strategy Statewide Implementation Plan (Page 4)

We are utilizing the MDE web site on TMDL implementation, have coordinated with Kenny Miller and are in the process of acquiring TMDL and Impaired Waters GIS information. We have also received data and mapping of Tier II stream segments from Bridget Hill. This information will be useful for overlaying with future SHA projects and in the development of the Framework for Watershed-Based Stormwater Management discussed in Section F.3.

As SHA works with local jurisdictions, TMDL related efforts within those watersheds will be added to our process. SHA will evaluate and prioritize SWM BMP retrofits in the watersheds where TMDLs are established along with our needs to retrofit existing failing facilities.

SHA has also been an active participant in the efforts to remove the Corsica River watershed from the 303(d) list of impaired waters. Although this is not a Phase 1 location, this watershed is Maryland's model watershed and SHA has taken an advisory position in working with Ms. Danielle Lucid and Mr. Adam Rettig of MDE and the town manager of Centreville.

SHA has also participated in prioritizing stormwater retrofits identified in the Corsica watershed through the Watershed Restoration Action Strategies (WRAS) program. Examples include a recently funded stormwater retrofit to treat significant amounts of highway runoff and some adjoining impervious areas in the town of Centreville. The project is under design and is expected to advertise for construction in 2008.

Similarly, SHA has participated in executive council meetings relating to the Anacostia Watershed Steering Committee and sub-committees led by Mr. Steve Pattison of MDE. As part of this effort, SHA has looked at our involvement and compiled a listing of our past environmental efforts within that area including wetland mitigation, stream restoration and stormwater BMPs. As work progresses in addressing watershed needs by the steering committee, SHA will determine project opportunities that fall into identified watershed priorities. This will work to ensure that the efforts of the watershed stakeholders happen in concert.

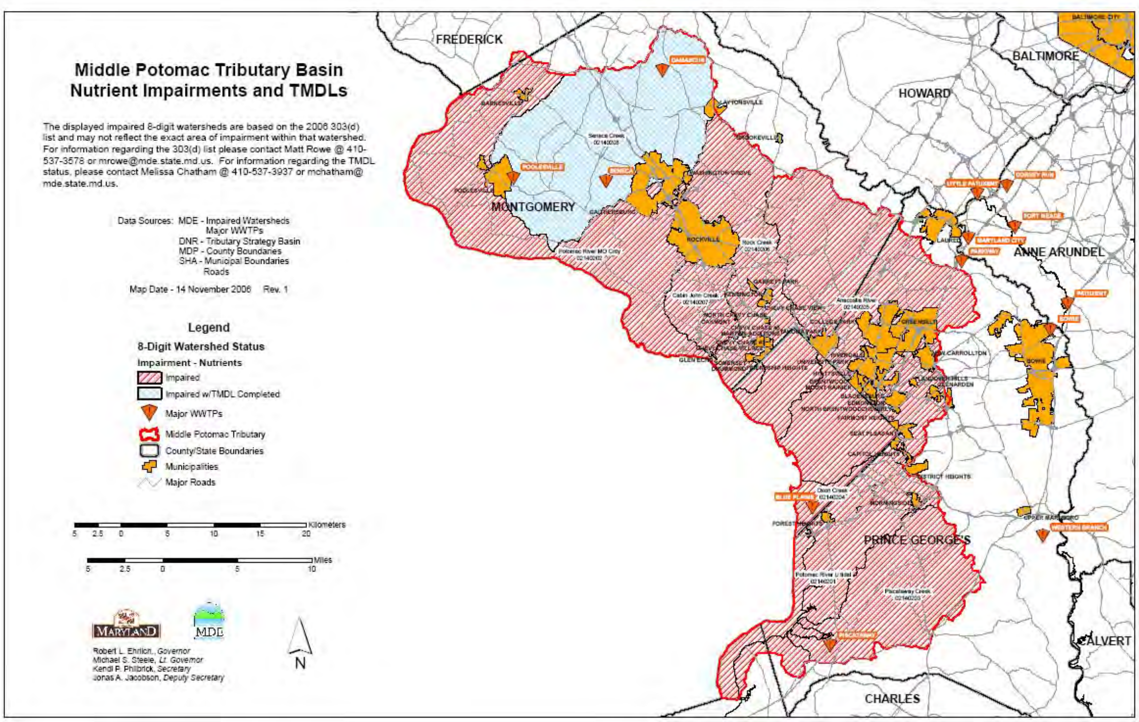


Figure 1-17 Middle Potomac Tributary Basin – Nutrient Impairments & TMDL

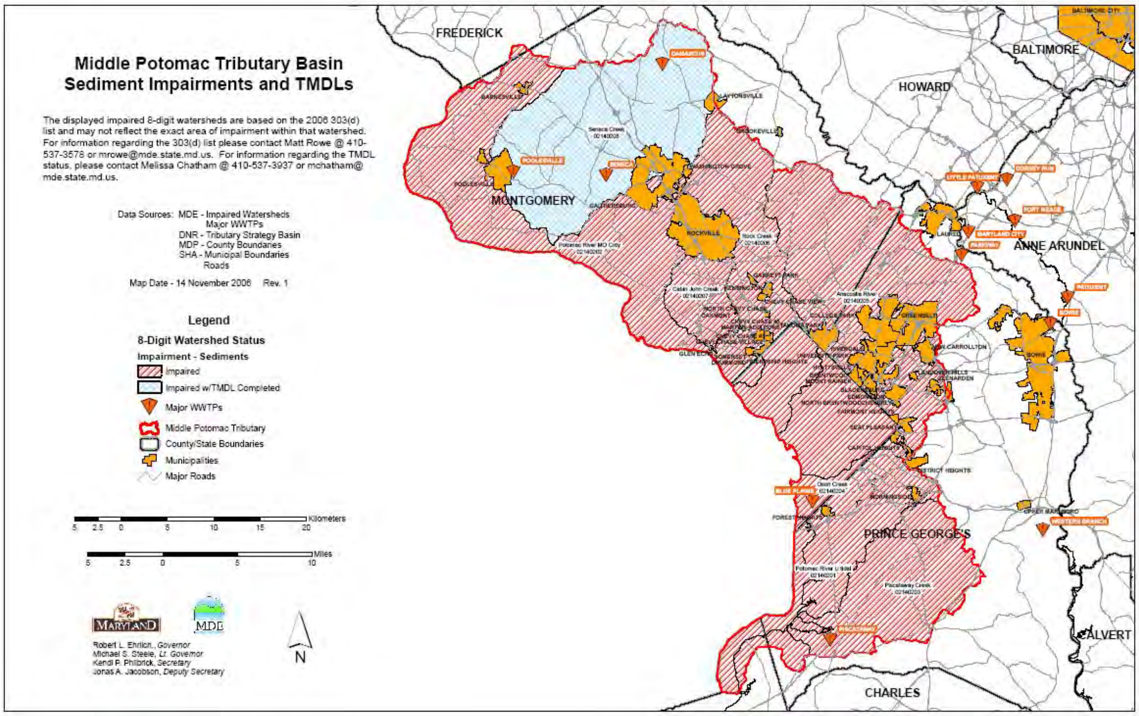


Figure 18 **Middle Potomac Tributary Basin – Sediment Impairments & TMDL**

PART TWO

Special Programmatic Condition

This section addresses the special condition contained in Part V. of the permit that reads:

> *Since the signing of the Chesapeake Bay Agreement in 1983, Maryland has been working toward reducing the discharge of nutrients and sediments to the Chesapeake Bay. SHA's highway network traverses all ten of the Bay's major tributaries in Maryland. This NPDES permit encourages the SHA to coordinate with localities specified in Part I.B. of this permit and assist with the implementation of the Tributary Strategies designed to meet the nutrient and sediment reduction goals.*

SHA is committed to reducing the discharge of nutrients and sediments to the Chesapeake Bay. The fact that the State and Federal highway networks traverse all the major Bay tributaries in Maryland points out the important role we have in impacting the success of statewide tributary strategies. In Part One of this report, we discuss in detail our many efforts underway to keep the Chesapeake Bay perspective in view while at the same time plugging into local watershed level activities. Here, we discuss efforts on a state, regional or national level.

Urban Stormwater Work Group (USWG)

SHA is a participating member of the Urban Stormwater Work Group. The USWG is a Chesapeake Bay Program committee that is a combination of the Nutrient Subcommittee and the Toxics subcommittee and seeks to address issues related to the prevention and reduction of chemical contaminants, nutrients and sediment from urban and suburban runoff. As a participating member, SHA is particularly aware of the challenges in establishing the BMP efficiencies for the Bay Model. The USWG work plan focuses on the following five initiatives:

- Stormwater Directive Implementation,
- Tributary Strategies Development, Implementation and Modeling Support,
- Low Impact Development (LID) and Environmental Site Design (ESD),
- Maintenance of Urban Stormwater BMPs,
- Innovative Technologies.

Green Highways Partnership (GHP)

SHA has been a founding partner in the Green Highway Partnership, an effort sponsored by EPA, FHWA and SHA. The mission of the GHP is:

> "Through concepts such as integrated planning**,** regulatory flexibility**,** and market-based rewards**,** GHP seeks to incorporate environmental streamlining and stewardship into all aspects of the highway lifecycle."

SHA early involvement of the Green Highway Initiative included:

- Executive Session, College Park, MD, Nov 2005 – Participated in roundtable planning effort.
- Green Highways Forum, College Park MD, Nov 2005 – Moderated sessions, lead workshops, presented.

Recent Involvement in Green Highways Partnership includes:

- Anacostia Executive Charette, College Park, MD, Nov 2006 – Participated in executive meeting intended to begin a dialogue on restoring the Anacostia watershed.
- US 301 Green Highways Charrette, April 2007 –US 301 is targeted to be the first

green highway project. Three components of the green highway recognition are watershed based stormwater management, recycle/reuse and environmental design and protection.

- Framework to Implement a Watershed Based Approach to SWM – Grant from GHP through EPA. This is discussed in Part One in Section F.4.

Chesapeake Bay Tributary Strategies

As active members of the Chesapeake Bay watershed, SHA is also active in the tributary strategies published by the Maryland Department of Natural resources in the document *Maryland's Chesapeake bay Tributary Strategy Statewide Implementation Plan, August 2, 2007*. Under other state initiatives to address the implementation gaps, SHAs involvement is described as:

Maryland State Highway Administration (SHA) – Transportation Components

New Erosion/Sediment Control Program
SHA has launched new erosion and sediment control policies that took effect on all SHA projects advertised after April 1, 2006. Changes to the program provide for: • New incentives and revise liquidated damages for erosion and sediment control; • Mandatory enhanced training and certification requirements for inspectors, contractors, designers, and engineers, including SHA personnel, over and above the MDE "Green Card" training; • Improved limit of disturbance labeling on construction plans; and • An improved E&S rating form for Quality Assurance (QA) inspectors.

Environmental Monitors
Several MDOT agencies employ separate Environmental Monitors for large, complex or design/build projects to work closely with all parties to inform and resolve issues as they arise.

Green Highways Partnership
SHA is a leader and active participant in the Green Highways Partnership, a proactive approach to improving the environmental performance of highways and their integration into watersheds through coordination with local governments and the private sector. Green highways are defined by an effort to leave the project area "better than before" through community partnering, environmental stewardship, and transportation network improvements in safety and functionality. What this means differs from project to project, and location to location and SHA has partnered with EPA to define the Green highway parameters for stormwater management. In this capacity, SHA is involved in demonstration projects promoting innovative stormwater management practices. These include developing a watershed-based approach for managing stormwater (through a grant initiative with EPA) and partnering with Prince George's County and the Chesapeake Bay Alliance to implement a decision support model that operates as a guiding principle for stormwater concept development.

In addition to their transportation mission, SHA is a supporter of watershed based stormwater management. They define this vision of stormwater management as a concept that recognized that highways coexist with other land uses in watersheds, and a collaborative approach with others by providing an opportunity for highway agencies to plan and deliver stormwater management that is not only a better fit for the watershed, but is also sustainable, exhibits improved visual quality and is cost effective.

SHA has created a GIS database in response to NPDES requirements and this tool has proved useful in supporting the Green Highway initiative by allowing GIS analysis tools to be employed in establishing and responding to watershed priorities. The result is improved monitoring of the system overall, improved effectiveness of stormwater management on a local and statewide level, and better decisions making for future facilities.

Transportation Enhancement Program
In addition to the management of stormwater on construction projects MDOT, supports the use of the Transportation Enhancement Program (TEP) to fund watershed improvement projects, such as stream restorations, fish blockage removal, wetland restorations and stormwater retrofits. Since 2000 the TEP has funded 30 such proposals, both by local governments and as SHA projects.

Green Infrastructure
SHA is working with DNR and other resource agencies in using Maryland's Green Infrastructure (GI) Program to assist in decision making under the National Environmental Policy Act (NEPA). Through the assessment and mapping of existing natural lands, DNR identifies the areas that are most valuable in providing ecosystem services, such as cleaning the air, filtering and cooling water, storing and cycling nutrients, sequestering carbon, and protecting areas against storm and flood. The GI process also identifies land cover "gaps" that can be targeted for restoration. In the planning process for major projects, such as improvements to U.S. 301 through Waldorf, green infrastructure

assessment and mapping is assisting planners in avoiding the most ecologically valuable land during the selection of projects alternatives. As project planning progresses, the GI process can be used to enhance mitigation of necessary impacts by identifying ecologically significant land for conservation and targeting impaired areas for restoration.

Continuing Commitment

The initiatives and collaboration discussed above and throughout this document testify to our concern for the survival of this valuable resource, the Chesapeake. Our commitment is in the hope that it can endure to grace the lives of generations to come.

PART THREE

Stormwater Management Facilities Program

3.1 Introduction

This section of the report summarizes Maryland SHA's Stormwater Management (SWM) Facilities Program activities between October 2006 and October 2007.

Based on the latest estimates SHA owns about 2,240 stormwater management (SWM) facilities statewide that were constructed since the early 1980's. Since 1999, SHA has managed a comprehensive program to locate, inspect, evaluate, maintain and remediate BMPs to sustain their functionality, improve water quality, and protect sensitive water resources.

The program's primary goal is to maintain SHA's stormwater facilities to operate as designed and to strategically enhance their functions to meet today's stormwater standards. The SWM Facilities Program consists of four major components:

- Identification, inspection and database development to manage SHA assets,
- Maintenance and Remediation of BMPs,
- Visual and environmental quality enhancements, upgrades and retrofits,
- Monitoring, research and technology tools development.

The program focuses on the remediation and enhancement of BMPs. This effort requires continuous improvement of the BMP inspection procedures, data management system, tools to track the performance and remediation actions. SHA has developed a prioritization system for remedial activities, and to develop new technologies for repairing or retrofitting BMPs including visual and functional enhancement projects. A part of the SWM Facilities Program is research on performance and efficiency of commonly used BMPs.

3.2 Inventory and Inspection

The following section summarizes the inspection system and inventory results to provide a status of SHA-owned SWM facilities.

3.2.1 Inspection Protocol

The key to an efficient maintenance program is a detailed and consistent inspection assessment. Therefore, SHA had updated the BMP inspection manual that became a Chapter 3 of the NPDES Standard Procedures Manual.

Performance Rating

The initial assessment of a SWM facility is a field inspection where individual parameters are *scored* (on scale 1 to 5) then used to establish an overall BMP performance rating:

A **No Issues** – BMP functioning as designed with no problem conditions identified. There are no signs of impending deterioration.

B **Minor Problems** are observed, however, BMP is functioning as designed.

C **Moderate Problems** are observed, however BMP is functioning as designed, but some parameters indicate the performance and functionality are compromised.

D **Major Problems** are observed, and facility is not functioning as designed. Several issues may exist that have compromised the BMP performance or indicate failure

E **Severe Problems** – exist, and facility is not functioning as designed with several critical parameters having problem conditions. BMP facility shows signs of deterioration and/ or failure. Remedial action should be performed immediately.

The inspection protocol is summarized in the recently updated guidance document "*Best Management Practice Field Inspection & Collection Procedures*", dated August 2007. The manual documents the methodologies used in the field for identifying, locating, and inspecting SWM facilities statewide. SHA has expanded the protocol to include criteria for visual quality as well as inspection for potential water quality and visual enhancements.

SHA Remediation Rating

SHA performs qualitative evaluation for maintenance and remediation by assigning the remedial rating. This is based on the overall initial inspection rating, performance, functionality, integrity and visual appearance; and also scope and complexity of the potential remedial work:

I **No Response Required** – schedule for multi-year inspection.

II **Minor Maintenance** – perform as necessary to sustain BMP performance. Upon remedial action and re-inspection, can be candidate for multi-year inspection.

III **Major Maintenance or Repair** – is needed to return the site to original functionality within the existing footprint of the facility. Structural defects require repair and/or restoration.

IV **Retrofit Design** – is required on-site or at another location, since BMP cannot be returned to its original functionality within its existing footprint.

V **Immediate Response** – is mandatory to address any public safety hazards regardless of the functionality of the BMP.

VI **Abandonment** – of the BMP when the facility is not maintainable and will not provide sufficient benefits if retrofitted due to the lack of access for construction and maintenance, limited space or minimum impervious area treated.

3.2.2 Inventory

BMP Inventory is being performed countywide on SHA's roadways in Maryland jurisdictions with Phase I and II MS4 permits, and on a district-level. Table 3-1 summarizes total number of BMPs identified in each County and SHA District. Figure 3-1 provides a statewide status of the SWM Program in terms of identification, inspection and remediation as of October 2007.

Table 3-1 Current Statewide SWM Facility Inventory Summary

District	County	No. BMPs	Totals
1	Dorchester	24	139
	Somerset	10	
	Wicomico	78	
	Worchester	27	
2	Caroline	3	114
	Cecil	3	
	Kent	5	
	Queen Anne's	101	
	Talbot	2	
3	Montgomery	267	530
	Prince George's	263	
4	Baltimore	167	276
	Harford	109	
5	Anne Arundel	613	746
	Calvert	15	
	Charles	107	
	St. Mary's	11	
6	Allegany	37	66
	Garrett	11	
	Washington	18	
7	Carroll	47	369
	Frederick	75	
	Howard	247	
State			**2,240**

BMP inventories are being constantly updated as remediation and retrofit projects are completed. In some instances, SWM may be replaced, consolidated, retrofitted, constructed or re-constructed by private developer to serve as a Joint Use facility. In order to track pending changes in BMP inventory, SHA keeps improving the internal process and database management tools. As the inventory spans statewide major efforts of inspection and maintenance are strategically expedited in NPDES counties.

3.2.3 Field Inspection

The BMP inventories in counties listed under Phase I and II MS4 jurisdictions in the SHA NPDES Permit are being performed as part of the source identification. In addition, SHA is inventorying and inspecting BMP in non-MS4 counties. SHA previously completed the inspections in Montgomery, Howard, Anne Arundel, Prince George's, Queen Anne's, Baltimore, Harford, Garrett, Allegany, Washington and Frederick Counties. Inventory and inspections are also underway in Carroll and Charles Counties, re-inspections are currently being preformed in Anne Arundel and Prince Georges Counties. The remedial rating for each inspected county is summarized in the Table 3-2.

This year SHA has initiated statewide inventory and inspections of SWM facilities located at SHA maintenance shops and salt dome areas. It is estimate about 50-70 BMPs will be located and inspected. The SHA shops BMP inventory will be merged with the current database in spring 2008.

Table 3-2 SWM Facilities Remedial Ratings Summary by County

Type of BMP	Number Inspected	Rating				
		I	II	III	IV	V
Allegany County						
Detention	**10**	2	0	8	0	0
Extended Detention	**13**	6	0	3	4	0
Retention	**4**	2	2	0	0	0
Infiltration Basin	**0**	0	0	0	0	0
Infiltration Trench	**5**	5	0	0	0	0
Shallow Marsh	**0**	0	0	0	0	0
Other	**5**	5	0	0	0	0
Totals	**37**	**20**	**2**	**11**	**4**	**0**
Anne Arundel County						
Detention	**46**	39	1	2	4	0
Extended Detention	**6**	5	0	1	0	0
Retention	**46**	35	1	6	4	0
Infiltration Basin	**54**	25	0	2	27	0
Infiltration Trench	**269**	154	60	12	43	0
Shallow Marsh	**2**	2	0	0	0	0
Other	**1**	1	0	0	0	0
Totals	**424**	**261**	**62**	**23**	**78**	**0**

Table 3-2 SWM Facilities Remedial Ratings Summary by County

Type of BMP	Number Inspected	Rating				
		I	II	III	IV	V
Baltimore County						
Detention	**27**	22	3	3	0	0
Extended Detention	**4**	3	0	1	0	0
Retention	**19**	15	1	1	2	0
Infiltration Basin	**34**	25	0	2	7	0
Infiltration Trench	**71**	36	5	2	28	0
Shallow Marsh	**7**	6	1	0	0	0
Other	**5**	4	1	0	0	0
Totals	**167**	**110**	**11**	**9**	**37**	**0**
Frederick County						
Detention	**11**	4	6	1	0	0
Extended Detention	**4**	1	3	0	0	0
Retention	**18**	9	5	3	1	1
Infiltration Basin	**12**	2	6	4	0	0
Infiltration Trench	**25**	10	4	10	1	0
Shallow Marsh	**1**	0	1	0	0	0
Other	**4**	1	1	2	0	0
Totals	**167**	**27**	**26**	**23**	**1**	**1**
Garrett County						
Detention	**1**	1	0	0	0	0
Extended Detention	**2**	2	0	0	0	0
Retention	**2**	0	1	1	0	0
Infiltration Basin	**0**	0	0	0	0	0
Infiltration Trench	**4**	4	0	0	0	0
Shallow Marsh	**0**	0	0	0	0	0
Other	**2**	2	0	0	0	0
Totals	**11**	**9**	**1**	**1**	**0**	**0**
Harford County						
Detention	**14**	8	3	3	0	0
Extended Detention	**5**	3	0	2	0	0
Retention	**8**	5	2	1	0	0
Infiltration Basin	**20**	12	5	3	0	0
Infiltration Trench	**59**	28	11	5	15	0
Shallow Marsh	**3**	3	0	0	0	0
Other	**0**	0	0	0	0	0
Total	**109**	**59**	**21**	**14**	**15**	**0**

Table 3-2 SWM Facilities Remedial Ratings Summary by County

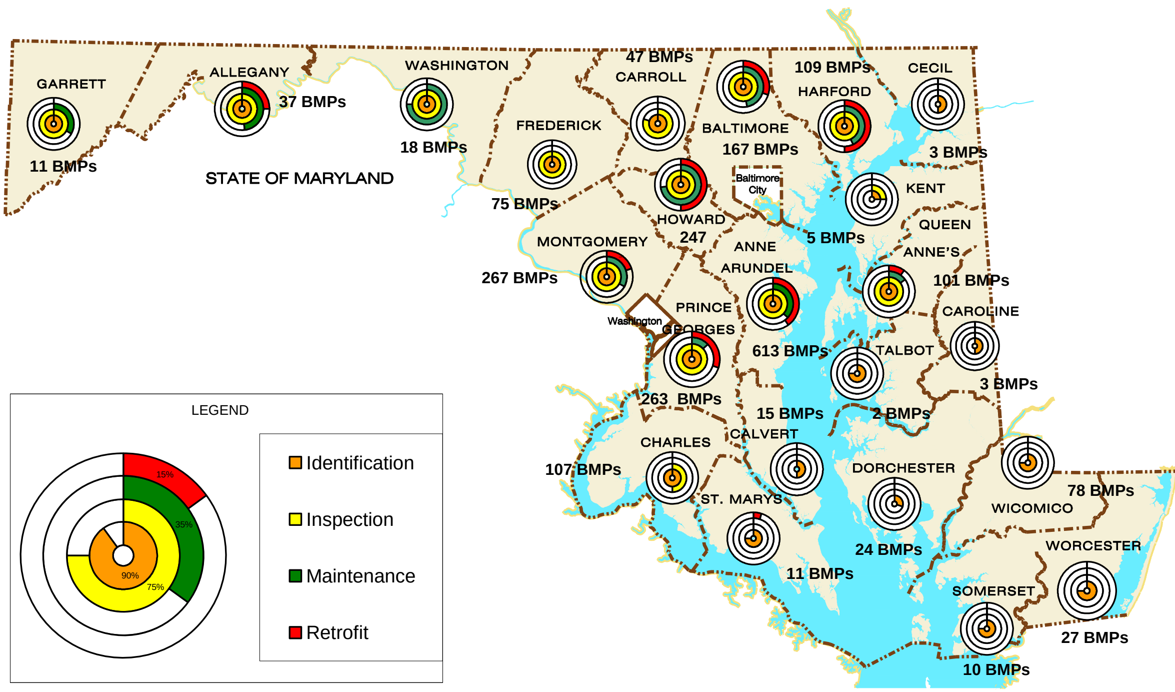
Type of BMP	Number Inspected	Rating				
		I	II	III	IV	V
Howard County						
Detention	**13**	13	0	0	0	0
Extended Detention	**28**	25	0	3	0	0
Retention	**24**	21	1	2	0	0
Infiltration Basin	**17**	9	0	0	8	0
Infiltration Trench	**103**	72	0	6	25	0
Shallow Marsh	**16**	16	0	0	0	0
Other	**22**	18	1	3	0	0
Totals	**247**	**198**	**2**	**14**	**33**	**0**
Montgomery County						
Detention	**31**	14	6	19	2	0
Extended Detention	**25**	16	2	7	0	0
Retention	**47**	14	10	21	2	0
Infiltration Basin	**20**	8	2	9	1	0
Infiltration Trench	**118**	72	1	34	11	0
Shallow Marsh	**7**	3	1	2	1	0
Other	**19**	13	1	0	2	0
Totals	**11**	**140**	**26**	**82**	**19**	**0**
Prince George's County						
Detention	**13**	10	1	1	1	0
Extended Detention	**4**	2	1	0	1	0
Retention	**35**	30	2	2	1	0
Infiltration Basin	**16**	12	1	2	1	0
Infiltration Trench	**84**	32	24	9	19	0
Shallow Marsh	**23**	21	1	1	1	0
Other	**5**	5	0	0	0	0
Totals	**180***	**111**	**30**	**15**	**24**	**0**
Queen Anne's County						
Detention	**2**	0	1	1	0	0
Extended Detention	**0**	0	0	0	0	0
Retention	**16**	7	0	8	1	0
Infiltration Basin	**1**	0	0	1	0	0
Infiltration Trench	**8**	5	0	2	1	0
Shallow Marsh	**11**	7	1	3	0	0
Other	**63**	0	63	0	0	0
Totals	**101**	**19**	**65**	**15**	**2**	**0**

Table 3-2 SWM Facilities Remedial Ratings Summary by County

Type of BMP	Number Inspected	Rating				
		I	II	III	IV	V
Washington County						
Detention	**7**	7	0	0	0	0
Extended Detention	**0**	0	0	0	0	0
Retention	**2**	2	0	0	0	0
Infiltration Basin	**2**	0	0	1	1	0
Infiltration Trench	**4**	1	0	1	2	0
Shallow Marsh	**0**	0	0	0	0	0
Other	**3**	2	0	1	0	0
Total	**18**	**12**	**0**	**3**	**3**	**0**

* This inventory includes only inspected and rated BMPs. Additional facilities have been identified since the last inspections cycle.

Figure 3-1 Statewide SWM Facilities Program Status



3.3 Maintenance & Remediation

This section summarizes the status of SHA maintenance and remedial responses to deficiencies identified through the inspections of SWM facilities. The program's primary goal is to keep SHA stormwater facilities operating as designed and to strategically enhance their functions. The responses are separated between routine maintenance major maintenance and retrofit projects. Figure 3-1 shows the status of the remediation responses by either maintenance or retrofit/enhancement design.

3.3.1 Routine Maintenance

Routine maintenance is generally considered a repair activity that addresses minor issues. The objective is to maintain performance of a BMP and/or to avoid deterioration of specific BMP elements. SWM facilities that require routine maintenance are assigned "II" rating by SHA.

SHA has currently completed most of routine maintenance in many of the inspected counties using two $1.5 million Open Ended Maintenance contracts that were advertised during the summer 2005. These contracts perform both routine and major maintenance on the average of every 24 months. Due to an extensive workload, routine maintenance tasks are completed by a contractor selected through a competitive bidding process rather then SHA Office of Maintenance crews. However, once the statewide inventory/ inspection database and full cycle of maintenance are completed, the SWM routine maintenance tasks may be managed by individual SHA District maintenance offices.

Table 3-3 lists the number of facilities requiring routine maintenance and the total number that were maintained since the last report to this date. The Table 3-4 summarizes the routine maintenance cost by county between October 2006 and October 2007.

SHA is also developing a new SWM Facilities Design, Operate and Maintain Program. Innovative contracting bid document will be prepared and advertised to select DBOM (Design-Built-Operate-Maintain) team through the competitive bidding process. The team consisting of a private consulting company and a contractor will be responsible for a county wide inspections, inventory database updates, SWM facilities maintenance and remediation, possibly retrofits design, permitting and construction with specific performance goals.

Table 3-3 Minor Maintenance Summary

County	District	BMPs for Maintenance	BMPs Maintained 10/2006.to 10/20007
Allegany	6	2	11
Anne Arundel	5	62	9
Baltimore	4	11	0
Frederick	7	26	0
Garrett	6	1	4
Harford	4	21	26
Howard	7	2	17
Montgomery	3	26	52
Prince George's	3	30	0
Queen Anne's	2	65	0
Washington	6	0	9
Total		**246**	**128**

Table 3-4 Minor Maintenance Cost
Year 2006 / 2007

Funding Allocation	Funding Amount
Allegany County	$2,992.00
Anne Arundel County	$5,660.00
Garrett County	$1,558.00
Harford County	$29,309.00
Howard County	$24,190.00
Montgomery County	$47,787.00
Washington County	$4,056.00
Total	**$115,552.00**

3.3.2 Major Maintenance

SHA performs major maintenance tasks that address significant deficiencies at BMPs through the time & material open ended contract lead by Highway Hydraulics Division. The intent is to restore performance of a BMP and/or to avoid failure of specific elements. SWM facilities that require major or remedial maintenance are assigned a "III" rating by SHA. Figure 3-2 shows an example of SWM Facility requiring major maintenance.

Figure 3-2 SWM Pond Major Maintenance

SHA continues performing detailed field assessments for BMPs identified for major maintenance. A workorder and a summary report is prepared for each BMP that provides sketches using as-built plans, photographs, cost estimate, repair recommendations, specifications MOT.. Figure 3-3 shows one of the most common repairs – SWM pond outfall stabilization.

Major maintenance is underway in all inspected counties. Table 3-5 lists the total number of facilities requiring major maintenance and the total number that were maintained between October 2006 and October 2007. Table 3-6 summarizes the associated costs in each county.

Figure 3-3 SWM Pond Outfall Stabilization at BMP 13347

Table 3-5 BMP Major Maintenance Summary

County	District	BMPs for Major Maintenance	BMPs Maintained 10/06-10/07
Allegany	6	11	1
Anne Arundel	5	23	1
Baltimore	4	9	18
Frederick	7	20	0
Garrett	6	1	0
Harford	4	14	0
Howard	7	14	27
Montgomery	3	82	1
Prince George's	3	15	4
Queen Anne's	2	15	0
Washington	6	3	0
Total		**207**	**52**

Table 3-6 Major Maintenance Cost
Year 2006 / 2007

Funding Allocation	Funding Amount
Allegany	$6,167.00
Anne Arundel County	$1,456.50
Baltimore County	$41,109.58
Howard County	$51,734.13
Montgomery County	$285.00
Prince George's County	$26,448.17
Total Costs	**$127,200.38**

3.3.3 Infiltration Trench Remediation

SHA continues remedial actions for infiltration trenches since they represent almost half of SHA's current SWM facilities inventory. The infiltration trenches were originally designed to provide water quality treatment for the first ½ in runoff based on the older MDE design standards. Nearly half of inspected the trenches have been identified as failed or requiring remediation.

Field inspections also identified a significant number of trenches located throughout various counties without an observation well. In order to determine the functionality of the trench, a test pit has to be excavated. If the trench was more than 50% full of water, no observation well is being installed, and the trench is considered for abandonment or retrofit. If the trench is sufficiently dry an observation well is installed. Figures 3-4 and 3-5 show an installation of monitoring well by the SHA contractor.

Figure 3-4 Installation of Infiltration Trench Monitoring Well and Media Replacement for BMP 3195 in Baltimore County

Figure 3-5 Installation of Infiltration Trench Monitoring Well and Media Replacement before, during and after for BMP 3135 in Baltimore County

3.3.4 SWM Retrofits, Visual and Functional Enhancement Projects

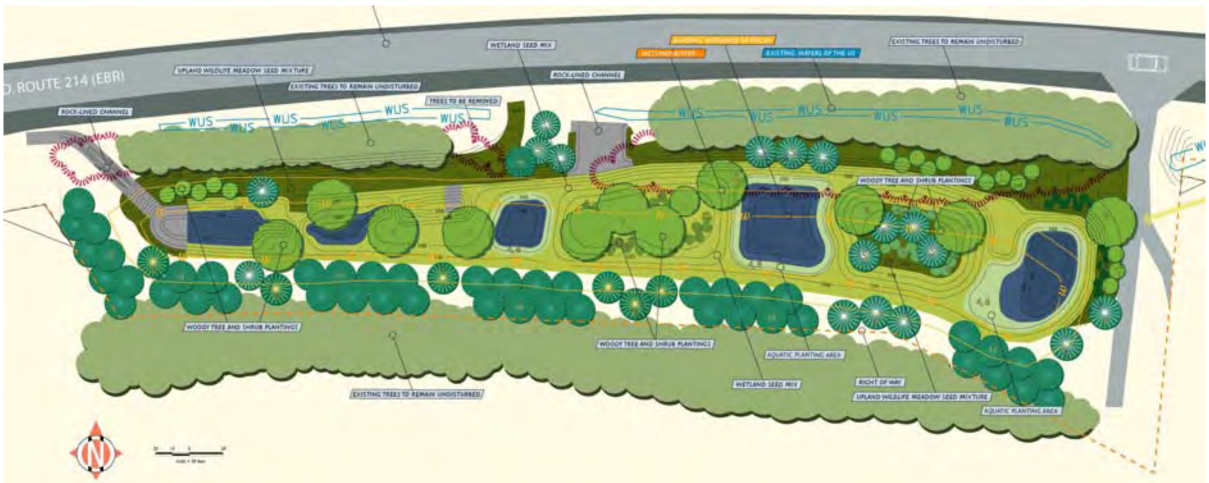
MD SHA has actively continued design as well as construction phases of *SWM Functional Enhancement Projects* funded through State Fund for drainage improvements. When appropriate, SHA seeks partial funding match from the Transportation Equity Act for the 21st Century (TEA-21) Enhancement Funds. The projects have been initiated with the intention to improve the pollutant removal efficiency and bring the functional parameters up to the current standards required by the MDE 2000 *Maryland Stormwater Design Manual*, Volumes I and II and MDE *Guidelines for State and Federal Projects*, dated July 1, 2001. The new design criteria include groundwater recharge volume, and water quality volume. In addition to the functionality upgrades, the enhancement projects are intended to improve aesthetic value, provide refuge to local wildlife and increase the water quality benefits.

In previous reports, SHA provided a list of BMP retrofit/enhancement sites proposed in Anne Arundel and Prince Georges Counties. The Anne Arundel County project has been separated into 2 phases due to the permitting issues and each phase was advertised at different time. The status of the current projects is summarized in Table 3. The total cost does not include $1, 750,000 for projects currently under preliminary design.

Table 3-7: BMP Enhancement and SWM Retrofit Projects Summary

No.	Project	County	No. of BMPs	Contract Number	Construction Cost Estimate	Status
1	Functional Enhancement of SWM Facilities	PG	9	PG6235174	$2,034,545	Construction to be completed in Fall 2007
2	Functional Enhancement of SWM Facilities – Phase 1	AA	4	AA3495174	$998,821	Construction to be completed in Summer 2008
3	Functional Enhancement of SWM Facilities - Phase 2	AA	7	AA5535174	$1,961,326	Bid Opening Date 10/18/2007
4	Functional Enhancement of SWM Facilities Along US 50	AA	5	AA4195174	$689,047	Construction to be completed in Fall 2007
5	VEQ-S BMP Enhancement Project	BA & HA	8	AT7995225	$774,701	Construction to be completed in Fall 2007
6	Stormwater Functional Enhancements in AL County	AL	3	AL3555174	$828,324	Advertisement Date 08/05/2008
7	I-97 SWM Facilities Functional Upgrades	AA	14	AA5355174	$937,401	Advertisement Date in Fall 2008
8	Glen Burnie SHA Maint. Shop Bioretention Retrofit	AA	1	AT387A21	$178,108	Advertisement Date in Summer 2008
9	MD 235 - SWM Facility Retrofit	SM	1	SM356A21	*Preliminary $200,000*	Under Design
10	MD 4 - Retrofit of Failed Infiltration Basins	AA	5	AA5515174	*Preliminary $800,000*	Under Design
11	MD 10 - Retrofit of SWM Facilities 2250 and 2565	AA	2	AA486A21	*Preliminary $500,000*	Under Design
12	MD 355 – Retrofit of SWM Facility 15012	MO	1	MO410A21	*Preliminary $250,000*	Under Design
	Total		**60**		**$8,402,273***	

Before the construction *During the construction*



Landscaping Design Plan

Figure 3-6 Reconstruction of Infiltration Basin at MD 214 (BMP 16059)

Infiltration basin before the construction *Sand Filter after construction*

Figure 3-7 Functional Enhancement of Infiltration Basin at US 50 (BMP 2491)

Infiltration basin before the construction

Construction of pocket wetland

Figure 3-8 Reconstruction of Infiltration Basin at US 50 (BMP 2273)

Before construction

During construction of Micropool Extended Detention Pond

Figure 3-9 Functional Enhancement of Infiltration Basin at US 50 (BMP 2481)

Figures 3-6 through 3-9 show the construction progress of SWM facility enhancements in Anne Arundel and Prince Georges Counties.

Since SHA's intent is to duplicate this effort with the ability to design, build and implement another successful enhancement project, in the year 2006 and 2007 the primary focus was on retrofit design in Anne Arundel County. The selected sites are shown in Figure 3-10.and summarized in Table 3-8

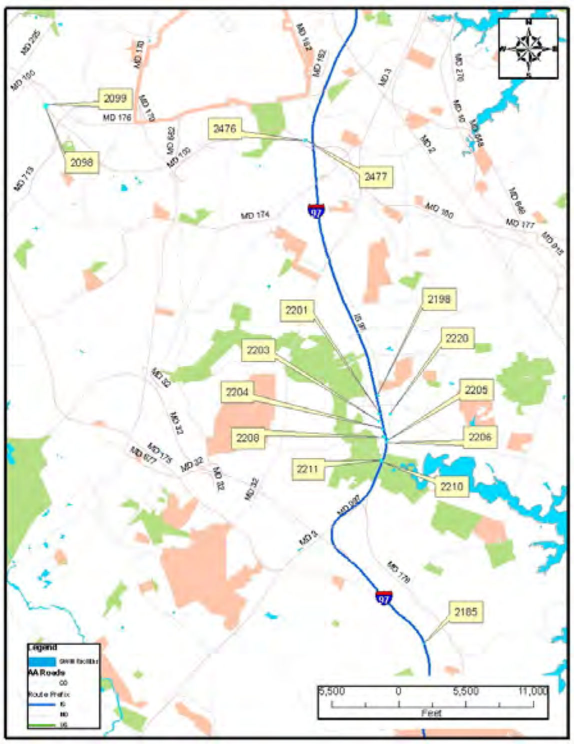


Figure 3-10 SWM Enhancement Sites Along I-97 in Anne Arundel County

Proposed project includes infiltration trenches enhancements or replacement to increase treatment from 1/2 to 1 inch of runoff and as well as to improve water quality treatment to meet current standards. Most selected sites are in environmentally sensitive watersheds including Severn River. The enhancements focus on maximizing pollutant removal efficiencies and improving functionality by upgrading facilities to meet today's standards.

The new standard elements and criteria include channel protection volume, groundwater recharge volume, water quality volume, micropools, aquatic benches with wetland plantings, pre-treatment forebays, appropriate riser control structures to provide water quantity control and to minimize downstream adverse impacts, as well landscaping and visual enhancement to increase the aesthetic value of highly visible SWM facilities.

In summary, the proposed enhancements will significantly improve water quality of the receiving water bodies. The enhancements will incorporate a number of water quality treatment features as well as native Maryland flora landscaping plans, which will maximize treatment efficiency and add aesthetic and habitat value in the environmentally sensitive watersheds. Some of the watersheds where these enhancements are proposed include the Severn River, South River and Patapsco River.

Watershed studies that were performed in these areas by local jurisdictions and state agencies have identified significant impacts to the receiving waters, particularly from transportation related infrastructure. Several highway pollutants that have contributed to water pollution, particularly in these watersheds include sediment, toxics, heavy metals and trash. It is expected that proposed enhancement projects will dramatically reduce such highway pollutants and will be complimentary in meeting the water quality goals of on-going restoration efforts in many of these watersheds.

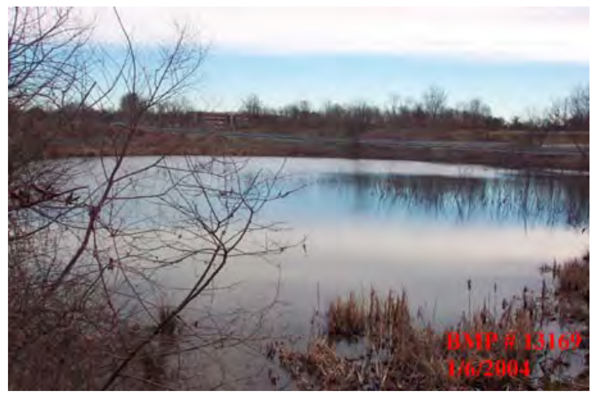
3.3.5 In- Stream SWM Facilities

Overall effort, time, and resources needed for a SWM facility retrofit or enhancement is several order higher compared to major maintenance. SHA desires to achieve 90% of its SWM facilities functioning by 2010. In recent years, a typical SWM facility retrofit/enhancement project takes 2 to 3 years in design and permitting and construction. SHA's experience indicates that most time and effort is associated with permitting as oppose to the design itself. Most resource consuming process involves the facilities that are considered jurisdictional wetlands or are in-stream facilities. Figure 3-11 show examples of SHA owned in-stream facilities.

Table 3-8 BMP Enhancement Sites in Anne Arundel County

No .	BMP No.	SWM Facility	SHA Road	Proposed Enhancement
1	2098	Infiltration Trench	MD 100	Dry Swale (O-1)
2	2099	Infiltration Trench	MD 100	Dry Swale (O-1)
3	2185	Infiltration Trench	I-97	Dry Swale (O-1)
4	2198	Infiltration Trench	I-97	Wet Swale (O-2)
5	2201	Infiltration Trench	I-97	Wet Swale (O-2)
6	2203	Infiltration Trench	I-97	Dry Swale (O-1)
7	2204	Infiltration Trench	I-97	Wet Swale (O-2)
8	2205	Infiltration Trench	I-97	Dry Swale (O-1)
9	2206	Infiltration Trench	I-97	Dry Swale (O-1)
10	2208	Infiltration Trench	I-97	Dry Swale (O-1)
11	2210	Infiltration Trench	I-97	Dry Swale (O-1)
12	2211	Infiltration Trench	I-97	Underground Sand Filter (F-2)
13	2220	Infiltration Trench	I-97 / MD 178	Surface Sand Filter (F-1)
14	2476-2477	Infiltration Trench	I-97 / MD 100	Wet Pond (P-2)

BMP 2248 – Anne Arundel County



BMP 13169 – Howard County

Figure 3-11 Examples of SHA Owned In-Stream Facilities

In order to achieve SHA goals and develop strategies that result in wise use of resources and also produce desired results, it was necessary to understand the magnitude of such inventory that may be jurisdictional. As a first step, SHA initiated a study to investigate the number of existing in-stream stormwater management facilities in Anne Arundel, Baltimore, Howard, Montgomery and Prince George's Counties.

The data used to identify the in-stream BMPs were the SHA NPDES SWM databases, Arc View GIS shape files for SWM facilities, existing storm drain features photos, hydrography and photogrammetry mapping. Data used for this study was acquired from the respective counties or the EPA. Typically, the hydrography data used is either 200 Scale digital line graph data or EPA reach files (1:500,000 scale).

The methodology used in this investigation was to create a short list by querying all the SWM facilities that intersect the hydrography shape file using Arc View GIS. However, the field assessment to verify the in-stream SWM facilities will follow up. As shown in the Table 3-9, about 78 in-stream SWM facilities have been identified in the 5 listed counties. Figure 3-12 shows some of the locations.

Generally speaking, in-streams facilities result in a number of issues Most of them have been designed in the past to control the peak runoff from the watershed and over the years have been acting as sediment traps preventing the sediment transport through the natural stream, causing downstream channel degradation and stream banks instability.

The permitting of maintenance or retrofit has become very difficult since they are located within jurisdictional waters. Over the years, many of the facilities have established wetland areas and any impact need to be approved by MDE as well as COE, possibly mitigated off site. Environmental agencies are generally supportive of redesigning such BMPs as off-line SWM facilities and restoring the natural channel to its original form. However, removal of the detention or retention facility often results in the increase of the peak flow at the downstream channel and possible flooding of the adjacent properties or potentially unstable channel conditions.

Given the extent of this inventory, with a recognition that these facilities have been approved at some time and also the fact that SWM regulations have changed over period of time, a new look at this challenge is necessary. SHA seeks to obtain MDE support in reaching a multi-agency understanding of this issue and streamlined permitting.

Table 3-9 SHA Owned In-stream SWM Facilities

County	No. SWM Facilities	No. In-Stream SWM Facilities
Anne Arundel	424	9
Baltimore	167	13
Howard	247	15
Montgomery	267	29
Prince George's	180	12

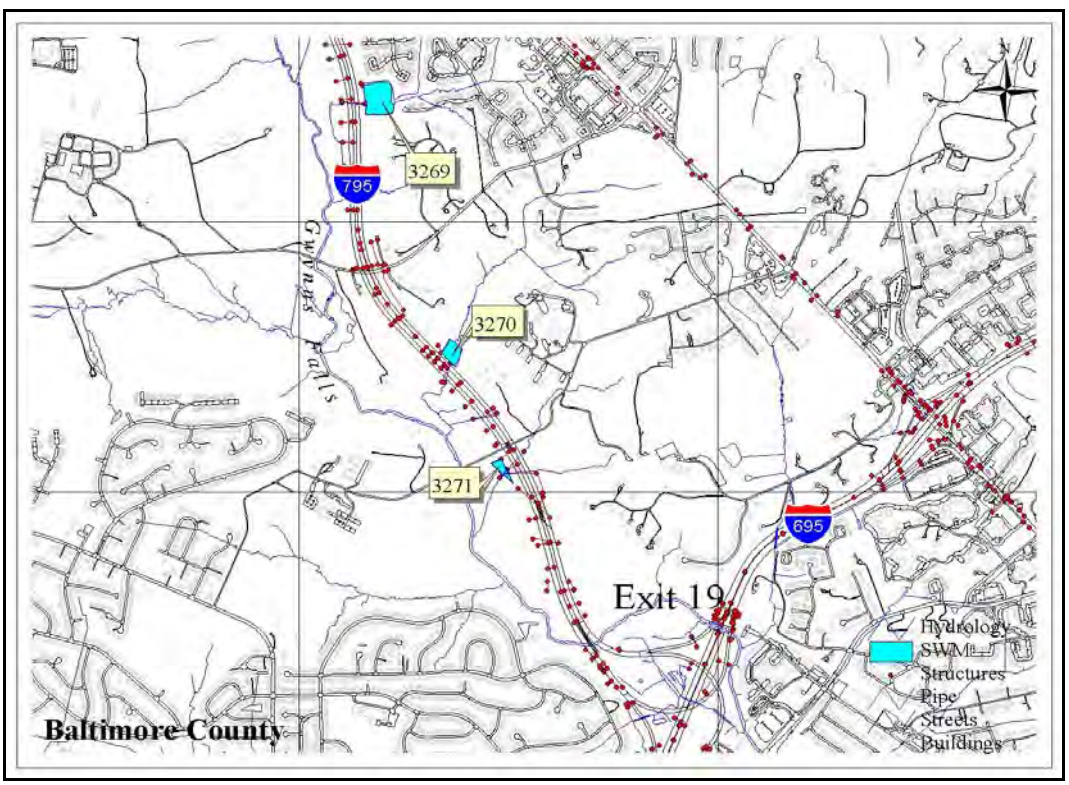


Figure 3-12a In-Stream facilities in Baltimore County

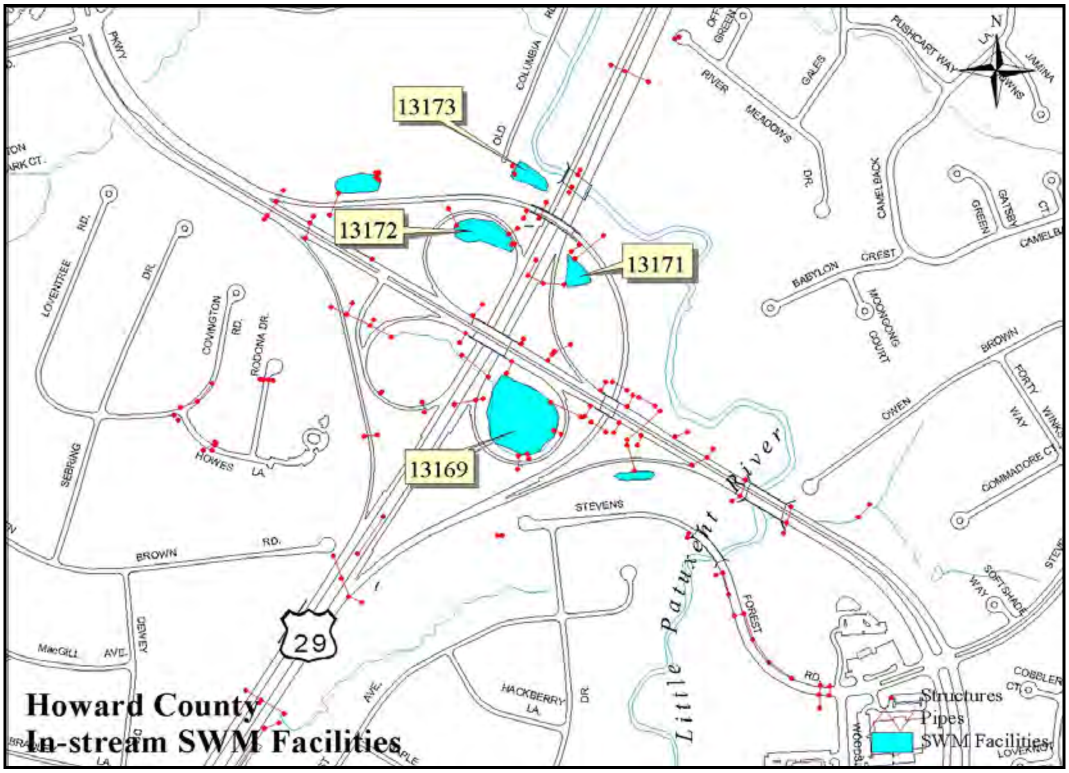


Figure 3-12b In-Stream facilities in Harford County

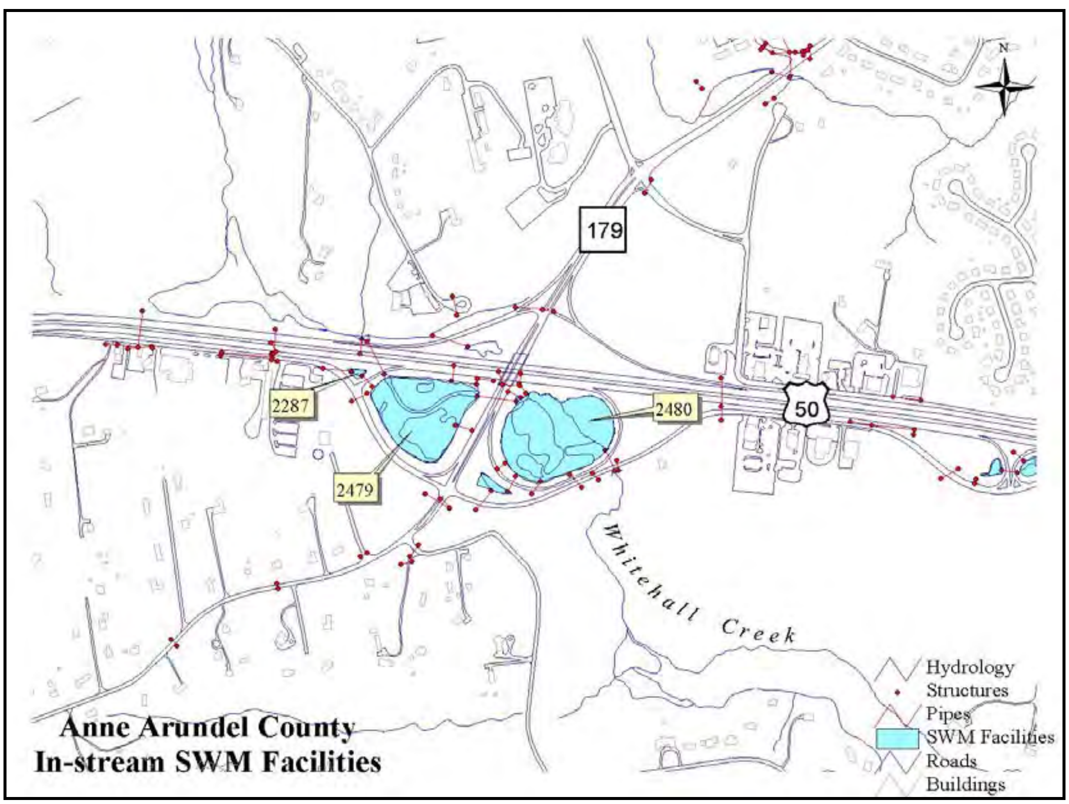


Figure 3-12c In-Stream facilities in Anne Arundel County

3.4 Other Topics

3.4.1 Data Management

To-date SHA has performed inventory of SWM drainage infrastructure in seven counties and BMPs in all twenty-three counties. In addition, SHA has performed field inspections of BMPs in eleven counties and initiated two additional counties. SHA has proceeded with the second cycle re-inspection in four counties. This work involves the continuous creation and updating of GIS data for source identification and database records for inspections and remediation activities.

SHA has finalized the structure of ESRI geodatabase that consolidates the data previously stored in ESRI ShapeFiles and MS Access relational database. The geodatabase has a detailed schema that allows for the establishment and enforcement of topologic and/or network rules and unique data entry. The new database format resulted in improved data intelligence and integrity. In addition, SHA is developing automated Quality Assurance (QA) checks to ensure the quality of the data being routinely created by either SHA staff or consultants.

Along with the new database format, a new data viewer tool needs to be developed to replace the old BMP Viewer. The functionality of this tool allows the user to view the spatial information as well as digital images associated with each BMP including as-built plans, photographs, inspection reports and other documents. BMP Viewer can be used to view data from various levels such as a highway corridor, MSHA district, County, or watershed.

The primary goals of the new tool are the:

- Design Web-based environment using up-to-date technology,
- Preserve functionality of the current desktop tool,
- Develop new components which capture and streamline the existing BMP business process and rules.

Figure 3-14 includes several screen captures of the newly developed tool. Currently the BMP Viewer functionality includes the following components:

- Mapping Tool
- Data Query Builder
- Grid View Tools
- Detail Reporting View
- Historical Data View
- Maintenance Activities Tracking
- Design Project Management Tool

The new BMP Viewer is being designed to provide functions that will help SHA staff to manage the overall SWM Program, as well as allow wide range of users to access the available BMP and drainage system data more efficiently in order to administer day-to-day activities.

3.4.2 Standard Procedures Updates

Since the last Annual Report SHA completed updates to the Standard Procedures Manual including *Chapter 3 Best Management Practice Field Inspections & Data Collection Procedures* to improve the standardization of all relevant data. The document is included in the Appendix A.

Figure 3-13 BMP Field Inspections during Standards Procedures Workshop

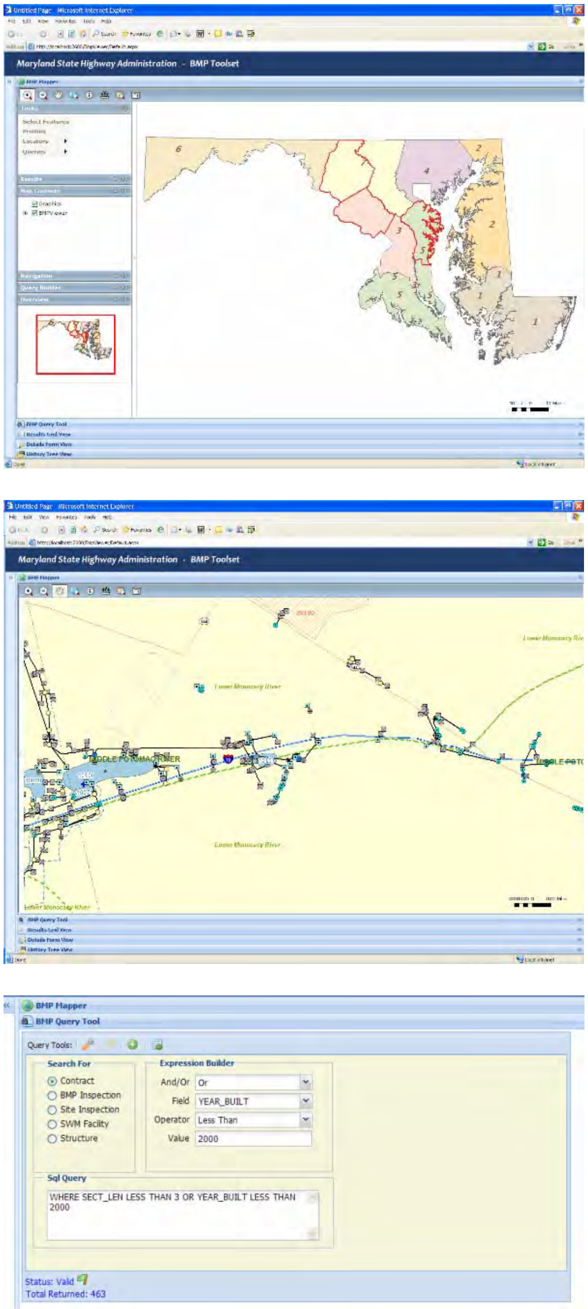


Figure 3-14 BMP Viewer Screen Captures

The updated inspection manual provides methodology to evaluate and rate the physical condition of BMP facilities so that statewide inspections are performed with consistency in terms of the following four components:

- **Sustainability** - considers the structural integrity and overall condition of the facility with a focus on evaluating the site features necessary to ensure longevity;
- **Environmental Quality** - investigates the facility with respect to environmental aspects such as water quality treatment, stormwater management performance, habitat conditions, functionality, flood control, quantity management;
- **Safety** - reviews the safety of the public, field inspectors, and maintenance personnel;
- **Visual Quality** - assesses the level of aesthetic impact the facility has by looking at the facility within its surrounding context.

The current document includes the updates on the data collection as the result of the integration of the data into Geodatabase and SHA's continued efforts to improve the NPDES Program.

In order to maintain consistency and compatibility in the data collected during source identification and BMP inspection, SHA has conducted NPDES Standard Procedures Workshop for outfall inspections, BMP inspections and illicit discharge screening. (Figure 3-13) Approximately 20 consultants and SHA engineers completed the 3 day training in May 2007 and another group of 20 is scheduled for training in November, 2007.

3.5 Summary

SHA continues improving protocols and standard procedures for inventorying and inspecting SMW facilities. This leads to the development of a responsive maintenance program to sustain BMP performance, and also includes functional and visual enhancements to upgrade SWM to the today's standards. SHA also progressively researches SWM facility performance through monitoring and research studies. SHA continues development data management technology to manage and utilize BMP data more efficiently. Tools are being developed to help to make timely decisions on remedial actions, and meet and exceed SHA's NPDES permit requirements. SHA is reviewing and organizing information on the costs to operate and maintain BMPs; and to quantify benefits and costs on SWM facilities performance.

SHA's Business Plan goes beyond the NPDES permit requirements by promoting the statewide inventory and a high-level of BMPs performance. The goal is to bring 90 percent of SHA owned SWM facilities to their functionality by FY 2010. Figure 3-15 summarizes the progress.

SHA SWM Facilities Program has demonstrated environmental stewardship in the areas of innovative and integrated state-of-the-art inspection and data management technology as well as BMP promotion of visual and functional enhancement techniques. The program components collectively have laid a solid foundation of a systematic and strategic approach not only to meet the NPDES Permit requirements but also to optimize and enhance the performance SWM facilities to meet watershed needs.

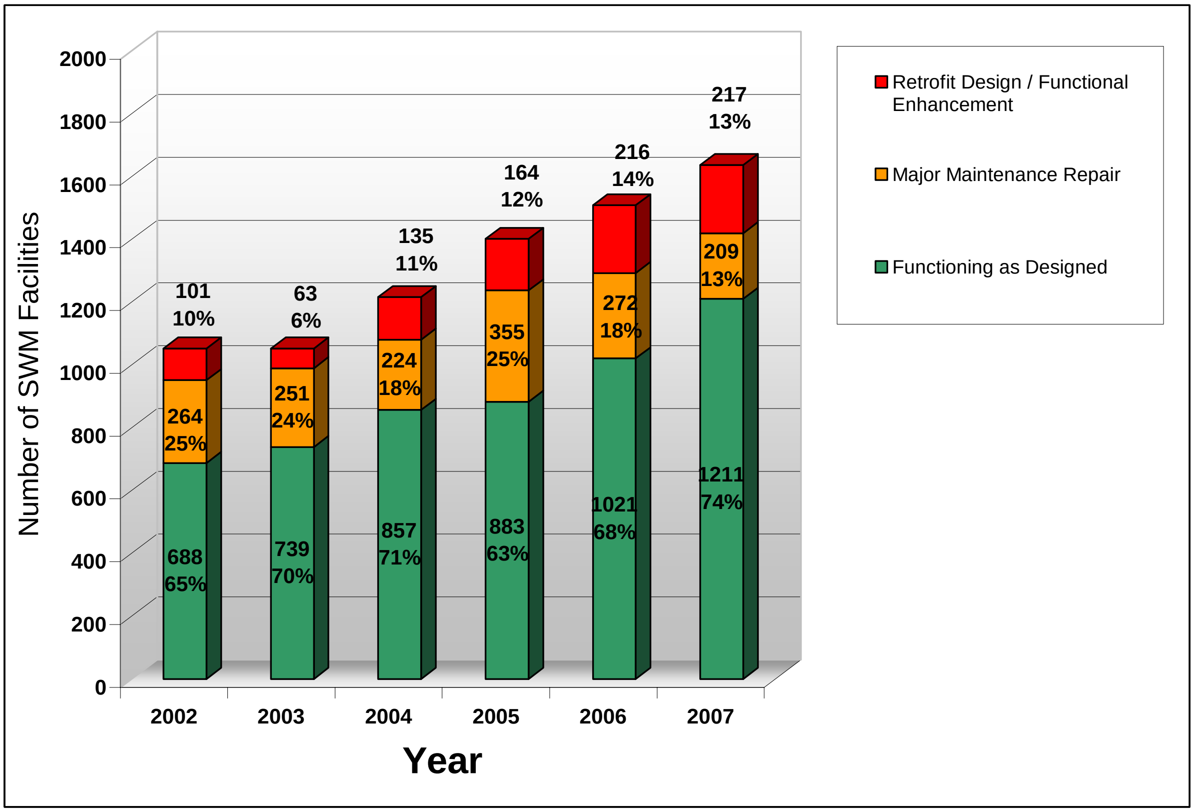


Figure 3-15 Progress in SWM Facilities Program

APPENDIX A:

BMP Field Inspection & Data Collection Procedures

August 2007

Chapter 3

Best Management Practice Field Inspections & Data Collection Procedures

August 2007

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Chapter 3

BMP Field Inspections & Data Collection Procedures

3.1 INTRODUCTION

This chapter provides guidelines for field inventory and inspection of stormwater BMPs. The information gathered is used for making decisions on the inspection, maintenance, repair, and retrofit of BMPs. As such, a method to achieve uniform inspection ratings is necessary. The following provides methodology to evaluate and rate the physical condition of BMP facilities so that statewide inspections are performed with consistency. SHA approaches BMP design, construction and maintenance in terms of the following four components:

- **Sustainability** - considers the structural integrity and overall condition of the facility with a focus on evaluating the site features necessary to ensure longevity;
- **Environmental Quality** - investigates the facility with respect to environmental aspects such as water quality treatment, stormwater management performance, habitat conditions, functionality, flood control, quantity management;
- **Safety** - reviews the safety of the public, field inspectors, and maintenance personnel;
- **Visual Quality** - assesses the level of aesthetic impact the facility has by looking at the facility within its surrounding context.

References are listed at the end of this chapter that should be consulted for clarifications. In order to facilitate quick response to questions that arise during the inspections, the field team leader should be familiar with the contents of this reference material.

This chapter is used in conjunction with *Chapter 2, Source Identification*. The physical aspects of BMPs are gathered during the source identification phase which is described in Chapter 2. It is assumed that all of the BMPs to be inspected have been located either as part of previous inspections, that these inspections are being performed in conjunction with source identification, or that other source information such as design plans have been provided by SHA.

A systematic inspection program requires planning and organization to maintain consistency and compatibility in the data collected. These field inspection results are the foundation of the BMP database and SHA's BMP maintenance program.

3.2. PREPARATION

3.2.1 Pre-Field Investigation

The objective of this phase is to gather all available information in preparation for the field investigation. SHA will provide the consultant with available source information such as construction plans (grading, details and profile sheets), as-builts, stormwater management reports, modifications performed under access permits and existing GIS/database information including previous inspections and the SHA response table if applicable. The inspection team should review the provided information, along with base mapping to gain a thorough understanding of the function of the BMP to be inspected and its relationship to the SHA stormwater infrastructure and the surrounding area.

Digital or paper field maps should be prepared for reference during the BMP inspection. These should include relevant features such as the subject SHA roadway with the stormdrain network, hydrographic features such as stream crossings, and if available, land-use information adjacent to the SHA right-of-way. If during the BMP inspection it is determined that the existing stormdrain network database contains outdated, inconsistent, or erroneous data, the questionable data should be identified and reported to SHA. Alternatively, if the BMP inspection is being performed in conjunction with an update to the source identification data, the appropriate revisions should be made according to Chapter 2.

The pre-field investigation should identify potential safety issues such as road access, traffic hazards, and BMP site conditions. Based on potential conditions, the inspection crew can prepare appropriately for the field investigation.

The field mapping package in either digital or paper form should include:

- A field map (100 or 200 scale mapping) with features located including roads distinguished between SHA-owned and others, ramps, interchanges, BMPs identified by number, BMP drainage areas, pipe networks, SHA building/parking complexes such as maintenance shops, district offices, rest areas and park ‘n rides. It is helpful to have contours and topographic features on this mapping to orient the field personnel;
- GIS attribute data from the feature classes SWMFAC, DRAINAGE_SWMFACILITY, SWMRISER, WEIR;
- The SHA Response Table, if applicable, that contains the most up-to-date information regarding maintenance/retrofit history;
- BMP plan sheet with grading and planting;
- Field forms for data collection and inspection;
- Determine an acceptable range of BMP Numbers to be used if additional BMPs are located in the field that are not pre-defined.

3.2.2 Field Inspection Team

Inspection teams should consist of at least two individuals for safety in the field. Individuals on the team should be familiar with BMP design and the *Maryland 2000 Stormwater Design Manual*. Their backgrounds should be a mix of water resources engineering, landscape architecture, and environmental science, or related fields. It is important that the team have experience performing BMP inspections.

It is understood that this diversity of experience may not be accomplished with just two individuals. It is the responsibility of the organization performing the BMP inspections to manage the required resources in an efficient manner. One strategy would be to have two teams of two people working in close proximity to each other on the same stretch of roadway. If these teams are in communication with each other by way of cell phone or two way radios, the expertise of all four individuals can be called upon when needed.

3.3. FIELD OPERATIONS

3.3.1 Equipment Requirements

As part of planning for the field inspection, the proper equipment must be on hand to ensure proper collection of data and ability to complete the task. Table 3.1 lists the required as well as optional equipment that may be used during BMP inspections. The equipment list includes both field inspection equipment as well as health and safety equipment.

Table 3.1 - Field Equipment List

Required	Optional
BMP Field Inspection & Data Collection Procedures	Field PC
Field log book	Insect repellent
Digital camera, back-up batteries	Distance measuring wheel
Field attire & orange safety vest	Equipment to clear debris (e.g. shovel)
Traffic cones (quantity 6)	Plumb bob
Amber flashing safety light for vehicle(s)	Surveyor stakes
Field mapping of investigation area (see 3.2)	Hammer, chisel
ADC map book	Surveyor flagging
Multiple hard copies of BMP Inspection forms	pH and/or conductivity meter
Pens/pencils & clip board	Probing stake/steel rod
Flashlight, back-up batteries	Personal cleaning materials
Min. 20 ft. length Measuring Tape	Supplemental field attire
Knife	Portable cellular phone
Manhole puller	Survey rod
Two-way radios or Cell Phones	Compass (azimuth)-
GPS unit and data logger	
First-aid kit	
SHA Authorization Letter	
Bolt cutters / hacksaw to cut locks and well caps	
Plumber wrench	
Knee-high boots / Waders	

BMP locations should be collected using Global Positioning System (GPS) equipment in NAD83 State plane, feet with a minimum accuracy of ± 3 meters. In areas where GPS signal is not adequate to obtain suitable survey, other alternatives can be used such as compass or aerial photographs.

3.3.2 Log Book

A field logbook is required to track daily field information and site-specific data. The daily entries are entered sequentially and maintain a common format. Should any changes to the field logbook be necessary after the investigation is completed, they should be done in a way that shows how the initial data was altered. If there are any alterations to the field book, the field crew should be consulted.

The daily information to be entered should include:

1. Date and starting time
2. Identification of field personnel
3. Weather conditions including date of last storm event
4. Summary of roadway names and counties investigated
5. Identification number of each BMP inspected or stormdrain structure
6. Type of BMP facility or SHA Standard stormdrain structure
7. Photograph numbers and subjects logged
8. Relevant sketches (optional)

3.3.3 Safety, Trespassing & Locks

Safety precautions should always be used while locating and inspecting BMPs along roadsides. SHA's *Safety Manual for Field Survey Personnel* should be reviewed for health and safety requirements along SHA roadways.

Inspectors should plan for and be aware of vehicular traffic and road conditions during field investigations. The field equipment list in Table 3.1 highlights the items required to alert local traffic of the inspector's presence and allow for safe inspection of the BMP. Field personnel must wear orange safety vests and carry work ID, driver's license and SHA field inspection authorization letter at all times during the field investigation. A flashing amber warning light on the field vehicle is also recommended. Where possible use several safety cones to alert oncoming traffic of a stopped inspection vehicle.

SHA DOES NOT AUTHORIZE TRESPASSING ONTO PRIVATE PROPERTY IN ORDER TO COMPLETE FIELD INSPECTIONS. If a facility is not accessible from SHA or other public right-of-way and no right-of-entry agreement has been obtained, this should be documented on the field form and the inspector should move to the next inspection site. The inspector should request a right-of-entry agreement through SHA Office of Real Estate prior to entering private properties.

Prior to performing field inspections, the local SHA maintenance shop should be contacted to determine if they have keys to any locks surrounding BMPs. If keys are not available, it will be necessary to cut the locks off of the gates. SHA should then be notified that the lock has been removed so that it can be replaced. Caps on observation wells that are immovable or locked should be cut to gain access. Again, SHA should then be notified that the cap was removed or broken so that a replacement can be installed.

3.3.4 Inspection Forms

Field forms to log inspection data are included in Appendix 3-A. The inspection requires the inspector to score parameters for the categories of Environmental Quality, Sustainability, Safety, and Visual Quality.

The parameters used to inspect SHA's stormwater BMPs include:

- Ponds
- Wetland Facilities
- Infiltration Facilities
- Filtering Devices
- Open Channel System
- Others (e.g. Underground Chambers, Proprietary SWM Devices)

Most of the inspected parameters apply to ponds and basin-type structures. The description of the parameters later in this chapter will indicate those that are specific to infiltration and filtering devices.

3.3.5 BMP Data Collection

It is important to inspect BMPs after suitable dry time to allow them to recover to their normal state. It is therefore required that there be a minimum of 72 hours of no precipitation prior to inspection.

The field inspection begins by collecting site-specific information that falls into two categories:

- BMP Inventory Data which consists of physical information
- BMP Inspection Data which consists of parameters that the inspector scores

An individual form should be used for each BMP site and data will be entered using an ink pen. Data collection may also be done digitally using a field data collector.

Each inspection parameter should be thoroughly reviewed by visual inspection and physical testing where necessary. All aspects of the BMP should be looked at closely, including the riser, all inlet and outlet points of the facility, both sides of the embankment, observation wells, and the downstream outlet.

It is not the intent of this program to perform detailed inspection of the inside of risers or pipes. This type of inspection would require OSHA confined space certification for the inspection crews. Under no circumstances shall the inspectors enter confined spaces. If the inspectors believe that there is an issue that should be investigated further requiring confined space entry, they should note the issue and notify SHA.

3.4 INSPECTION ACTION KEY

NPDES permit conditions change every five years and the conditions have become progressively more detailed and complicated over the years. Also in urbanized areas, land for development is expensive and sharing BMPs between landowners is becoming more common. For these reasons, SHA's SWM Facility Program has expanded to include off-site facilities that treat SHA runoff and facilities that have become joint-use through an agreement between SHA and adjacent developers (through the SHA Access/Utility/District Permit process).

The inspection team must inspect the BMPs identified from the Source Identification phase and the review of source documents provided by SHA. They should also be on the look out for BMPs that may not have been pre-identified, but may be treating SHA runoff or may be a joint-use facility.

The following BMP action key was developed to aid in the BMP inventory process and is presented on the following page (Figure 3.1). This key will aid the inspector in determining the course of action required for any scenario that is encountered.

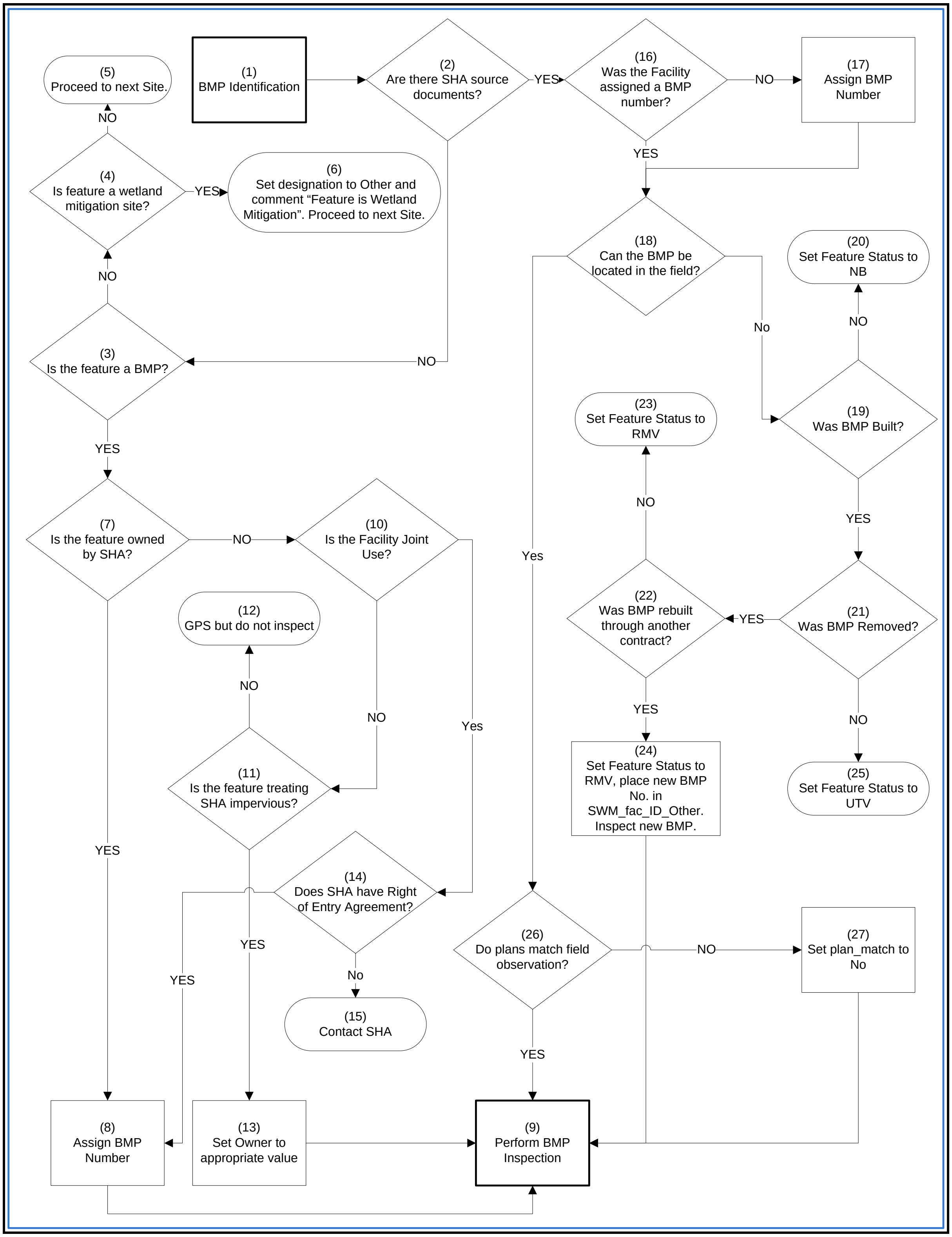

Figure 3.1 BMP Inspection Action Key

1. BMP Identification. A BMP inspection is to be performed, either due to source documentation, periodic source data updates, or a BMP is recovered in the field.

2. Are there SHA source documents? The inspection team will research the BMP before going out in the field by reviewing relevant documents, such as past inspections, design plans, stormwater management report, etc. The work flow process splits along two paths: BMP is thought to exist due to existing documentation, or it is to be recovered in the field with no supporting documentation.

** No Source Documentation **

3. Is the feature a BMP? A water resources engineer or other stormwater specialist should make the determination as to whether the feature is functioning as a BMP. Avoid features like abandoned sediment traps or localized depressions.

4. If the feature is not a BMP, determine if it is a wetland mitigation site. This determination should be performed by a water resources engineer or other environmental mitigation specialist. Generally, wetland mitigation sites typically do not have outfall control structures such as risers or weirs and are required to function naturally and to be self-sustaining.

5. If the feature is not a wetland mitigation site, proceed to next site.

6. If the feature is a wetland mitigation site, set BMP designation to "Other" and comment that feature is a wetland mitigation site. Proceed to next site.

7. If the feature is a BMP, determine if it is owned by SHA or within an SHA easement. This may be based upon right-of-way fencing in the field, but may require verification from SHA, the county, or property owners.

8. If access to the facility is within SHA right-of-way or easement, it does not require a right-of-entry. If access is through another property, it will require a right-of-entry (step 15). If it requires a right-of-entry and SHA does not have one, contact SHA (step 16). If it requires a right-of-entry and SHA has the agreement for accessing this facility, proceed to step 9.

9. If the BMP is owned by SHA then assign a BMP number.

10. Perform BMP inspection.

11. If the BMP is not owned by SHA, is the facility joint-use? Refer to Section 3.5.1, BMP Ownership, for discussion on joint-use facilities.

12. If facility is not joint use, does it have SHA impervious surfaces or other SHA right-of-way in its treatment area? If it does not, proceed to the next site.

13. If the facility does, set the owner to the appropriate value.

14. If the BMP does have SHA right-of-way in its drainage area, it may be a joint-use facility. The inspector should attempt to verify ownership with SHA records or other sources, or mark ownership as unknown. Joint-use documentation should be scanned. GPS the outline of the BMP, but do not perform an inspection.

15. If the facility is joint use, does SHA have a right-of-entry agreement?

16. If SHA does not have a right-of-entry agreement, contact SHA. If SHA does, assign a BMP number (see step 9) and perform a BMP inspection (see step 10).

** Source Documentation Available**

17. Source documents indicate that a BMP may exist, was a BMP number assigned?

18. If no, then assign a BMP number. See Section 3.5.2, BMP Inventory Data, for further discussion on the BMP number.

19. Source documents may indicate that a BMP should exist; can the BMP be located in the field?

20. Was the BMP built? An inspection of the local topography and drainage features should help determine if the BMP was built. Some BMPs will be easier than others to make this determination. If the inspection team confirms a BMP was not built, the answer is NO. If the team is unsure, then the answer is YES.

21. If the BMP was not built, the BMP outline should be approximated in the office and status set to NB (Not Built).

22. The BMP may have been removed (e.g. roadway widening, BMP retrofit). If a BMP was known to exist (e.g. previous inspection) and recent construction activity could have eliminated the BMP, SHA may need to address the loss of water quality treatment.

23. If the BMP is determined to have been removed, was BMP re-built through another contract?

24. If the BMP was not re-built, then set feature status RMV (Removed), and the BMP outline should be approximated in the office.

25. If the BMP was re-built, then set feature status RMV (Removed), and place the new BMP number in SWM_fac_ID_Other. Inspect the BMP and log the data under the new BMP number in the geodatabase.

26. If it cannot be determined if the BMP was built or if it was removed, or recovery in the field is not possible, then set the feature status to UTV (Unable To Verify). The BMP outline should be approximated in the office.

27. Do plans match field observation? If there is source documentation for the BMP and it is found in the field, make the determination if the BMP matches the available plans. If the BMP matches the plans, set the *plan_match* field to “Yes” then proceed with a BMP inspection (see step 9).

28. If the field observations do not match the plans, set the *plan_match* field to “No” then proceed to BMP inspection (see step 9).

3.5 BMP DATA

The following section describes the data recorded for the BMPs. Feature class items and table names are printed in capital letters (e.g. PIPE) and field names are printed in italics (e.g. *conveyance_id*).

Data other than comments entered into the geodatabase should be capital letters. All data entered as an acronym will not have periods following each letter, (e.g. CMP or BCCMP). Words that are abbreviated will have a period following the abbreviated word, (e.g. emb.). Where feasible, coded value domains exist for standard values to ensure these values are entered in the proper format. Coded values should be entered into the database tables. All of the feature class items, tables, and their associated field information are illustrated on the Geodatabase Design Schematic in the back of this report. Included also are associated relationships between each feature class and the tables, as well as the coded value domains to be used for data input. Those fields that do not have a required value should be left blank if the information is not given or known. The comments fields add to or clarify data given in other fields. They should be used liberally to alleviate questions later on.

There are two primary types of data captured for every BMP, physical attributes and condition assessment. The physical attributes of a BMP typically stay static unless a retrofit of the BMP is performed. This information is stored in the SWMFAC table and is described in detail in Section 2.3.7. As part of the BMP inspection process, these physical attributes should be reviewed to determine if they have been modified. If they have, the SWMFAC table should be updated including information for the construction contract under which the modification was performed. If a significant retrofit has been performed such as changing the treatment type, merging multiple BMPs or splitting BMPs, then a new BMP number should be assigned along with a new record in the SWMFAC table. The old record in the SWMFAC table should have the new BMP number populated in the *swm_fac_id_other* field and the feature status set to RMV (removed).

3.5.1 BMP Ownership

There are multiple scenarios that can occur regarding ownership of BMPs and treatment of SHA impervious area. BMPs that treat SHA right-of-way should receive a BMP number, a record in the SWMFAC table, be represented by a polygon, and receive a treatment area. These BMPs can be SHA-owned, joint-use, private, other public, or unknown ownership. The ownership field should be completed for any facility receiving a BMP number. Only those facilities within SHA ownership or with a joint-use agreement between SHA and another entity should be inspected. When available, joint-use documentation should be scanned as per requirements of Chapter 2. Figure 3.2 illustrates the flow of work to be followed when inspecting and assessing a BMP.

If BMPs with SHA right-of-way in their treatment area are on private property, permission must be obtained from the owner to enter their property through the SHA District Office of Real Estate. This is especially important for schools or restricted government property. If the BMP is not partially or fully owned by SHA or subject to a joint-use agreement, only an approximation of the outline of the BMP is required and no inspection is to be performed. This means that the outline of the BMP can be developed using other sources such as aerial photography if necessary.

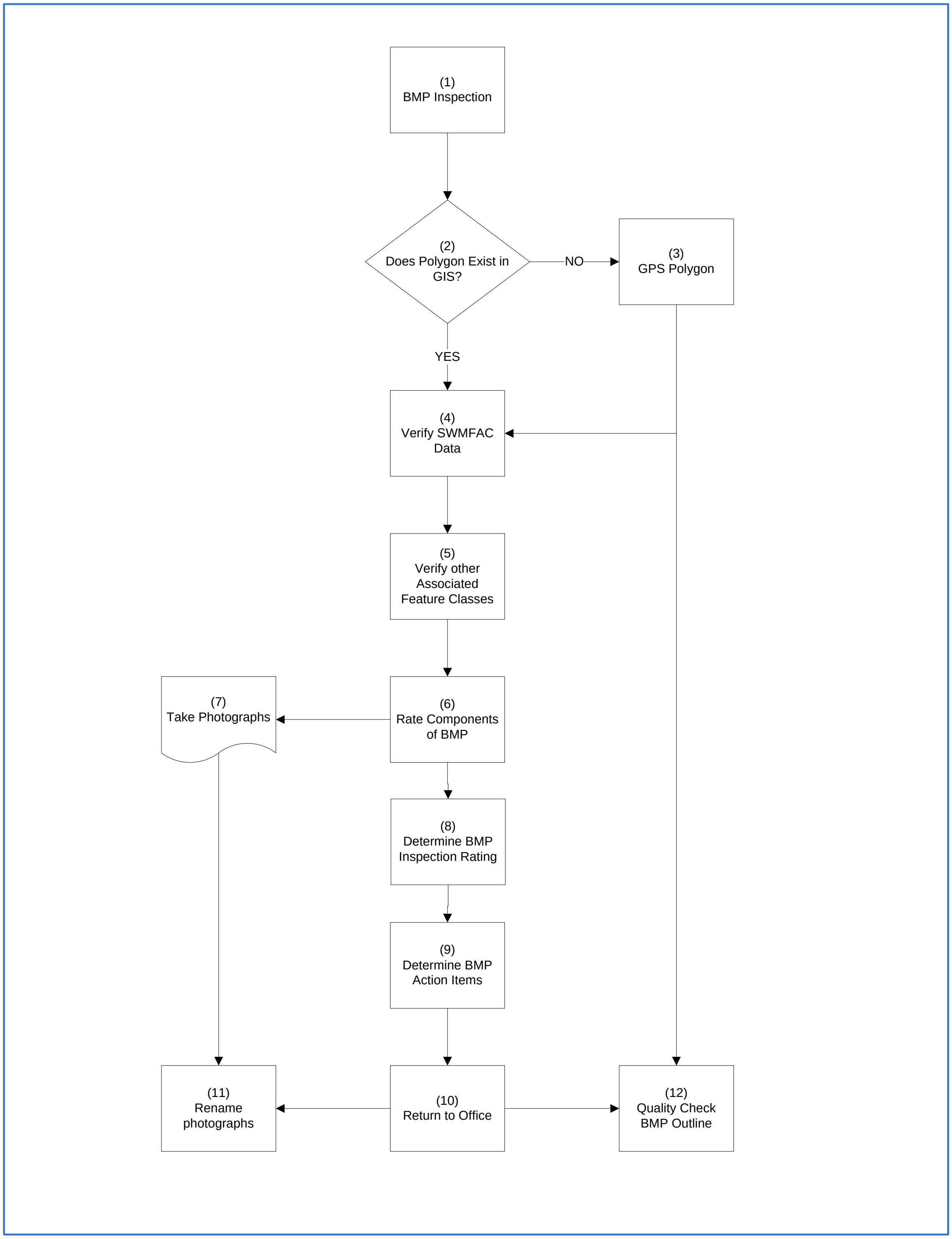

Figure 3.2 BMP Inspection Work Flow

If a BMP has been identified for inspection and located and it has been determined that the facility should be inspected, the following steps should be taken according to Figure 3.2, above:

1. Locate the BMP in the field and proceed to inspect.

2. If this inspection is a periodic source data update to the geodatabase, there is no need to perform another GPS survey of the perimeter unless the facility has changed since the last update.

3. GPS the perimeter of the BMP as per Section 3.8 if this BMP has not been identified and entered into the database previously. Note that only BMPs in SHA ownership, partial ownership or joint-use agreements should have perimeters developed.

4. Verify the static BMP data identified in the SWMFAC table. If there are changes that need to be made, make the changes.

5. Verify the attributes of the other features related to the BMP such as outfalls into the pond or the riser table.

6. Rate the components of the BMP according to the BMP Inspection Criteria beginning in Section 3.5.3.

7. Take required photographs of the BMP and of any issues requiring documentation. Document the photograph names and subject in the field notebook.

8. Determine BMP Inspection Rating using Section 3.5.8, BMP Inspection Rating Categories. Note that this rating should be performed for the Environmental Quality and Sustainability parameters only.

9. Determine BMP action items as per Section 3.6.

10. Return to the office for post processing of the data.

11. Rename photographs as per Section 3.8.

12. Perform a quality review of the BMP polygons. Shapes should be smooth and not jagged. There should not be any self overlapping polygons (bowtie shape).

3.5.2 BMP Inventory Data

Every BMP is assigned a unique number that facilitates tracking it through documents such as construction drawings, permits, and stormwater management reports. This number is the *swm_fac_no* stored in the SWMFAC table described in Section 2.3.7. The number contains the appropriate County code and a four digit unique number. For example, 150001 is the first BMP located in Montgomery County (County Code=15).

Historically this number was a 3 digit unique number preceded by the County Code. Although all of the database records have been migrated to the new format, historic documents may refer to this old structure. If this situation arises, a zero should be placed after the preceding County Code to make the number a four digit unique number preceded by the County Code. Therefore, 15123 would become 150123.

The swm_fac_no is not populated in the BMP_INSPECTION table, only in the SWMFAC table. The following is general inspection information that is gathered in the field and entered into the BMP_INSPECTION table:

Inspection ID (*BMP_Inspect_ID*) – This is a unique inspection ID for every inspection performed. This number should be auto-generated within the geodatabase.

Facility ID (*Facility_ID*) – This is a unique Facility ID that links the inspection back to the SWMFAC table. This is not the BMP Number. This number should be auto-generated within the geodatabase.

Date (*date_insp*) – The date the inspection was performed. The geodatabase will not allow a "null" value for this field. Format is YYYYMMDD.

Inspector (*inspectr*) – First initial and last name (no space) of the members of the inspection team. The geodatabase will not allow a "null" value for this field. Multiple entries in this field should be comma delimited. This field should be used primarily for quality assurance by the organization performing the inspections.

Field Matches Plan (*plan_match*) – 1(Yes) or 2(No) D_BOOLEANVALUES field to indicate if the BMP as observed in the field matches the set of plans being reviewed.

Context (*context*) – This field is affiliated to a BMP's visual quality by determining the exposure of the BMP to surrounding land uses. The domain list is ranked in a hierarchical order indicating the land use which would suffer the most from an unaesthetic BMP. The inspector shall select the worst case or lowest value on the list of the land use immediate adjacent to the BMP. The following is the domain (*D_Context*), in the hierarchical order.

- NAT Natural areas - forests, community buffer zones vacant land and passive recreational areas.
- VAC Vacant, un-maintained lots or abandoned development.
- AGR Agricultural – includes cropland, fallow fields, orchards, pastures, livestock areas and nursery fields.
- IDEV Industrial Development– includes warehouses, manufacturing facilities, quarries, landfills and other industrial land uses.
- SDEV Commercial Strip development – Highly impervious, linear development fronting a roadway characterized by many entrance drives, parking between buildings and roadway and varying architecture and signs. This can include commercial, hotel/motel, theater, car lots, malls and other similar development.
- MUN Municipal – Libraries and municipal or other government functions.

SCO	Shopping, commercial, office/business park development – includes modern campus-like development other than schools and low density or single lot development commercial sites, etc.
SCH	Schools – includes public, private and religious institutions of learning such as university campuses, colleges, technical schools, art schools, elementary, middle and high schools. This also includes daycare facilities.
REC	Active Recreational - ball parks, playgrounds, bike routes, golf courses and other active recreational facilities.
RES	Residential including single family, multi-family, townhouses, apartments

Occupation Hazard (*Site_Haz*) – 1(Yes) or 2(No) D_BOOLEANVALUES field if an occupational hazard exists that future inspectors or maintenance individuals should be aware of. The COM_Overall field should be used to describe the hazard or multiple hazards. The following are examples of hazards.

Safe Structure Height – Structures that are over 48 inches in height without railings present a fall risk. The height is measured at the tallest dimension on the exterior of the structure. If the structure is adjacent to permanent water, the height is taken to the BMP bottom below the water surface. SHA prefers not to use railings and prefers to have structures less than 48 inches high. Examples of features to look for within BMPs include risers with manholes on the top, weir walls, and end/headwalls. Also, structures that are greater than 30 inches in height and have a manhole on top should have ladder rungs on the exterior of the structure.

Confined Space – It is not the intent of the SHA inspections to perform confined space entry. Therefore inspectors should not enter pipes, risers, or underground vaults. Considering that most ponds contain risers and pipes, it is not necessary to indicate the site hazard of confined space for these features. It is implied that they are present and should not be entered without proper training. However, features such as underground sand filters and underground storage facilities could require confined space entry to inspect and they should be noted as an occupational hazard.

Safe Structure Size – A minimum of 50 inches is required from edge of manhole on two sides to adequately open a manhole lid (Figure 3.3). This allows the inspector sufficient space to stand on the structure and maneuver the manhole cover from the frame.

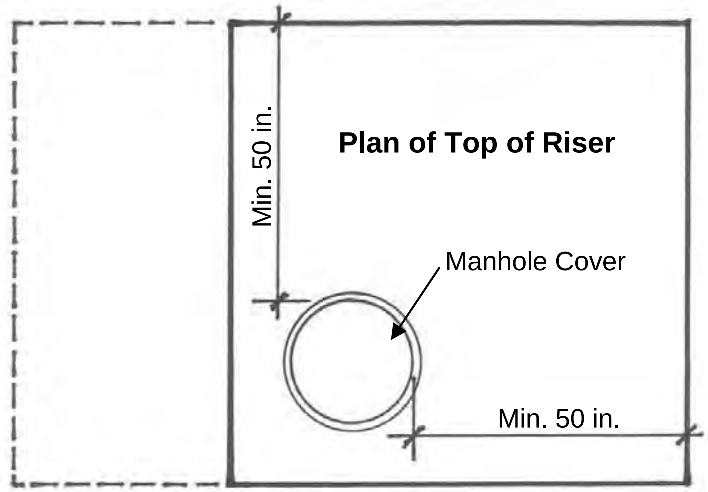

Figure 3.3 Riser Top Dimension Requirements at Manhole

3.5.3 BMP Inspection Criteria

This section describes the BMP inspection parameters and criteria to rate them in the field.

Each of the inspection parameters are scored on a scale of 1 to 5. The scoring defines the *relative* condition of each parameter. The objective is to provide a consistent framework for performing the scoring of individual parameters. In general the scoring reflects:

1 – Operating as Designed, No Issues Observed
2 – Functional, Minor Problems Exist
3 – Functional, Moderate Problems Exist
4 – Performance is Compromised, Major Problems Exist
5 – Non-Functional, Imminent Failure, Hazardous Conditions

When a parameter identifies an element that is not part of the BMP, the scoring is:

0 – Not Scored

When a parameter is part of the BMP and could not be inspected, then the scoring is:

NR – Not Rated

3.5.4 Environmental Quality Inspection Parameters

Environmental quality parameters focus on environmental functions of the BMP such as water quality treatment, stormwater management performance, and wildlife/aquatic habitat. This also assesses how the facility may negatively impact the surrounding environment with conditions such as erosion and litter. These parameters are recorded for all BMPs.

1. **Debris** *(debris)* – scores the overall condition of the BMP related to the physical presence of unwanted woody/leafy material, garbage accumulations, and sedimentation that possibly can block the outlet structure. This parameter should be evaluated based on the existing debris build-up, potential sources of debris, and potential blockage that could occur during future precipitation events.

   Scoring Value Evaluation:

   1. Facility and/or outlet structure is absent of woody/leafy debris, garbage, and/or sediment accumulations.
   2. Facility has *minor* accumulations of woody/leafy debris, garbage, and/or sediment blocking 0 to 25% of the outlet structure.
   3. Facility has *moderate* accumulations of woody/leafy debris, garbage, and/or sediment blocking 26 to 50% of the outlet structure and/or the amount of debris potentially could cause problems during future precipitation events. Maintenance needs to be scheduled.
   4. Facility has *major* accumulations woody/leafy debris, garbage, and/or sediment blocking 51 to 75% of the outlet structure and/or the amount of debris potentially could cause problems during future precipitation events. Maintenance needs to be performed immediately.
   5. Facility has overwhelming accumulations of woody/leafy debris, garbage, and/or sediment blocking 76 to 100% causing the outlet structure and the structural integrity of the facility to be compromised. Maintenance needs to be performed immediately.

2. **Inflow Condition** *(qin_cond)* – scores the overall impact of the discharges into a BMP and their adverse effects that may impair the performance of the BMP. This focuses on discharges from swales or pipe conveyances.

   Scoring Value Evaluation:

   1. Facility is operating as designed and there are no problems as a result of discharges into the BMP. No maintenance required.
   2. Facility is operating as designed, but has minor issues related to sedimentation or scour within the BMP at the discharge points into the BMP. No maintenance is required, but condition should be monitored.
   3. Facility shows moderate evidence that BMP performance is compromised due to sedimentation or scour. Maintenance should be performed.
   4. Facility shows major evidence that BMP performance is not being maintained due to discharges that may be causing instabilities at discharge points into the BMP. Maintenance should be performed.
   5. Facility shows evidence that BMP performance has failed due to unstable discharge points into the BMP. Maintenance should be performed immediately.

3. **Inflow Stability** *(qin_stability)* – scores the condition of flows into a BMP, such as areas of sheet flow, swales, and storm drains discharging into the BMP. Evidence of instabilities around the periphery of the BMP, such as erosion or exposed areas lacking vegetative cover, is evaluated. Areas exhibiting instabilities within the stormwater treatment portion of the site are evaluated under the parameter **Conveyance Stability**

(i.e.erosion at perimeter of pond due to vertical fluctuatioin of the water surface for storm storage).

Scoring Value Evaluation:

1. Channels, areas of sheet flow or conveyance pipes are functioning properly. No maintenance required.
2. Channels, areas of sheet flow or conveyance pipes show minor evidence of erosion. No maintenance is required, but condition should be monitored.
3. Channels, areas of sheet flow or conveyance pipes show moderate evidence of erosion. Erosion is actively occurring and discharging sediment in the BMP facility. Maintenance should be performed.
4. Channels, areas of sheet flow or conveyance pipes show major evidence of erosion. Erosion is actively affecting the structural integrity of the embankment. Maintenance should be performed.
5. Channels, areas of sheet flow or conveyance pipes are eroded. Embankment failure has occurred or failure is anticipated during the next precipitation event. Maintenance should be performed immediately.

4. **BMP Vegetation** *(bmp_veg)* – this parameter must be evaluated during the growing season between the May 15th to October 30th; otherwise the specific vegetation can not be adequately assessed. This scores the condition of vegetation that is associated with the BMP function. Condition of plants is scored according to effective area of plant cover at the treatment area, the physical condition of the plants and the presence of invasive species. Invasive species will be noted in the BMP Concerns table described in Section 3.7. The inspector should rate the vegetation according to the worst parameter. For example, the vegetation may cover 80% of the treatment area, but 60% of the species are invasive. In this case the scoring would be 4 due to the large percentage of invasives present.

   Only the site area providing stormwater treatment is considered, so areas such as the embankment and site vegetation are scored with different parameters. If a BMP does not have specific plants defined for stormwater treatment, this parameter is not scored.

   To inspect these areas, the inspector may need to wade into water depths up to 3 ft and should be prepared for this by using appropriate field equipment. The inspector should have a copy of the original planting/landscape plan, and as-built certification plans (if available) with a planting checklist. The checklist is used to evaluate the vegetation. If no planting/landscape information is available, the vegetation should still be scored but a comment is required in the overall comments (*com_overal*).

   Certain BMPs require plants to perform the treatment and the planting is integral to the success of the facility. These types of BMPs include:

   - Filtering Devices with Vegetation (e.g. bioretention, bio-inlets)
   - Stormwater wetlands
   - Submerged benches at stormwater
   - Wet swales

ponds

The types of planting areas the inspector is likely to encounter include:

- Marshes with water depths varying from 6 to 18 inches. The types of plants to be expected in these areas are emergents (rooted into the substrate with erect stems and leaves emerging from water surface) and floating aquatics (rooted into the substrate with leaves floating on water surface). These areas may also be planted with or become established with water tolerant woody vegetation (shrubs or trees).

- Micropools or deep water areas with water depths 3 ft or greater. These areas may not be planted but if they are the plants will often be submerged aquatic plants (free floating plants that do not root into the substrate). It is not likely that woody vegetation will be planted into these deeper areas, but with time, some may become established.

- Confined, mulched planting areas with special planting soil underlain with underdrains that daylight or connect to a closed storm drain system. This confined area may be placed in the landscape or be within a concrete or other type of structure. The depth of the special planting soil over the underdrains may dictate the type of plants that are appropriate. These areas are frequently inundated and have standing water for up to 24 hours or more after a rain event. They will be planted with a mix of native trees, shrubs and herbaceous plant that are ponding tolerant. If the planting depth is less than 2½ ft., large trees should not be present in the facility. The inspector should review the BMP design details to determine the planting depth.

<u>Scoring Value Evaluation:</u>

1. Treatment area has >80% vegetation cover. The species are predominantly native with <10% invasive. The plants are predominantly in good health.
2. Treatment area has 60-80% vegetation cover. The majority of species are native species with 10-30% invasive. There are a few species exhibiting poor health.
3. Treatment area has 40-60% vegetation cover. Native species are becoming overcome by invasives with 31-50% invasive species present. The plants are largely healthy with 20% exhibiting stress or other signs of poor health.
4. Treatment area has 20% to 40% vegetation cover. Invasive species are dominant with 51-70% invasives present. The plants are unhealthy with 20-40% exhibiting signs of stress or poor health.
5. Treatment area has <20% vegetation cover. Invasive species predominate with >70% invasive. The majority of plants are in poor health indicating something systemic or toxic.

5. **BMP Contamination** *(bmp_cont)* – scores the overall condition of the BMP related to residue of contaminants from nearby activities or non-point source pollution within the watershed. Examples are visual evidence of oil sheen on the water surface from illegal dumping or roadway runoff, heavy sedimentation, potentially hazardous waste (containers, vehicle batteries, tires, etc.) and thick algae growth. This evaluation should consider the type of contamination, potential effects of the decomposition or releases of

the waste, quantity within the facility, and potential effects to downstream resources. The inspection will log specific contaminations identified and added to the Concerns table.

Scoring Value Evaluation:

1. Facility is absent of residual litter or hazardous waste and has no potential for contamination.
2. Facility has minor accumulations of residual litter and/or hazardous waste, but no observed or potential contamination.
3. Facility has moderate accumulations of residual litter and/or hazardous waste, and there is observed or potential for minor contamination.
4. Facility has major accumulations of residual litter and/or hazardous waste, and there is observed or potential for significant contamination.
5. Facility has major accumulations of residual waste and/or hazardous waste, and there is observed or potential for major contamination.

6. **Ponding** *(ponding)* – scores the accumulation of stormwater beyond 72 hours after a storm event resulting in loss of storage for water quality and/or detention. The ponding may be due to the loss of infiltration capacity, loss of storage capacity, or blockage at the outlet control structure. This issue can be common to SWM facilities such as detention ponds, dry extended detention ponds, and infiltration and filtration practices. Ponds in general can be impacted by loss of temporary storage that may result in reduced management of peak flows, and increased risk for dam breaching. Infiltration and filtering devices can be impacted by loss of sub-surface volumes that may result in reduced treatment and allow bypassing of stormwater.

   Ponding is usually a result of the dewatering device malfunctioning, blockage of the outlet structure, or improper design or construction. In some cases it can be caused by additional runoff directed to the BMP from new off-site construction. This parameter can be associated with other ones such as BMP-Contamination and BMP-Debris.

   An inspector should be conscious of precipitation events prior to the inspection. BMP inspections must be performed no less than 72 hours after a storm event to allow a BMP adequate time to dewater. As part of this parameter, measurement of standing water depth (*wat_depth*) above the design elevation from construction plans will be taken. When an observation well is present (e.g., infiltration trenches), the standing water depth is measured within the observation well.

   <u>Scoring Value Evaluation:</u>

   0. Observation well not installed or found during the inspection, but needed as part of the BMP type.
   1. **SWM Facility** is dewatering at design rate or found dry.

      Infiltration / Filtering Device has <10% of water retained in the facility. Note: % of water retained = (standing water depth/ observation well depth) x 100
   2. **SWM Facility** has minor ponding, but overall is functioning properly. Facility is retaining between 0 to 25% more volume than designed.

      Infiltration / Filtering Device has 11 to 25% of water retained in the facility.
   3. **SWM Facility** has moderate ponding. Facility is retaining 26 to 50% more volume than designed.

      Infiltration / Filtering Device has 26 to 50% of water retained in the facility.
   4. **SWM Facility** has major ponding. Facility is retaining 51 to 75% more volume than designed.

      Infiltration / Filtering Device has 51 to 75% of water retained in the facility.
   5. **SWM Facility** has ponding causing the emergency spillway to be regularly utilized to release runoff during precipitation events. Facility is retaining >76% more volume than designed. Erosion may be actively occurring near the earthen berm with a potential of dam failure during future precipitation events.

      Infiltration / Filtering Device has >76% of water retained in the facility.

7. **Ponding Depth** *(wat_depth)* – is a measurement of the depth of the ponded water in the facility. It is measured to the nearest tenth of a foot, where possible.

   For Infiltration and Filtering Devices, this is the depth of standing water within the observation well. In the field, water level is measured from the top of the observation well to the surface of water. Depth of standing water is then calculated by subtracting water level in observation well from the observation well depth. For observation wells with locked/immovable caps, the cap should be removed using appropriate tools (e.g., bolt cutters, hack-saw). Any modification to well cap or observation well should be reported within the comments field for maintenance purposes. The comment "observation well locked or could not be accessed" is unacceptable. For these devices without observation wells, no value is entered and the field is to be left blank.

   Other BMPs use design elevations from plans and field observations.

8. **Permanent Pool** *(permpool)* – scores the condition of BMPs with permanent standing water that is designed for water quality treatment. The intent of this parameter is to identify loss of permanent pool volume. This may occur by displacement of the volume (e.g. sedimentation or excessive vegetation) or by reduction (e.g. insufficient source of water). The BMP types that may meet this criterion include ponds (e.g. wet pond, wet extended detention pond, pocket pond or detention pond with micro-pools), Stormwater Wetlands, and Wet Swales. Design plans, profiles and details are necessary to properly estimate the design permanent pool elevation.

   The inspection requires the comparison of the maximum observed water depth of the permanent pool(s) against the design depth(s). Observed water depth(s) should be measured at the deepest point of the pool area. In many cases this may be in the middle of the pool area, but safe access may not be feasible due to location, deep water, and/or bottom conditions. With care measurements can possibly be taken at alternative locations (e.g. riser) or by visual approximation. The depth of water should be measured to the nearest tenth of a foot, where possible. Note that depth measurements do not consider features such as forebays or plunge pools.

   Inspection for loss of volume should consider evidence of excessive sedimentation (e.g., filled forebay, delta-like deposits at in-flow points) and/or excessive vegetation within BMP area dedicated to permanent pool. Inspection for irregular water source should consider evidence of fluctuating shoreline, exposure of underwater safety bench that may include vegetation. Inspection for excessive water loss should consider evidence of improper impervious liner or improper low-flow device.

   This parameter may be scored in conjunction with BMP Vegetation parameter when aquatic plants are dependent on standing water as part of the design.

Scoring Value Evaluation:

0. No permanent standing water was included in the design.
1. Water depth matches the design plans, and no there is no evidence of irregular water-levels.
2. Water depth is 75% to <100% of the design depth OR there is evidence of minor fluctuations of water-levels. A note is required in the overall comments (*com_overal*) whether issues relate to sedimentation and/or irregular source of water.
3. Water depth is 50 to <75% of the design depth OR there is evidence of moderate fluctuations of water-levels. A note is required in the overall comments (*com_overal*) whether issue relates to irregular source of water.
4. Water depth is 25 to <50% of the design depth OR there is evidence of significant fluctuations of water-levels. A note is required in the overall comments (*com_overal*) whether issues relate to sedimentation and/or irregular source of water.
5. Water depth is <25% of the design depth OR there is evidence of major fluctuations of water-levels. A note is required in the overall comments (*com_overal*) whether issues relate to irregular source of water or diversion of designed runoff.

9. Pretreatment *(pretreat)* – scores the BMP feature(s) relating to pretreatment of stormwater prior to entering the treatment area. Examples are forebay, pea gravel diaphragm, filter strip, mulch layer in bioretention facilities or other types of pretreatment. Care must be taken to ID a forebay. Typically the forebay is smaller than the impoundment area. This field scores the condition of an existing forebay or other type of pretreatment relating capacity to trap incoming sediment. Forebays should have adequate freeboard to capture and retain sediment. If freeboard is absent, then sediment removal is warranted.

Scoring Value Evaluation:

0. Pretreatment does not exist.
1. Pretreatment is absent of vegetation, woody/leafy debris, garbage, and/or sediment accumulations.
2. Pretreatment has *minor* accumulations of vegetation, woody/leafy debris, garbage, and/or sediment comprising of <25% of the volume.
3. Pretreatment has *moderate* accumulations of vegetation, woody/leafy debris, garbage, and/or sediment comprising of 26 to 50% of the volume. BMP facility is receiving minor accumulations of sediment. Maintenance needs to be scheduled.
4. Pretreatment has *major* accumulations of vegetation woody/leafy debris, garbage, and/or sediment comprising of 51 to 75% of the volume. BMP facility is receiving moderate accumulations of sediment. Maintenance needs to be performed immediately.
5. Pretreatment is non-functional and has major accumulations of vegetation woody/leafy debris, garbage, and/or sediment comprising of >75% of the volume. BMP facility may be receiving major accumulations of sediment. Maintenance needs to be performed immediately.

3.5.5 Sustainability Inspection Parameters

The following parameters include those relevant to all BMPs and also those that are specific to structural elements of impoundments with embankments/berms and/or structural outlets. These parameters are identified in Maryland Pond 378 Regulations and SHA uses the regulations as a guide. The following parameters are specific to transportation related BMPs and SHA maintenance operations. These parameters are critical to SWM ponds designed under these regulations. However, these parameters can also be applied to BMPs that have structural elements that if they fail may cause significant damage.

10. Mowability (mow) – scores the areas requiring routine mowing and their slope considerations for allowing the mowing function to take place. Mowing should take place on the embankment to minimize the chances of woody vegetation taking hold, 15 ft. along the toe of embankment on both the upstream and downstream sides, 25 ft. wide around the outfall structure, along the maintenance access road, at the emergency spillway opening, bottom and sides of surface sand filters, dry swales and infiltration basins (if vegetated in turf) and grassed filter strips. Areas that require routine mowing should be relatively flat (4:1 steepness or flatter) to allow mowing equipment to safely traverse slopes.

Scoring Value Evaluation:

0. If facility does not require routine mowing. (e.g. sand filter with aggregate surface treatment, aggregate access road and rest of site is forested.)
1 If all areas requiring routine mowing are sufficiently flat and accessible by tractor type mowing equipment.
2. If structural components of the facility (embankment, spillway, outfall structure and access road) are flat enough to mow with tractor type mowers but other components within the facility requiring routine mowing are too steep to mow with tractor type equipment.
3. If structural components of the facility (embankment, spillway, outfall structure and access road) are getting too steep to mow with tractor type mowers allowing only portions to be kept clear without using hand equipment.
4. If structural components of the facility (embankment, spillway, outfall structure and access road) are too steep to mow with tractor type mowers requiring the use of hand equipment to keep these areas clear. Other components within the facility make it impossible to use tractor type or push mowers and require hand trimming with mechanized trimmers (e.g., many observations wells are located within a surface sand filter and they are not flush with the ground).
5. If structural components of the facility (embankment, spillway, outfall structure and access road) are too steep to mow with either tractor type mowers or hand mowers, requiring the use of hand trimmers, boom arms attached to larger equipment or other specialized equipment.

11. Access *(access)* – scores the existence of a maintenance access road and if it exists, how well is it designed to meet SHA criteria. SHA requires that all new SWM BMPs have maintenance access designed to the following criteria.

The inspector should tally the number of criteria that are met and use the following table to determine a scoring.

Scoring Value Evaluation:

Criteria Met	Scoring
5	1
4	2
3	3
1,2	4
0	5

Unobstructed – It should be accessible from a public roadway with no obstructions such as traffic barrier blocking the entrance. If the access is obtained by entering a privately owned parking lot, this requirement has not been met because it is not a public roadway. County, city, and park roads are examples of public access. If traffic barrier rails obstruct the access, this criterion has not been met, even if it is possible to remove the rails and reinstall them without obstructing traffic. If a gate has been provided but is overgrown with vegetation, this requirement has not been met.

Pull-Off – a pull off should be provided for trailers and other equipment to be parked without blocking the access to the facility or blocking traffic on the roadway. If a maintenance of traffic scheme is required in order for a crew to get all their equipment on the site and park their vehicles, this requirement has not been met. A pull off can be a roadway shoulder if it is 12 ft. wide.

Turnaround – area should be provided at the top or entrance of the access for a large dump truck to turn around and back down into the facility.

Stabilized and Maximum Steepness of 6.6:1 (15%) – access surface should be stabilized against rutting by large equipment tires or erosion. Buried gravel is acceptable for this. If either the stabilization or the steepness criteria is not met, this requirement has not been met.

10 ft. Minimum Width – width is essential to allow equipment to the areas necessary for maintenance. The width should extend the whole length of the access, to outfall structures (upstream and downstream sides), forebays or pretreatment areas, upstream and downstream sides of embankments, emergency spillways and other areas requiring routine maintenance. If the access is obstructed by vegetation, this requirement has not been met.

12. **Access Comments** (*com_access*) – describes issues relating to accessing a BMP site for field inspection or remedial actions. This information is logged in a comment field. Relevant issues to investigate include:

    - Guardrails hinder Maintenance of Traffic, entry into facility, or navigating the facility
    - Ground conditions (e.g. rip-rap, vegetation, soft ground) hinder access into or around the facility
    - Steep slopes (3:1 or greater) between the roadway and the facility
    - Structures (e.g. jersey wall) or features (utilities) restrict access or navigating the facility

13. **Conveyance Stability** (*Convey_Stability*) – scores the stability of flow conveyance through the stormwater treatment area. This parameter takes into consideration erosion, ground cover, control features (gabion, check dams, earthen dam), and berms. The conveyance feature should be stable and have adequate grass/vegetative cover and be free from erosion. This also includes areas that experience instabilities from frequent water surface fluctuations. These areas are located above the facility bottom, and may appear eroded, have slumped shoreline, and/or lack established vegetation. This parameter may also consider the performance of BMPs with underdrains.

    Scoring Value Evaluation:

    1. Overall conveyance is stable.
    2. Overall conveyance has minor erosion, but ground cover is stable.
    3. Overall conveyance features have minor erosion, loss of ground cover, but structure is intact.
    4. Overall conveyance features have major erosion around and over dams, ground cover is limited, and structures show signs of deterioration.
    5. Overall conveyance features have failed and are not performing as designed. Berms and dams have failed due to severe erosion. Needs attention immediately.

14. **Downstream Channel Condition** (*DS_conditions*) – scores the overall downstream channel conditions beyond the SHA ROW. The downstream channel should show no signs of erosion and be stable.

    Scoring Value Evaluation:

    1. Downstream channel is intact and free of erosion.
    2. Downstream channel has minor erosion not affecting nearby area. Channel is stable. No headcut has formed.
    3. Downstream channel has major erosion not affecting vegetation. The channel width is wider than designed and a headcut has formed. There is minor vegetation loss. Channel is unstable and may be a pedestrian hazard.
    4. Downstream channel has major channel erosion and vegetation loss. Trees have fallen into the channel and a major headcut has formed.
    5. Downstream channel has completely eroded. Vegetation on the banks is minimal. A major headcut has formed and can be considered a pedestrian hazard. Needs repair immediately.

15. **Site Vegetation** (*site_veg*) – should be scored during the growing season between the dates May 15th to October 30th. This parameter scores the need for vegetation management other than routine mowing to be undertaken at the facility. Vegetation management includes tree trimming, selective tree thinning, and tree and shrub removal using Maryland State approved herbicide application methods by a licensed applicator. This parameter will determine if proper vegetation management is currently being undertaken or if steps need to be taken to pursue management.

    The need for vegetation management should evaluate how well managed or overgrown the vegetation is by considering whether fencing is overgrown, access road is traversable, and if gate is clear. This parameter should also consider accessibility to all pond features due to vegetation growth. Invasive species will be noted in the BMP Concerns table described in Section 3.7.

    The inspector should look at site areas other than the treatment area if the BMP Vegetation parameter was scored for this facility. If the BMP Vegetation parameter was not scored for this facility, the whole site including the treatment area should be considered in the scoring. The embankment, embankment toe and 25 ft. area around the riser/weir structure is scored under embankment cover parameters.

    Scoring Value Evaluation:

    1. Perimeter of site has well managed vegetation, is free from fallen, dead or damaged trees and access to all pond features is available. Access road is free of overgrown vegetation. No vegetation management other than routine mowing needs to be undertaken.
    2. The site is 0 to 25% overgrown and access to all pond features is available. No vegetation management other than routine mowing needs to be undertaken.
    3. The site is 26 to 50% overgrown making it difficult to access and inspect pond features. Vegetation management is recommended.
    4. The site is 51 to 75% overgrown making it very difficult to access and inspect pond features. Inflow structures cannot be seen due to heavy vegetation, and navigation within the facility is nearly impossible. Vegetation management is necessary to complete inspection properly.
    5. The site is 76 to 100% overgrown making it impossible to access the facility. Access gate is sealed due to vegetation and an inspection of the facility is impossible. Vegetation management is urgent and inspection could not be completed.

16. **Upstream-Cover** (*embu_cvr*) **–** typically this parameter is scored during the growing season between the dates of May 15th and October 30th." The parameter scores the overall vegetative condition of the upstream slope of the embankment, including within 15 feet of the embankment toe, related to type, size and percent coverage. There should be no woody vegetation on the dam embankments due to the potential of piping along the root systems from the upstream to the downstream trees**.** Additionally, an area 25 feet around the riser and weir structure should be kept free of woody species.

    Scoring Value Evaluation:

    1. Upstream cover on the embankment is densely vegetated with 100% herbaceous cover. There is no woody vegetation.

2. Upstream cover on the embankment is moderately vegetated with 76 to 100% herbaceous cover and/or minor sapling woody vegetation less than 0.5 inches in diameter identified.
3. Upstream cover on the embankment is moderately vegetated with 51 to 75% herbaceous cover and/or moderate woody vegetation, ranging in size from 0.5 to 1.5 inches in diameter identified. Maintenance needs to be scheduled.
4. Upstream cover on the embankment is vegetated with 26 to 50% herbaceous cover and/or major woody vegetation greater than 1.5 inches in diameter identified. Maintenance needs to be performed immediately.
5. Upstream cover on the embankment is vegetated with 0 to 25% herbaceous cover and/or woody vegetation greater than 1.5 inches in diameter that has compromised the structural integrity of the embankment and emergency spillway. Maintenance needs to be performed immediately.

17. Upstream Embankment Stability (*embU_ero*) **–** scores the condition of the upstream embankment stability related to erosion. Evaluation should consider identifying unvegetated areas, establishing source of hydrology for problem areas, as well as any problems with settlement, scouring, horizontal or longitudinal cracking, sloughing or rutting**.**

Scoring Value Evaluation:

1. Embankment shows no evidence of surficial erosion, slides, sloughing, or settlement. Embankment appears stable.
2. Embankment shows *minor* evidence of surficial erosion with no significant soil loss, settlement, or small sized horizontal/vertical slope cracks, but no evidence of sloughing. Erosion and settlement areas are small and isolated. Embankment appears stable.
3. Embankment shows *moderate* evidence of surficial erosion or sloughing AND *minor* embankment loss, settlement, or medium sized horizontal/vertical cracks with slight evidence of sloughing. Embankment appears stable, but requires maintenance.
4. Embankment shows *major* evidence of surficial erosion with major embankment loss, settlement or large sized horizontal/vertical slope cracks AND *moderate* evidence of sloughing that potentially may compromise the structural integrity of the embankment. Maintenance needs to be performed immediately.
5. Embankment shows *major* evidence of surficial erosion with major embankment loss, settlement, or large sized horizontal/vertical slope cracks AND *major* evidence of sloughing that has compromised the structural integrity of the embankment. Maintenance needs to be performed immediately.

18. Upstream Embankment Toe (*embU_toe*) **–** scores the condition of the upstream stability within 15 feet of the upstream toe of embankment. Evaluation should consider void areas created from embankment settlement, and/or evidence of rodent infestations, such as muskrat and groundhog, which can burrow through the embankment and create a potential piping situation. In addition, the holes should be evaluated for evidence of water entering the area**.**

Scoring Value Evaluation:

1. Upstream embankment toe is stable.
2. Upstream embankment toe is stable with minor settling.
3. Upstream embankment toe is stable with moderate settlement and/or presence of burrow holes. Maintenance needs to be scheduled.
4. Upstream embankment toe is unstable with major settlement and evidence of flow into burrow holes identified. Maintenance needs to be performed immediately.
5. Upstream embankment toe has compromised the structural integrity of the embankment with settlement, and/or evidence of flow conveying into the burrow holes. Maintenance needs to be performed immediately.

19. Downstream-Cover (*embD_cvr*) **–** typically this is scored during the growing season between May 15th and October 30th. This parameter scores the overall vegetative condition of the downstream slope of the embankment, including within 15 feet of the embankment toe, related to type, size and percent coverage. There should be no woody vegetation on the dam embankments for the potential of piping along the root systems from the upstream to the downstream trees**.** If the area 15 feet from the downstream toe is not within SHA right-of-way, the inspector should note this in the comments.

Scoring Value Evaluation:

1. Downstream cover on the embankment is densely vegetated with 100% herbaceous cover. There is no woody vegetation present.
2. Downstream cover on the embankment is vegetated with >75% herbaceous cover and/or *minor* sapling woody vegetation less than 0.5 inches in diameter identified.
3. Downstream cover on the embankment is vegetated with 50 to 75% herbaceous cover and/or *moderate* woody vegetation, ranging in size from 0.5 to 1.5 inches in diameter identified. Maintenance needs to be scheduled.
4. Downstream cover on the embankment is vegetated with 25 to 50% herbaceous cover and/or *major* woody vegetation greater than 2 inches in diameter identified. Maintenance needs to be performed immediately.
5. Downstream cover on the embankment is vegetated with <25% herbaceous cover and/or woody vegetation greater than 1.5 inches in diameter that has compromised the structural integrity of the embankment and emergency spillway. Maintenance needs to be performed immediately.

20. Downstream Embankment Stability (*embD_ero*) **-** scores the condition of the downstream embankment stability related to erosion. Evaluation should consider identifying unvegetated areas, establishing source of hydrology for problem areas, any problems with settlement, scouring, horizontal or longitudinal cracking, soughing or rutting**.**

<u>Scoring Value Evaluation:</u>

1. Embankment shows no evidence of surficial erosion, slides, sloughing, or settlement. Embankment appears stable.
2. Embankment shows *minor* evidence of surficial erosion with no significant soil loss, settlement, or small sized horizontal/vertical slope cracks, but no evidence of sloughing. Erosion and settlement areas are small and isolated. Embankment appears stable.
3. Embankment shows *moderate* evidence of surficial erosion or sloughing with minor embankment loss, settlement, or medium sized horizontal/vertical slope cracks with slight evidence of sloughing. Embankment appears stable, but maintenance needs to be scheduled.
4. Embankment shows *major* evidence of surficial erosion with major embankment loss, settlement or large sized horizontal/vertical slope cracks with moderate evidence of sloughing that potentially may compromise the structural integrity of the embankment. Maintenance needs to be performed immediately.
5. Embankment is actively eroding with major embankment loss, settlement, or large sized horizontal/vertical slope cracks with major evidence of sloughing that has compromised the structural integrity of the embankment. Maintenance needs to be performed immediately.

21. Downstream Embankment Toe Settling (*embD_toe*) **-** scores the condition of the downstream stability within 15 feet of the downstream toe of embankment. Evaluation should consider void areas created from embankment settlement, and/or evidence of rodent infestations, such as muskrat and groundhog, which can burrow through the embankment and create a potential piping situation. In addition, the holes should be evaluated for evidence of water entering the area**.**

<u>Scoring Value Evaluation:</u>

1. Downstream embankment toe is stable.
2. Downstream embankment toe is stable with minor settling
3. Downstream embankment toe is stable with moderate settlement and/or presence of burrow holes. Maintenance needs to be scheduled.
4. Downstream embankment toe is unstable with major settlement and evidence of flow into burrow holes identified. Maintenance needs to be performed immediately.
5. Downstream embankment toe has compromised the structural integrity of the embankment with settlement, and/or evidence of flow conveying into the burrow holes. Maintenance needs to be performed immediately.

22. Embankment Seepage (*embD_seep*) **–** scores the condition of downstream embankment related to water seeping out. Direct discharge and saturated soil conditions along the embankment face and/or toe should not be identified as a natural groundwater seep. Care should be taken in the determination process, because this condition may be evidence of piping through the embankment and the beginning of embankment failure.

Indicators of seepage would be saturated soil conditions, direct discharge, surficial erosion, sediment accumulations at the embankment toe, slides or sloughing, vertical or horizontal settlement, and any changes in vegetative characteristics, such as isolated hydrophytic (wetland) vegetation on embankment.

Scoring Value Evaluation:

1. Embankment is stable with no indicators of seep discharge.
2. Embankment is stable with *minor* soil saturation at the embankment toe. No evidence of concentrated discharge or erosion.
3. Embankment shows evidence of *moderate* evidence of soil saturation. Condition should be inspected and monitored annually.
4. Embankment shows evidence of *major* soil saturation, concentrated discharge and surficial erosion that potentially may compromise the structural integrity of the embankment. Maintenance needs to be performed immediately.
5. Embankment has concentrated discharge and surficial erosion that has compromised the structural integrity of the embankment. Maintenance needs to be performed immediately.

23. Emergency Spillway-Stability (*espw_stab*) **–** scores the stability of the emergency spillway relating to erosion of sides and bottom. Emergency spillway should be located in undisturbed ground and stabilized with herbaceous vegetation, riprap or gabions**.** An inspector should be conscious of precipitation events prior to the inspection of the BMP facility so that emergency spillway use frequency can be established. If the BMP is functioning properly, then by design, the emergency spillway should only be utilized to pass flows during high precipitation events.

In the event, that there is no emergency spillway and the riser design utilizes a combination of principal/emergency spillway the scoring should be "0".

Scoring Value Evaluation:

0. No emergency spillway.
1. Emergency spillway is stabilized and functioning properly.
2. Emergency spillway is stabilized with *minor* erosion of the sides and channel.
3. Emergency spillway has *moderate* erosion of the sides and channel but the crest invert remains stable. Maintenance needs to be scheduled.
4. Emergency spillway has evidence of *major* erosion of the sides and channel. Riprap may have relocated to the toe or gabions are undermined. Sediment is observed from active erosion of the crest invert that potentially may compromise the structural integrity of the embankment. Maintenance needs to be performed immediately.

5. Emergency spillway is actively eroding on the sides and channel, and crest invert. Active erosion of the crest invert has compromised the structural integrity of the embankment. Maintenance needs to be performed immediately.

24. Emergency Spillway-Opening (*espw_open*) **–** scores the condition of the emergency spillway weir opening to function as designed when necessary. The emergency spillway crest invert should be a minimum of 1 foot below the top of the settled embankment. The weir cross-sectional opening should be free of debris and woody vegetation.

Both emergency spillway conditions should be evaluated and scored based not only on the existing conditions, but also for future precipitation events that may potentially compromise the function of the opening. If there is no emergency spillway and the riser is a combination principal/emergency riser structure, then the Riser-Opening will be evaluated and a "0" will be recorded for the Emergency Spillway-Opening.

<u>Scoring Value Evaluation:</u>

0. No emergency spillway and riser structure exist.
1. Emergency spillway cross-section is free of any woody/leafy and garbage debris and potential blockage. Emergency spillway opening is free of any woody/leafy and garbage debris accumulations.
2. Emergency spillway cross-section has *minor* woody/leafy and garbage debris and potential blockage. Emergency spillway opening has *minor* woody/leafy and garbage debris accumulations.
3. Emergency spillway cross-section has *moderate* woody/leafy and garbage debris and potential blockage. Emergency spillway opening has *moderate* woody/leafy and garbage debris accumulations. Maintenance should be scheduled.
4. Emergency spillway cross-section has *major* woody/leafy and garbage debris and potential blockage. Emergency spillway opening has *major* woody/leafy and garbage debris accumulations. Maintenance should be performed immediately.
5. Emergency spillway cross-section is blocked with woody/leafy and garbage debris. Emergency spillway opening is blocked with woody/leafy and garbage debris accumulations. The blockage may have compromised the structural integrity of the embankment. Maintenance should be performed immediately.

25. Orifice Opening (*orf_open*) **–** scores the opening of the low flow orifice to allow for proper drainage of the BMP. This parameter evaluates the presence of vegetation, woody debris, sediment, and garbage to block the orifice. There should be no temporary sediment control appurtenances attached to the riser structure that would restrict the orifice function. Orifice opening should be evaluated and scored based not only on the existing conditions, but also for future precipitation events that may potentially be able to compromise the function of the opening.

<u>Scoring Value Evaluation:</u>

0. No low flow orifice exists.

1. Orifice opening is free of any woody/leafy and garbage debris.
2. Orifice opening is blocked <25% with woody/leafy and garbage.
3. Orifice opening is blocked 25 to 50% with woody/leafy and garbage debris. Maintenance should be scheduled.
4. Orifice opening is blocked 51 to 75% with woody/leafy and garbage. Maintenance should be performed immediately.
5. Orifice opening is blocked >75% with woody/leafy and garbage. As the result storage volume is reduced and other problems related to the BMP have compromised the structural integrity of the embankment. Maintenance should be performed immediately.

26. Orifice Trash Rack *(orf_trsh)* – scores the structural condition of the trash rack on the low flow orifice. Two (2) inch stone may be substituted for the trash rack. This parameter evaluates any damage, presence of vegetation, woody debris, sediment, and/or garbage in and around the orifice.

If there is no riser structure present and only a pipe with an end-section exists, then an evaluation scoring of "0" is recorded.

Scoring Value Evaluation:

0. No trash rack on the low flow orifice exists.
1. Orifice trash rack is free of any woody/leafy and garbage debris. Trash rack is undamaged and functioning properly.
2. Orifice trash rack is <25% with woody/leafy and garbage. Trash rack has minor damage, but functioning properly.
3. Orifice trash rack is blocked 26 to 50% with woody/leafy and garbage debris. Trash rack has moderate damage and only functioning partly. Maintenance should be scheduled.
4. Orifice trash rack is blocked 51 to 75% with woody/leafy and garbage. Trash rack has major damage and efficiency is compromised. Maintenance should be performed immediately.
5. Orifice trash rack is blocked >75% with woody/leafy and garbage. Trash rack is damaged and is compromised. Ponding is occurring, storage volume is reduced, or other problems have compromised the embankment structural integrity. Maintenance should be performed immediately.

27. **Riser Opening** *(rsr_open)* – scores the openings of the riser structure, weir, or end-section (also headwall, endwall) to allow for proper flow through the spillway. It evaluates the presence of vegetation, woody debris, sediment, and garbage blocking the orifice. There should be no temporary sediment control appurtenances attached to the riser structure that would restrict the orifice function.

    If the riser structure is a combination principal/emergency, then the riser opening parameters will be evaluated and a "0" recorded for the **Emergency Spillway Opening** parameter. If there is no riser structure present and only a pipe with an end-section exists, then only the riser opening parameter should be evaluated and scored. In the comment section, no riser structure should be documented.

    <u>Scoring Value Evaluation:</u>

    1. Riser opening is free of any woody/leafy, sedimentation, and garbage debris.
    2. Riser opening is blocked <25% with woody/leafy, sedimentation, and garbage.
    3. Riser opening is blocked approximately 26 to 50% with woody/leafy, sedimentation, and garbage debris. Maintenance should be scheduled.
    4. Riser opening is blocked approximately 51 to 75% with woody/leafy, sedimentation, and garbage. Maintenance should be performed immediately.
    5. Riser opening is blocked approximately >75% with woody/leafy, sedimentation, and garbage. As the result of the blockage, storage volume is reduced and other problems related to the BMP have compromised the structural integrity of the embankment. Maintenance should be performed immediately.

28. **Riser Trash Rack** *(rsr_trsh)* – scores the structural condition of the trash rack on the riser structure. This parameter evaluates any damage, presence of vegetation, woody debris, sediment, and/or garbage in and around the Riser trash rack.

    <u>Scoring Value Evaluation:</u>

    0. No trash rack on the riser exists or only a pipe with an end-section exists.
    1. Riser trash rack is free of any woody/leafy and garbage debris. Trash rack is undamaged and functioning properly.
    2. Riser- trash rack is blocked <25% with woody/leafy and garbage. Trash rack has minor damage, but functioning properly.
    3. Riser trash rack is blocked 26 to 50% with woody/leafy and garbage debris. Trash rack has moderate damage and only partly functioning. Maintenance should be scheduled.
    4. Riser- trash rack is blocked 51 to 75% with woody/leafy and garbage. Trash rack has major damage and efficiency is compromised. Maintenance should be performed immediately.
    5. Riser trash rack is blocked >75% with woody/leafy and garbage. Trash rack is damaged and efficiency is compromised. As the result of the blockage, ponding is occurring, storage volume is reduced and other problems related to the BMP have compromised the structural integrity of the embankment. Maintenance should be performed immediately.

29. Riser Sediment *(rsr_sedi)* – scores the amount of sediment accumulated inside the riser structure that could restrict the riser performance. In addition, accumulation of woody/leafy debris, garbage, remnant construction concrete forms, and/or riprap should be evaluated and recorded. This parameter should be evaluated based on the existing debris build up, amount of potential sources of debris, and potential blockage that could occur during future precipitation events.

Scoring Value Evaluation:

0. No riser structure exists.
1. Facility and/or outlet structure is absent of woody/leafy debris, garbage, and/or sediment accumulations.
2. Facility has minor accumulations of woody/leafy debris, garbage, and/or sediment blocking <25% of the outlet structure.
3. Facility has moderate accumulations of woody/leafy debris, garbage, and/or sediment blocking 26 to 50% of the outlet structure and/or the amount of debris potentially could cause problems during future precipitation events. Maintenance needs to be scheduled.
4. Facility has major accumulations woody/leafy debris, garbage, and/or sediment blocking 51 to 75% of the outlet structure and/or the amount of debris potentially could cause problems during future precipitation events. Maintenance needs to be performed immediately.
5. Facility has major accumulations of woody/leafy debris, garbage, and/or sediment blocking >75% of the outlet structure and the structural integrity of the facility has been compromised. Maintenance needs to be performed immediately.

30. Riser Structure *(rsr_strc)* – scores the overall structural integrity of the riser weir, or outlet structure. This parameter evaluates any cracks, spalling, bad joints, or errors in construction undermining, erosion, and/or leaning of the riser structure.

Scoring Value Evaluation:

0. No riser structure exists.
1. Riser or outlet structure has no evidence of cracks, spalling, bad joints, erosion, and/or leaning of the structure. Riser structure is stable.
2. Riser or outlet structure has minor evidence of cracks and spalling, but is functional and in satisfactory condition.
3. Riser or outlet structure has moderate evidence of cracks, spalling, and joint problems, but is functional and in satisfactory condition. Maintenance should be scheduled.
4. Riser or outlet structure has major evidence of cracks, spalling, and joint problems, and/or leaning. Condition with riser structure is not functioning as designed and is in unsatisfactory condition. Condition may potentially compromise other parameters of the BMP. Maintenance needs to be performed immediately.
5. Riser or outlet structure has major evidence of cracks, spalling, and joint problems, and/or leaning. Condition of the riser has compromised the structural integrity of the BMP. Maintenance needs to be performed immediately.

31. **Riser Valve** *(rsr_valv)* – scores the condition of the valves and associated appurtenances of the riser. This parameter evaluates any physical damage and access to the valves; however, the valves should not be tested during the inspection. The valve should be chained and locked to prevent unauthorized use. If any damage is observed, then a subsequent inspection with SHA maintenance personnel is warranted.

Scoring Value Evaluation:

0. No valve.
1. Valve appears to be functional and is chained and locked.
2. Valve appears to be functional and is chained and locked, but debris and may present a difficulty in operation.
3. Operation of valve appears to be questionable, but is chained and locked.
4. Valve appears to be damaged and/or lacks chain and lock. Maintenance is suggested.
5. Valve has failed and needs to be fixed. Maintenance is required.

32. **Principle Spillway** *(prin_spwy)* – scores the overall condition of the principle spillway (pipe / barrel). This parameter evaluates any blocking, joint problems, sedimentation, irregularities in the flow line, and pipe structural integrity.

Scoring Value Evaluation:

1. Pipe is free of any woody/leafy, sedimentation, and garbage debris. Flow is unrestricted. Pipe shape, joints, and material condition is structurally in satisfactory condition. Repairs / retrofits remain in satisfactory condition.
2. Pipe is blocked <25% with woody/leafy, sedimentation, and garbage. Flow is partially restricted. Pipe shape, joints, and material condition is structurally in satisfactory condition. However, minor defects are present. Indicators may include minor changes in shape, dents, and/or slight gaps in joints.
3. Pipe is blocked 26 to 50% with woody/leafy, sedimentation, and garbage debris. Flow is restricted. Pipe shape, joints, and material condition is structurally in satisfactory condition. However, moderate defects are present. Indicators may include moderate changes in shape (top or side deflection), bolts or rivets under stress at the seams or joints may have gaps with minor soil exposure, pipe bottom may have moderate to major evidence of corrosion or abrasion, and/or minor flow line grade changes or deflections. Maintenance should be scheduled.
4. Pipe is blocked 51 to 75% with woody/leafy, sedimentation, and garbage. Flow significantly blocked. Pipe shape, joints, and material condition is structurally in unsatisfactory condition in isolated areas. Indicators may include major changes in shape (side or top deflection), stress fractured bolts or rivets at seams or joints have moderate gaps with minor voids and major soil exposure, culvert bottom has major evidence of corrosion or abrasion, and/or moderate flow line grade changes or deflections. Maintenance should be performed immediately.
5. Pipe is blocked >75% with woody/leafy, sedimentation, and garbage causing the flow to be completely blocked. Pipe shape, joints, and material condition is structurally in critical condition throughout the full length of the pipe. Indicators may include major

changes in shape (side or top deflection), stress fractured bolts or rivets at the seams or joints have major gaps with major voids, major soil deposition within the pipe, pipe bottom is completely deteriorated, and/or major flow line grade changes or deflections. As the result of the condition, BMP structural integrity has been compromised. Maintenance should be performed immediately.

33. Spillway Outfall *(spwy_out)* – scores the condition of the outfall of the principle spillway and within 25 feet of the principal spillway structure. This parameter evaluates channel erosion, side slopes, transitions to natural stream areas, sedimentation, and debris blockage.

Scoring Value Evaluation:

1. Outfall shows no evidence of stream erosion. Channel invert and slopes are stabilized with dense vegetation or riprap. Outfall is free of any woody/leafy debris, sedimentation, and garbage debris.
2. Outfall shows minor evidence of stream erosion. Channel invert and slopes are stabilized with dense vegetation or riprap. Outfall is blocked <25% with woody/leafy, sedimentation, and garbage.
3. Outfall shows moderate evidence of stream erosion. Channel invert and slopes are moderately steep with non-uniform vegetative cover and slight erosion is actively occurring. Minor areas of riprap material are moving downstream. Outfall is blocked with about 26 to 50% with woody/leafy, sedimentation, and garbage.
4. Outfall shows major evidence of stream erosion. Channel invert and slopes are slightly wider than deep. Slopes are steep with no vegetation and minor sloughing actively occurring with stream channel. Major areas of riprap material are being washed out and relocated downstream. Outfall is blocked approximately 51 to 75% with woody/leafy, sedimentation, and garbage. Maintenance should be performed immediately.
5. Outfall has active stream erosion and the channel invert and slopes is deep as wide. Slopes are steep with no vegetation and major bank sloughing actively occurring with stream channel. Major areas of riprap material are being washed out and relocated downstream. Outfall is blocked >75% with woody/leafy, sedimentation, and garbage. Maintenance should be performed immediately.

3.5.6 Safety Inspection Parameters

These parameters are for safety, with primary focus on preventing public access to sites.

34. Public Hazard (*pub_haz*) – evaluates the evidence of trespassing, temporary habitation or downstream occupancy. Code 378 embankment considerations such as hazard classes are not considered.

If the facility lies along a pedestrian path (sidewalk may not be present), this should be considered in the scoring evaluation. Evidence of trespassing can include pedestrian traffic on or adjacent to the site such as a foot path worn in vegetation, presence of a sidewalk, presence of a bus stop, or pedestrians are observed traversing the site by the inspectors.

Evidence on the site of homeless habitation or recreational uses can include cardboard dwellings, clothes lines, fire pits, and tree houses. If evidence of trespassing or temporary habitation on the site is observed, it should be photographically documented.

Scoring Value Evaluation:

1. There is no evidence of trespassing or temporary habitation on, adjacent to or downstream of the site.
2. There is evidence of infrequent trespassing but no evidence of temporary habitation or downstream occupancy.
3. There is evidence of frequent trespassing but no evidence of habitation adjacent to or downstream.
4. There is evidence of frequent trespassing or habitation adjacent to or downstream.
5. There may be evidence of daily trespassing or long-term habitation adjacent to or downstream. There may also be evidence of vandalism and tampering with the facility.

35. Potential for Public Hazard (*pub_haz_pot*) – scores the potential for trespassing or temporary habitation based upon surrounding land uses. Although there may not currently be any evidence of trespassing or temporary habitation directly on the site, the surrounding context should be used here to rate the potential for these activities to occur on the site. When identifying land uses to be used in the scoring, look within half a mile in any direction. In the case where multiple land uses exist, use the one that gives the worst scoring.

Scoring Value Evaluation:

1. No sidewalk, bike or hiking trail present; AND no bus stop within vicinity of site; AND land uses are natural areas or vacant land.
2. No sidewalk, bike or hiking trail present; OR surrounding land uses are transit related such as park 'n ride lot, bus stop, train station with parking, visitor centers and rest areas; OR land uses are isolated commercial, passive parks, and agricultural.
3. Sidewalk, bike or hiking trail may be present. Land uses are oriented to driving rather than walking such as commercial strip development characterized by highly impervious linear development fronting a roadway with many entrance drives, parking between buildings and roadway and varying architecture and signs. This can include commercial, hotel/motel, theater, car lots, malls and other similar development.
4. Sidewalk, bike or hiking trail may be present. Land uses are public accessible facilities such as libraries, recreational centers and post offices.
5. Sidewalk, bike or hiking trail may be present. Land uses are schools, universities, religious institutions, day care facilities, active recreation areas (such as ball fields, tennis courts), play grounds, and residential communities of all types and densities (e.g., multi-family, single family, townhouses).

36. Fencing (*fences*) – scores the fencing condition by considering placement and structural condition when fencing exists to secure the BMP (other than right-of-way fencing). Placement considerations are whether the fence interferes with the functioning of the facility. This can include blocking spillway openings, suspending fence fabric over weir openings, blocking channels and other considerations as necessary. Structural condition considers the physical condition of the fence components, construction and installation as well as any security breaches that may be evident.

This parameter does not rate the need for fencing based upon site context or the visual obtrusiveness of fencing.

<u>Scoring Value Evaluation:</u>

0. No Fencing.
1. Fencing is in good condition and does not interfere with the facility functioning. No maintenance is required.
2. Fencing is showing wear but no security breaches have occurred. The fencing has some placement issues that cause minor interference with functioning of facility, but this interference is only evident with large storm events and no blockage is evident. No maintenance is required.
3. Fencing has damage but is still upright and no security breach has occurred. The fencing is located to cause functional interference and minor evidence of blockage or interference (such as accumulated trash/debris against fabric) is evident. The condition and placement of the fence should be monitored and maintenance or relocation may be needed in the future.
4. Fencing has existing openings that are less than 1 foot in any direction that may allow animals to access the facility, but no evidence of human access is evident. The fence is blocking functioning (e.g., evidence of accumulated debris/trash against the fence is obvious blockage) that is compromising the facility. A fence repair/relocation should be performed.
5. Fencing has fallen or serious breaches that allow human access to the site. A fence repair is required.

37. Safe Water Depth *(safe_waterdepth)* – scores the potential safety risk to the public due to deep water. Design water depths ≥2 feet are considered hazardous and should be indicated in the scoring. SHA policy discourages fencing and prefers the use of features that mitigate the potential for public hazard such as benching grade at water surface edge, flattened side slopes and the use of ‘No Trespassing’ signs.

Scoring Value Evaluation:

0. If NO permanent standing water is DESIGNED into the facility. If the facility is not designed for permanent water, but has standing water, rate it with the appropriate value in this table and also indicate proper scoring in *wat-depth*, included in the Sustainability Inspection Parameters.
1 If the permanent water depth is less than 2 ft. and is designed as such (e.g., stormwater wetland, wet forebay).
2. If permanent water depth is 2 ft. or greater, is not fenced and has 'No Trespassing' signs, 15 foot bench at the water surface AND side slopes of 4:1 or flatter. (Must have all three features, otherwise it should be scored a 4 or 5 as described below.)
3. If permanent water depth is 2 ft. or greater and the facility is securely fenced. Right-of-way fencing along the edge of the site but open to the roadway is not adequate unless the fence completely encircles the site.
4. If permanent water depth if 2 ft. or greater, does not have ALL of the safety features listed in 2, the facility is not fenced and is in a loop ramp or remote location.
5. If permanent water depth is 2 ft. or greater, does not have the safety features listed in 2, the facility is not fenced and location is within inhabited areas or there is evidence of pedestrian traffic near the site (i.e., foot paths worn in vegetation or bus stop nearby).

3.5.7 Visual Quality Inspection Parameters

38. Visibility (*visible*) – scores the relative visibility of the facility from surrounding roadways, office complexes, shopping centers, residential areas or other areas. Visual quality evaluation is tied to whether the facility is visible at all. Use the table below to select the visibility scoring by choosing the roadway and surrounding land use parameters that best fit the BMP location. Enter this number on the field form. NOTE: The value that is currently in the database as of July 2007 is based on a different methodology and may not be accurate based on the matrix below.

Scoring Value Evaluation:

Roadway / Surrounding Land Uses	Not Visible From Roadway	Visible From Expressways or Arterial Roads	Visible From Collector and Local Roads	Visible from Park-N-Rides, Gore Areas, Loop Ramps, Intersections
Not Visible from surrounding land uses or Visible from Natural areas or vacant un-maintained lots.	0	2	3	3
Visible from Agricultural or industrial development.	1	3	4	4
Visible from areas frequented by the general public such as commercial, residential, municipal, schools, etc.	5	5	5	5

Expressways – A divided highway with full control of access, on which all cross roads and railroads are grade separated and all entrance and exit maneuvers are by way of interchange ramps.

Arterial Roads –Highways, other than expressways, which are on a continuous route, with a high degree of continuity and which serve as the major carriers of through traffic for any given corridor. Partial control of access can be used to give preference to through traffic, but at-grade intersections, channelizations or interchanges may be provided.

Collector – A road or street serving as a connector between two arterials or between arterials and local streets. Collectors have the combined function of providing direct access to abutting properties and accommodating limited volumes of through traffic.

Local Road — A road or street, other than a State Highway, primarily serving as direct access to abutting properties

3.5.8 BMP Inspection Rating Categories

BMP Inspection Rating *(rating)* - This rating is a qualitative evaluation of the individual parameters relating to Environmental Quality and Sustainability to establish an overall rating value for the BMP facility. The rating does not include the parameters relating to Safety or Visual Quality. The objective of the rating classes is to evaluate the existing conditions, while also considering impending conditions. The rating categories can be used by SHA in planning inspection intervals, maintenance schedules, repair or replacement of BMP, and potentially identify BMPs at-risk for failure. Table 3.2 summarizes the overall rating categories and a brief description. Although a mathematical calculation could be performed to tally the component ratings, the importance of certain ratings versus others could tend to skew the results. For instance, a pond could be in perfect condition on all aspects, except for a twenty foot embankment that is showing signs of failure. This should precipitate a general rating of E due to the safety concerns and immediate hazard.

The inspectors must spend the time to assess the overall condition of the BMP taking into consideration all of the components. The following table provides a general description of each category.

Table 3.2 - BMP Inspection Rating Categories

Rating Class	Description
A	The BMP is functioning as designed with no problem conditions identified. No signs of impending deterioration. Candidate for multi-year inspections.
B	Minor problems are observed, however, BMP is functioning as designed with no critical parameters with problem conditions. Candidate for multi-year inspections, however, depending on problem conditions may require annual inspection.

Rating Class	Description
C	Moderate problems are observed, however, BMP is functioning as designed with no critical parameters with problem conditions. BMP performance is being compromised. Candidate for bi-annual inspection depending on problem conditions. Structural defects may require repair and/or restoration. Maintenance of the BMP should be scheduled.
D	Major problems are observed, and facility is not functioning as designed with several critical parameters with problem conditions. Conditions associated with the facility have compromised the BMP performance. BMP facility shows signs of impending deterioration with potential for failure. Maintenance should be performed immediately.
E	Severe problems are observed, and facility is not functioning as designed with several critical parameters with problem conditions. Conditions associated with the facility have compromised the BMP performance. BMP facility shows signs of impending deterioration and/or failure. Maintenance should be performed immediately.
NR	Not rated due to insufficient inspection or BMP could not be accessed.

Comment Response *(com_respon)* – This section allows for a response to comments made during previous inspection cycles.

Overall Comments *(com_overal)* - This section allows for any additional comments, such as specific site conditions, maintenance requests, and any other additional information associated with the BMP.

3.6 BMP INSPECTION ACTION

The BMP Inspection Action table allows the inspectors to identify an unrestricted number of action items that they recommend be performed on the BMPs. The table stores codes identifying the required actions identified during the BMP inspections. Data is only entered into this table if the inspections identify the need for subsequent inspections, maintenance, or repair.

BMP Inspection ID (*bmp_inspect_id*) – The unique identifier for the inspection during which the action was determined. This number should be auto-generated by the geodatabase and will not allow a "null" value.

Action Comment (*com_action*) – Action code describing the maintenance or repair activities identified during the BMP inspection and refers to d_com_action (Table 3.3). This field does not accept a "null" value. The following table lists the action comments in association with their action type category.

Table 3.3 – Summary of Action Items

Action Type Code	Action Comment Code	Action Comment Description
Earthwork:		
EW	BE	Rebuild Embankment to Provide Required Freeboard
EW	BN	Install Pond Bench/Shelves
EW	CO	Construct Emergency Spillway Opening
EW	CP	Construct Pull-off at Access Road
EW	CR	Construct Access Road
EW	CS	Clear Sediment
EW	RB	Repair Banks or Side Slopes
EW	RD	Repair Roadway Damage
EW	ES	Repair Earth Spillway
Fencing & Signs		
FS	AG	Add Gate to Fence
FS	RG	Repair or Replace Gate
FS	IF	Install Fence
FS	RF	Repair Fence
FS	XF	Remove Fence
FS	PS	Post No Trespassing Sign(s)
FS	RL	Replace Lock
Inspections:		
IN	ID	Inspect Non-SHA Discharge
IN	DI	Perform Illicit Discharge Inspection
IN	SI	Perform Outfall Stability Inspection
IN	IN	Inspect 72 Hours after Rain Event
IN	IS	Could Not Inspect, Submerged
IN	RI	Re-inspect Ponding/Infiltration Rates
IN	VT	Test Valve
Remove Material:		
RM	CD	Remove Trash and Debris

Table 3.3 – Summary of Action Items

Action Type Code	Action Comment Code	Action Comment Description
RM	CH	Remove Chemical Containers
RM	DT	Remove Downed Trees
RM	HW	Remove Hazardous Waste
RM	RO	Contain and Remove Oil Sheen
Structure Construction or Repair:		
SC	CA	Construct Concrete Apron at Access Road Entrance
SC	CC	Construct Depressed Curb at Access Road Entrance
SC	PO	Provide Opening in Traffic Barrier at Access Road
SC	AW	Add Monitoring Well
SC	MW	Repair or Replace Monitoring Well
SC	WC	Replace Monitoring Well Cap
SC	BO	Construct Orifice Opening
SC	OP	Repair or Replace Orifice Plate
SC	RW	Repair Weir Opening
SC	RT	Repair or Replace Top Slab
SC	FC	Repair Cracks
SC	FS	Repair Spalling
SC	LD	Repair Ladder Rungs
SC	ML	Replace Manhole
SC	RM	Repair/Replace Manhole Frame
SC	RP	Repair Pipe
SC	NP	Replace Pipe
SC	PD	Repair Pipe Deflection
SC	CV	Reset Pipe to Convey Water
SC	OS	Repair or Replace Outfall Stabilization/Structure
SC	RC	Replace CMP Riser with Concrete
SC	RS	Repair Structure
SC	SF	Replace Structure
SC	TR	Install Trash Rack
SC	TK	Repair or Replace Trash Rack
SC	RU	Repair or Replace Under-drains
SC	RJ	Repair of Replace J-Hook Vents
SC	RV	Repair or Replace Valve
SC	VG	Remove Valve
SC	PP	Repair or Replace Perforated Pipe
SC	PC	Repair or Replace Pipe Connection
SC	FB	Repair or Replace Aggregate Filter Blanket
Stabilization:		
ST	CB	Cover Backfill Material
ST	ER	Repair Erosion
ST	FA	Fill Animal Burrows
ST	RR	Replace Rip-Rap
ST	SC	Repair Seepage
ST	SH	Repair Sinkhole

Table 3.3 – Summary of Action Items

Action Type Code	Action Comment Code	Action Comment Description
ST	SS	Stabilize Saturated Areas
ST	UC	Repair Undercutting
Vegetation Management:		
VM	BH	Brush Hogging
VM	CT	Cut/Remove Trees
VM	BC	Brush Control[1]
VM	GR	Plant Growth Regulator Application[1]
VM	GC	Planting – Ground Cover
VM	LS	Planting– General Site
VM	TF	Selective Tree Felling[2]
VM	TT	Selective Tree Trimming[2]
VM	TA	Remove Trees from SWM Embankment – ≤ 4 in. Diameter Breast Height (DBH)
VM	TB	Remove Trees From SWM Embankment – > 4 in. DBH
VM	MM	Mow Meadow
VM	MO	Mow Turf[1]
VM	MH	Mulch - Shredded hardwood
VM	MS	Mulch – Straw or Wood Cellulose Fiber
VM	NM	Nutrient Management Plan Needed
VM	SG	Lay Sod
VM	TS	Turf Seeding
VM	CI	Invasive Species Control – Cattail Control[1]
VM	IV	Invasive Species Control – General
VM	TI	Invasive Species Control – Thistle Control[1]
VM	MI	Invasive Species Control – Meadow
VM	PI	Invasive Species Control – Phragmites Control[1]
VM	II	Invasive Species Control – Poison Ivy Control[1]
VM	TP	Planting – Treatment Area
VM	SP	Planting – Treatment Area Shading
VM	TV	Trim Vegetation
VM	SB	Weed Control in Shrub Beds[1]

Notes:
[1] See SHA Integrated Vegetation Management Manual for Maryland Highways for description of activity requirements
[2] See SHA Standard Specifications for Construction and Materials for description of activity requirements

Action Location (*loc_action*) – Location at which the action needs to take place and refers to d_loc_action. An unlimited number of locations can be specified for each action item by recording multiple records in the BMP_INSPECTION_ACTION table. Inspectors should use the location codes which are most specific to the comments; however, there are general codes if the action is required over a more general location. The following are the locations and their codes.

Table 3.4 – Action Locations

Code	Action Location
AB	Aquatic Bench
AP	Adjacent Property
AR	Access Road
BA	Basin
CO	Clean Outs
CS	Control Structure
DA	Entire Drainage Area
DE	Downstream Embankment
DT	Downstream Toe
EF	Entire Facility
EM	Embankment SWM
EN	Non SWM Embankment
ES	Emergency Spillway
FB	Forebay
FN	Fence
FP	Facility Perimeter
FW	Forebay Weir
GW	Groundwater Monitoring Wells
IF	Inflow to BMP
LS	Level Spreader
MP	Micropool
OC	Outflow Channel
OF	Orifice
OW	Observation Well
PS	Principal Spillway
RI	Riser Interior
SB	Safety Bench
UE	Upstream Embankment
UT	Upstream Toe
VA	Valve

3.7 BMP CONCERNS

To help in the evaluation of watershed health, SHA is tracking the presence of contaminants and invasive species in BMPs. The results of the inspection for these concerns should be collected in the BMP_CONCERN table. The following are the fields to be populated.

BMP Inspection ID (*bmp_inspect_id*) – The unique identifier for the inspection during which the action was determined. This number should be auto-generated by the geodatabase and will not allow a "null" value.

Concern Type (*type_conc*) – The type of concern should be entered as either contamination (C) or invasive species (I).

BMP Concern (*bmp_conc*) – The specific concern observed should be noted. Use d_BMP_conc domain values. Contaminants that should be noted are listed in Table 3.5 below.

Table 3.5 – Contaminants

Code	Contaminant
AL	Algae
FE	Fecal Matter
CS	Construction Sediment
OS	Oil Sheens
CW	Chemical Waste
DF	Detergents/Foam
OD	Organic Debris
SS	Suspended Sediment
TR	Trash
OT	Other

The invasive species, listed in Table 3.6 below, should be identified during the course of the inspection if they are dominant components of the plant community. Appendix 3E contains photographs and descriptions of each of these species to aid in their identification.

Table 3.6 – Invasive Species

Code	Invasive Species
Trees:	
AO	Autumn Olive (Elaeagnus umbellate)
MR	Multiflora Rose (Rosa multiflora)
NM	Norway Maple (Acer Platanoides)
TH	Tree of Heaven (Ailanthus altissima)

Table 3.6 – Invasive Species

Code	Invasive Species
Grasses:	
JS	Japanese Stiltgrass (Microstegium vimineum)
RC	Reed Canary Grass (Phalaris arundinacia)
Vines & Groundcovers:	
MM	Mile-a-Minute Vine/Devil's Tear Thumb (Polygonum perfoliatum)
OB	Oriental Bittersweet (Celastrus orbiculatus)
PB	Porcelain Berry (Ampelopsis brevipedunculata)
Wetland Plants:	
CR	Common Reed (Phragmites australis)
PL	Purple Loostrife (Lythrum salicaria)
Herbaceous:	
BT	Bull Thistle (Cirsium vulgare)
CT	Canada Thistle (Cirsium arvense)
GM	Garlic Mustard (Alliaria petiolata)
HW	Hogweed (Heracleum mantegazzianum)
JK	Japanese Knotweed (Polygonum cuspidatum)

3.8 SPATIAL DATA COLLECTION

BMPs are represented spatially in the GIS as polygons. If inspectors are capturing the spatial location of a BMP for the first time, the perimeter of the BMP should be obtained using a GPS unit. For ponds, polygon features are recorded at the outline of the water surface elevation of the 10 year return period storm event. This may be estimated by the control structure. In a two-stage riser structure, the ten year water surface elevation is above the low flow orifice, but below the top of the riser. If the riser structure has only one orifice and no other control point, outline the pond at this elevation. The starting point is typically the BMP riser structure or outlet and the survey would end back at the riser structure. Some office cleanup may be required to make sure that the outline of the BMP is smooth and that there are not any self intersecting polygons (bowties) on the polygon.

Features such as trenches or underground facilities may require GIS editing in the office once the location and orientation of the features are obtained in the field. For example, trenches can be obtained by collecting GPS locations at either end of the trench. Using the width attribute from the SWMFAC table, a polygon can be generated.

3.9 PHOTOGRAPH MANAGEMENT

The FILE_ATTACH tables link digital files of features obtained during inspections of the BMPs.

bmp_inspect_id – This field links the file to the BMP_INSPECTION table if the media is about a BMP. The geodatabase will not allow a "null" value for this field.

filename – This is the filename and subdirectory paths of the photograph taken during the inspection. The filenames of the photograph should consist of the *swm_fac_no* (structure number if an outfall inspection) followed by a descriptor, followed by the date. For example, BMP #15306 would have a photograph of an outfall named 15306-out-20060218, if a photograph was taken February 18, 2006. The geodatabase will not allow a "null" value for this field. The directory path would consist of a directory for the county, with a subdirectory for photographs. For Howard County, this would read "\Howard\SWMPhotos\[filename]".

comments – Comments are used for any additional information. The field allows 120 characters, but should be used liberally. Information such as structure type or condition (buried, heavy vegetation, etc.) should be added here. These comments are useful when the structure cannot be seen in the photo due to heavy vegetation, buried, submerged, etc.

The most efficient and manageable digital photograph format is JPEG (aka JPG). This format can be generated by most digital cameras and is read by most computer applications. Care must be taken to balance image quality (e.g. low, medium, high resolution) with file size. The lowest resolution should be used that is still sufficient to clearly view the subject. File sizes should be under 2 MB. Every field photo must have the structure or BMP number, descriptor and date imbedded in the image. If a digital camera is not available, a conventional camera may be processed digitally, or the hard copy can be scanned into a digital image.

Multiple images may be captured for BMPs to document site conditions. Where possible, the photos should be comprehensive to reflect the inspection results and include relevant information relating to the BMPs performance. For ponds, the riser and embankments must be included, and where possible, the impoundment, inlets and outlets. The photo location is important so that future inspection photos can be captured at the same location. There are several options to document the photo location. The *comments* field can describe the location of the photograph or store GPS points. In some cases, permanent markers can be installed in the field. The following tables summarizes the conventions when naming photos:

Table 3.7 Standard Photo Naming Conventions

Subject	Naming Standard
Riser	12345-RIS-date.jpg
Outfall	OUT-date.jpg
Inflow	INFa-date.jpg INFb-date.jpg
Emergency Spillway	ES-date.jpg
Embankment	EMB-date
Overall	12345-date.jpg – no type necessary 12345a,b,c-date.jpg
Erosion	ERO-date.jpg
Low Flow Orifice	LOWFLOW-date.jpg
Control Structure	CS-date.jpg – hw, es, etc.
Weir	WEIR-date.jpg
Fence	FEN-date.jpg
Hazards	HAZ-date.jpg
Evidence Blocked	HAB-date.jpg
Access of Habitation	ACC-date.jpg

The following photograph is a sample of what should be produced.

Example of BMP Inspection Digital Photo

3.10 REFERENCES

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Appendix 3-A

Field Inspection Forms

BMP INVENTORY FORM

Field	Domain	Comments	Description
FACILITY_ID			Unique SWM Facility ID#
SWM_FAC_NO			6 digit BMP number
SWM_FAC_NO_OTHER			BMP number from other owner
CONTRACT ID			Contract ID number
DESIGNATION	D_Designation		Category of BMP type
DESIGN_SUB	D_Desg_Subcategory		Description of the facility designation
IN-STREAM BMP?	Y/N		BMP constructed in U.S. Waters
COMMENT - APPURTENANCE			Appurtenances associated w/ BMP
MDE-NO			MDE# when BMP was reviewed
VICINITY			ADC location of BMP
LOCATION			Location description of BMP
ROAD NAME			Nearest SHA roadway to the BMP
OWNER			# describing the owner
OWNER_ID			Onwer identification ID
SURFACE AREA			Surface area of the BMP polygon
DOWN STREAM STRUCUTURE			Main control structure ID number
FENCE MATERIAL	D_Fence		Fence material
DAM HEIGHT			Dam height of spill. embank (ft)
SEEPAGE CONTROL	Y/N		Seepage control exists
OBSERVATION WELL	Y/N		Observation well exists?
OBSERVATION WELL DEPTH			Observation well depth (ft)
TRENCH WIDTH			Infiltration trench width (ft)
TRENCH LENGTH			Infiltration trench length (ft)
HAZARD CLASS	D_Haz_Class		SCS-DNR haz. class. for the embank.
COMMENT - OVERALL			Overall SWMFAC comments
PEAK FLOW 2YR			2yr peak discharge out of BMP (cfs)
PEAK FLOW 10YR			10yr peak discharge out of BMP (cfs)
PEAK FLOW 100YR			100yr peak discharge out of BMP (cfs)
PLAN DATE			Year facility was designed
STATUS	D_Feat_Status_BMP		Present status of the BMP
DATE ABANDONED	YYYYMMDD		Date facility was abandoned
META ID			Link value to the METADATA table
4 MILE VICINITY AIRPORT	Y/N		BMP within 4 mile radius of airfield?

shading indicates information that cannot be verified in the field

BMP INSPECTION Form

Field	Domain	Rating	Comment	Description
BMP_INSPECT_ID				Unique identifier for inspection record
FACILITY_ID				Unique SWM Facility ID Number
DATE OF INSPECTION	YYYYMMDD			Date of field inspection
INSPECTOR(S)	ABC, DEF			Initials of inspector(s)
PLAN MATCH?	Y/N			Does BMP match plans?
CONTEXT	D_Context			Surrounding Land Use
OCCUPATIONAL HAZARD	Y/N			Indicates any OSHA hazard related to BMP features
Environmental Quality Inspection Parameters				
1. DEBRIS	1-5			Unwanted/unauthorized debris in/near facility
2. IN-FLOW CONDITION	1-5			Rates discharge into the BMP relating to overall condition
3. IN-FLOW STABILITY	1-5			Rates discharge into the BMP relating to overall condition
4. BMP VEGETATION	1-5			Veg. condition specific to water quality as part of BMP design
5. BMP CONTAMINATION	1-5			Watershed and non-stormwater contamination within BMP
6. PONDING	1-5			Unwanted/extended ponding in BMP
7. WATER DEPTH	feet			Depth (ft) of standing water
8. PERMANENT POOL	1-5			Condition of BMPs with permanent standing water
9. PRETREATMENT	1-5			Overall condition of any pre-treatment device
Sustainability Inspection Parameters				
10. MOWABILITY	1-5			Ability to mow designated areas
11. ACCESS	1-5			Access to and around the BMP relating to overall condition
12. COMMENT - ACCESS	Text			Negative comments regarding access to BMP
13. CONVEYANCE STABILITY	1-5			Stability of flow conveyance through and out of BMP
14. DOWNSTREAM CONDITION	1-5			Overall downstream condition beyond SHA ROW
15. SITE VEGETATION	1-5			Unwanted vegetation impacting overall site
16. EMB-U/S COVER	1-5			Cover/vegetation related to upstream embankment
17. EMB-U/S EROSION	1-5			Erosion related to upstream embankment
18. EMB-U/S TOE	1-5			Toe condition related to upstream embankment
19. EMB-D/S COVER	1-5			Cover/vegetation related to downstream embankment
20. EMB-D/S EROSION	1-5			Erosion related to downstream embankment
21. EMB-D/S TOE	1-5			Toe condition related to downstream embankment
22. EMB-D/S SEEPAGE	1-5			Seepage condition related to the downstream embankment
23. EMERG. SPILLWAY-STABILITY	1-5			Spillway condition related to overall stability
24. EMERG. SPILLWAY - OPEN	1-5			Spillway condition related to opening/clearance
25. ORIFICE-OPEN	1-5			Low-flow orifice opening
26. ORIFICE-TRASH	1-5			Low-flow orifice trashrack
27. RISER-OPEN	1-5			Riser opening(s)
28. RISER-TRASH	1-5			Riser opening(s) trashrack
29. RISER-SEDIMENT	1-5			Riser inside related to debris and sediment accumulation
30. RISER-STRUCTURE	1-5			Riser structure related to cracks, spalling, joints
31. RISER-VALVE	1-5			Riser valve
32. PRINCIPLE SPILLWAY	1-5			Principal spillway from riser
33. OUTFALL	1-5			Outfall to the principle spillway

BMP INSPECTION Form

Field	Domain	Rating	Comment	Description
Safety Inspection Parameters				
34. PUBLIC HAZARD	1-5			Overall hazard of BMP relating to public safety
35. PUBLIC HAZARD POTENTIAL	1-5			Potential for trespassing based on surrounding landuse
36. FENCES	1-5			Fencing surrounding BMP relating to overall condition
37. SAFE WATER DEPTH	1-5			Rates proper water safety practices in BMP
Visual Quality Inspection Parameters				
38. VISIBLE	1-5			Overall visibility of facility
Overall				
RATING	A - E			Overall inspection rating
COMMENT - RESPONSE	Text			SHA response required
COMMENT - OVERALL	Text			Overall inspection comments

Photo#	Photo Description

Invasive Species	Contam.

Action Type, Item, and Locations	Table 3.3,3.4,3.5

Appendix 3-B

BMP Geodatabase

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Appendix 3-C

Diagrams of Standard BMP Elements

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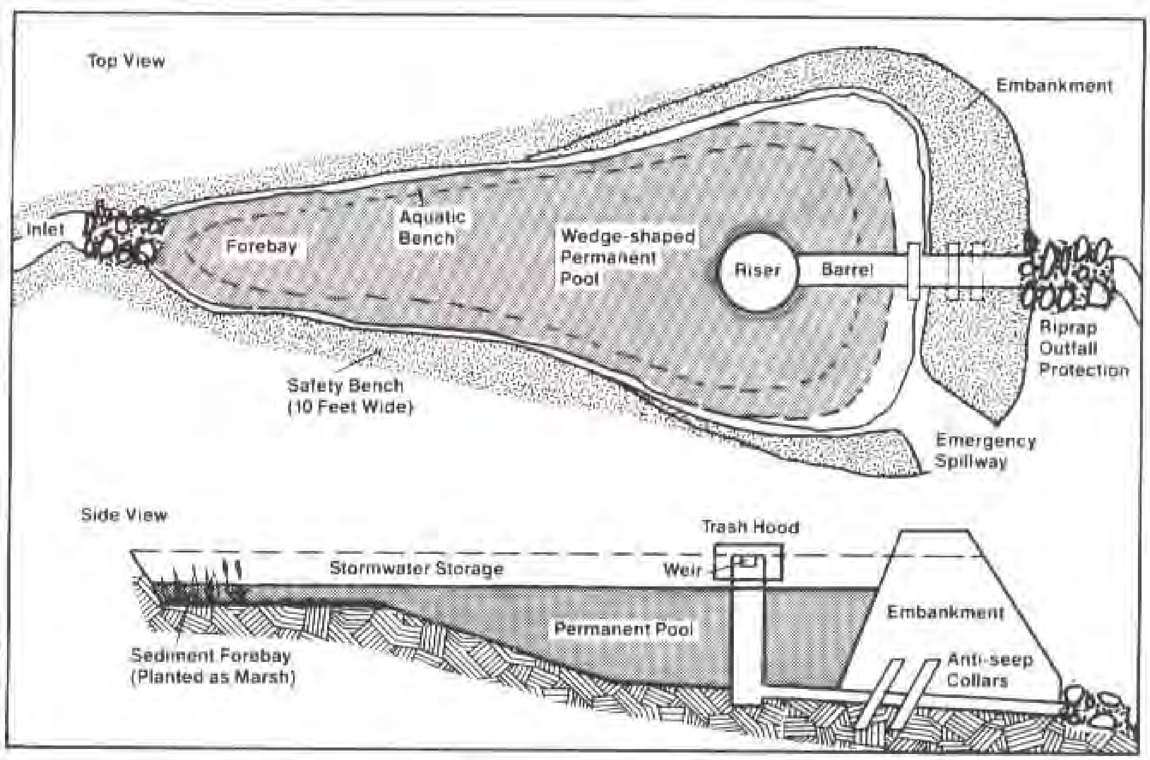
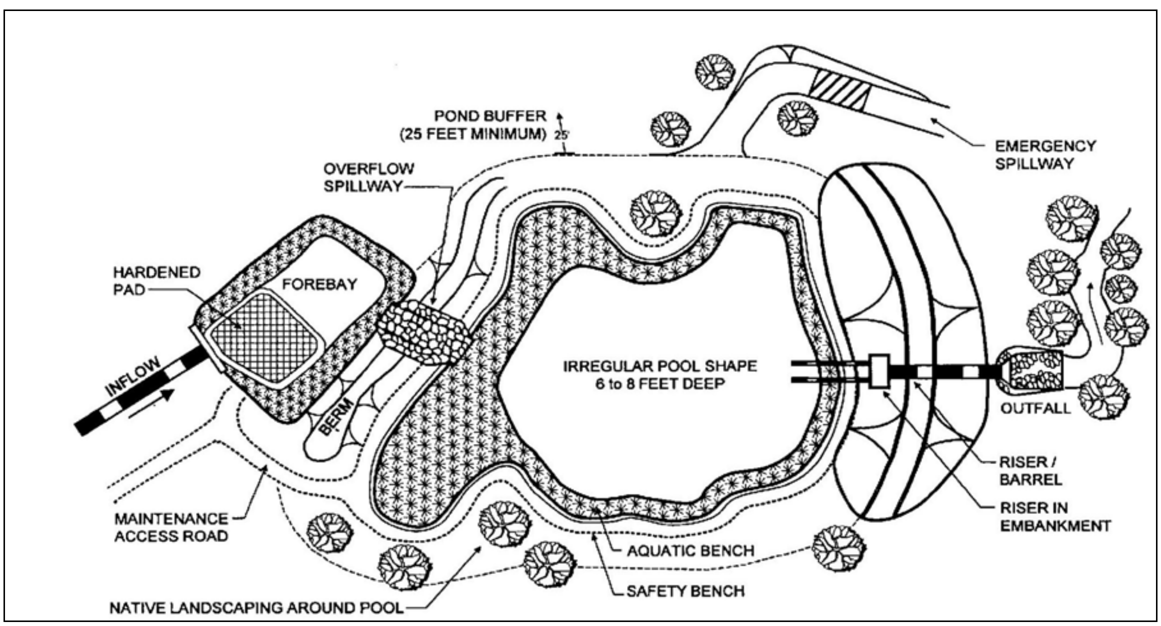
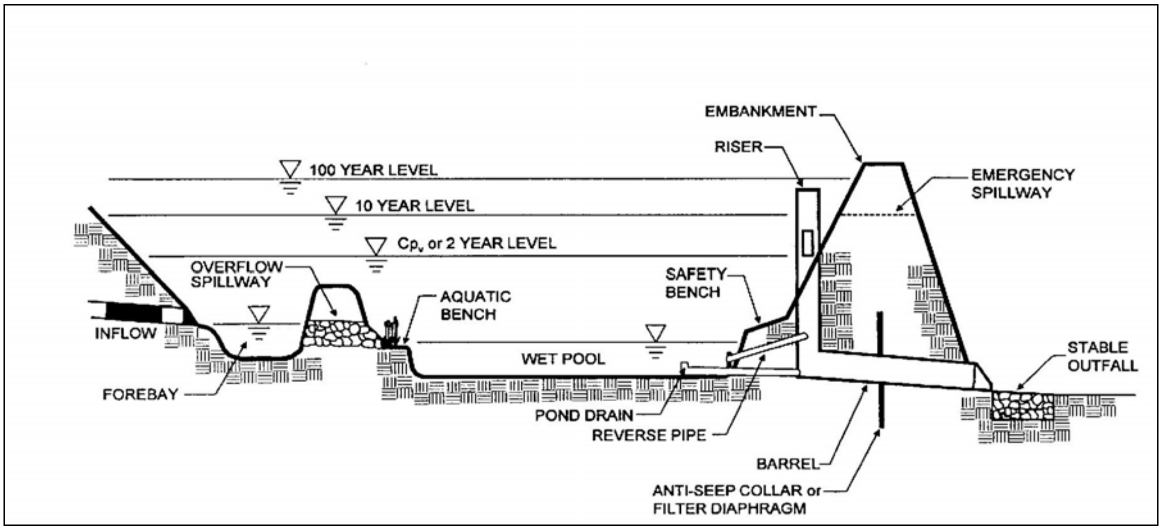
Retention Pond

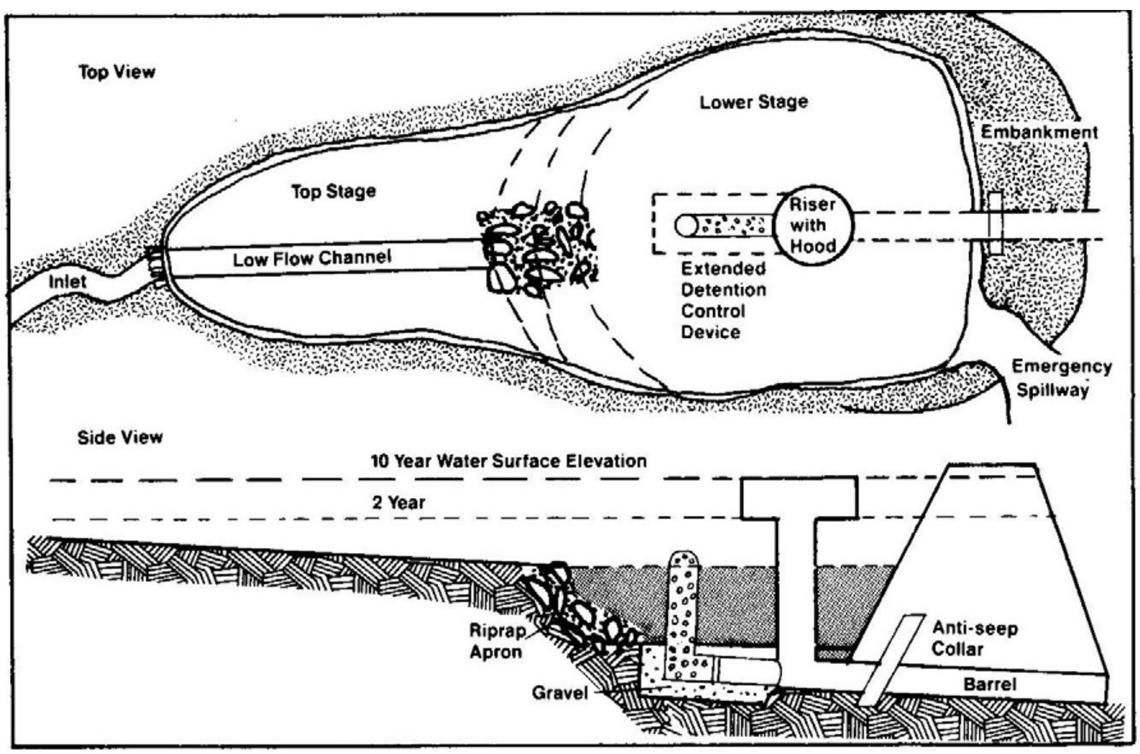




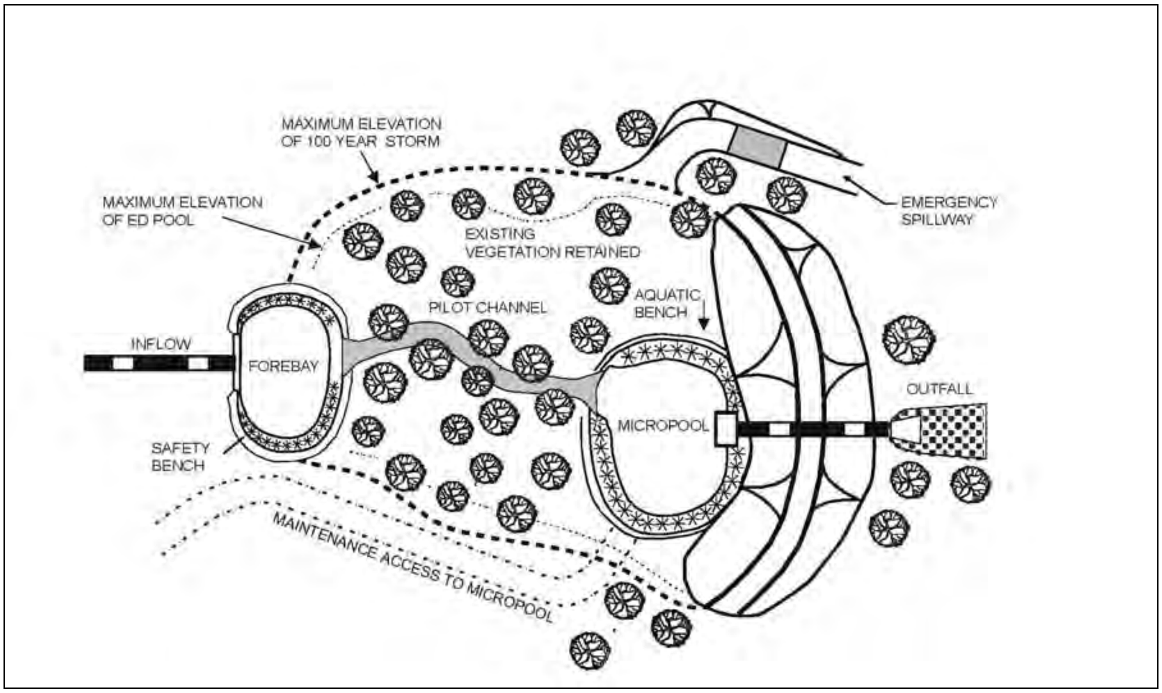
Retention Pond (continued)

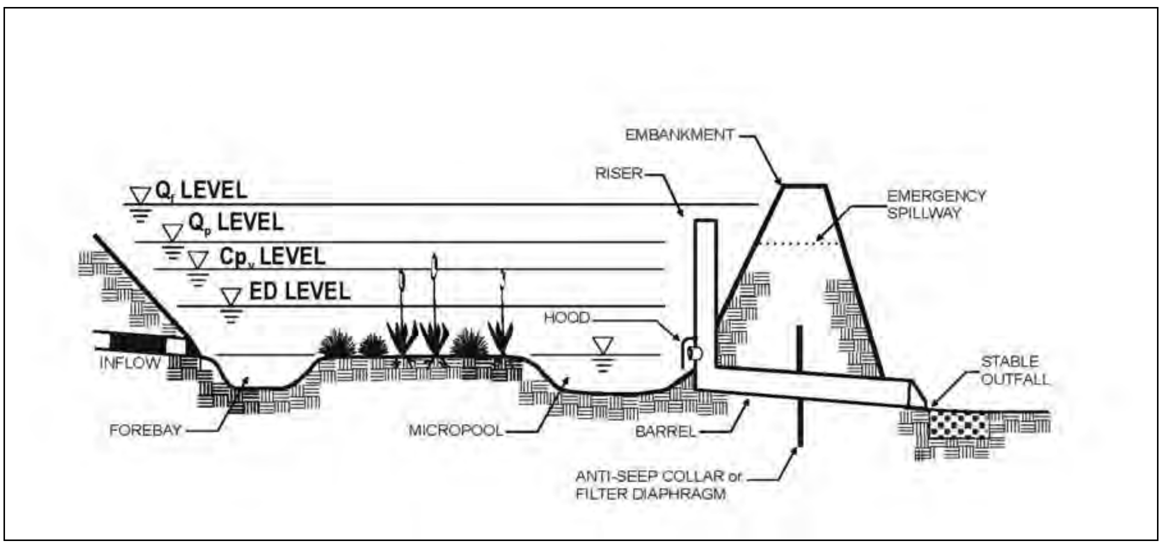


Detention/Extended Detention Pond

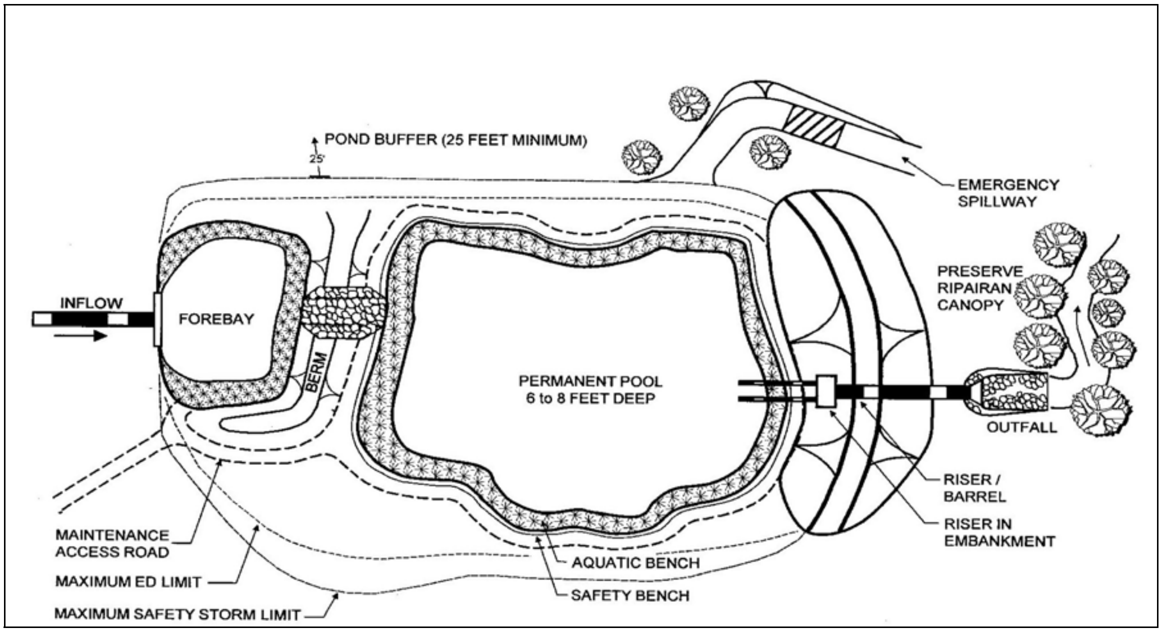


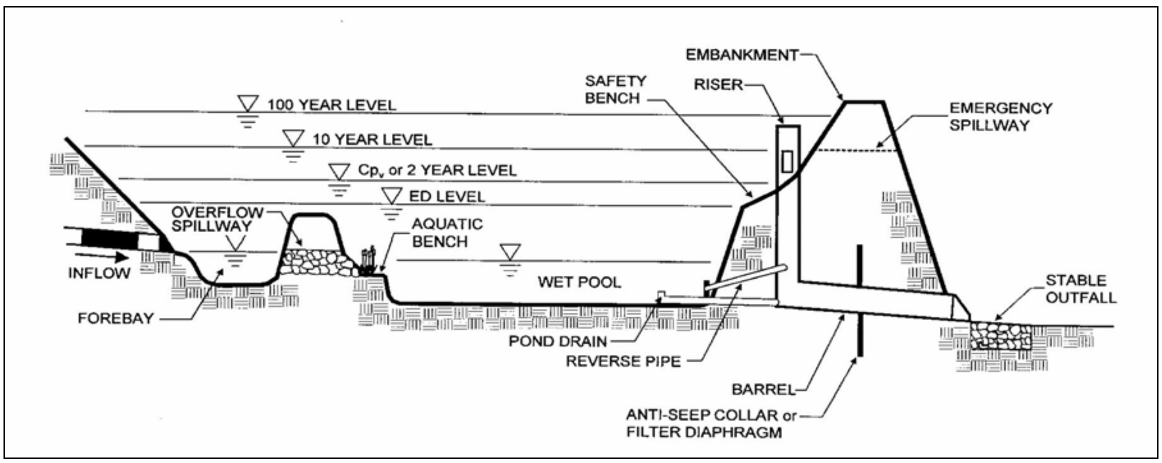
Micropool Extended Detention Pond



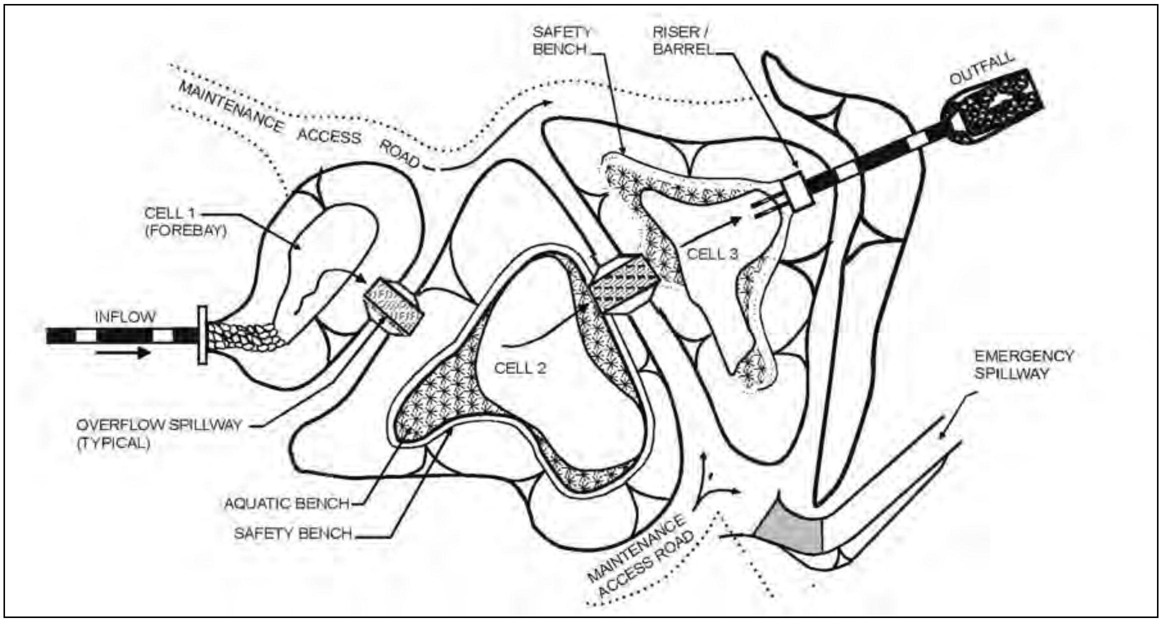


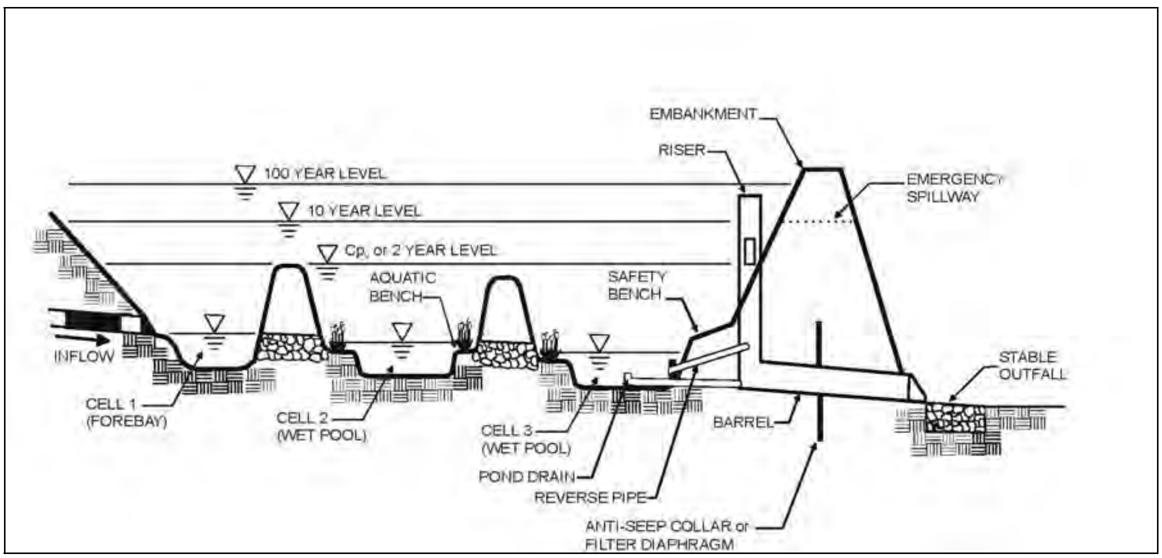
Wet Extended Detention Pond



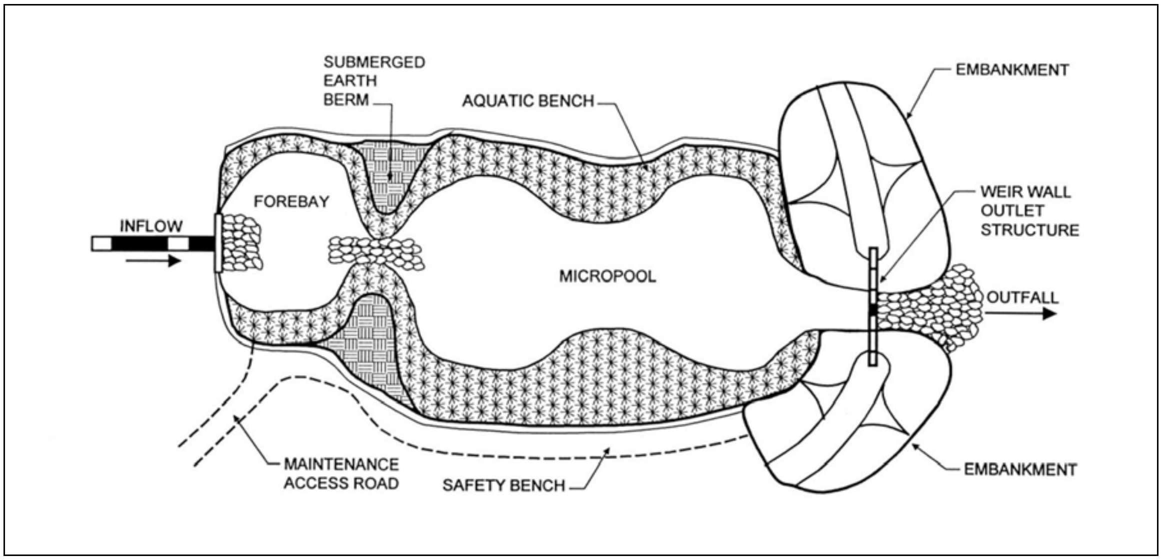


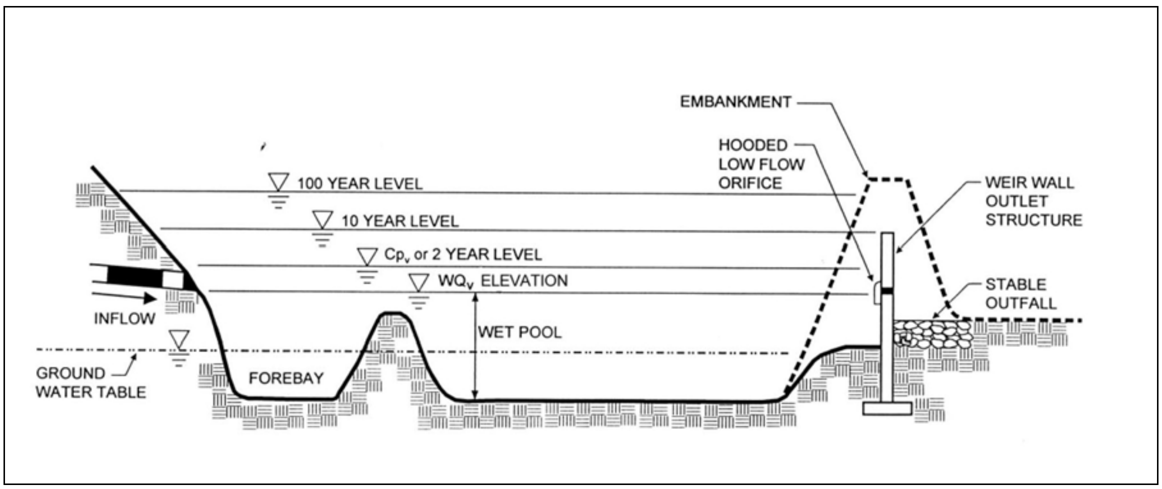
Multipond System



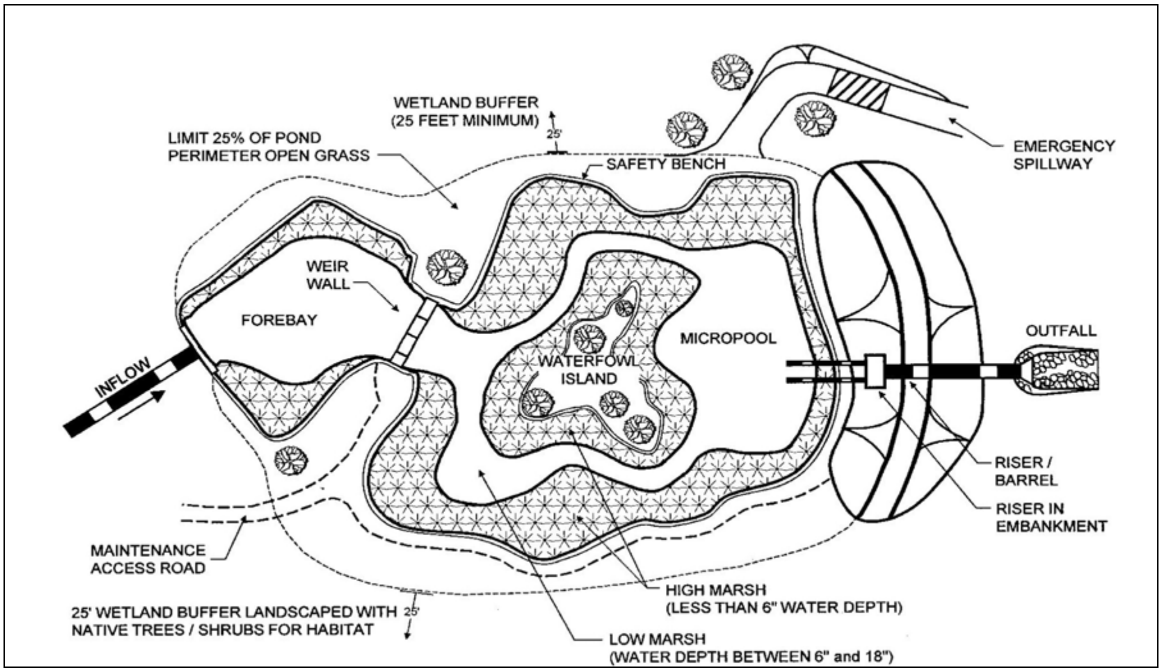


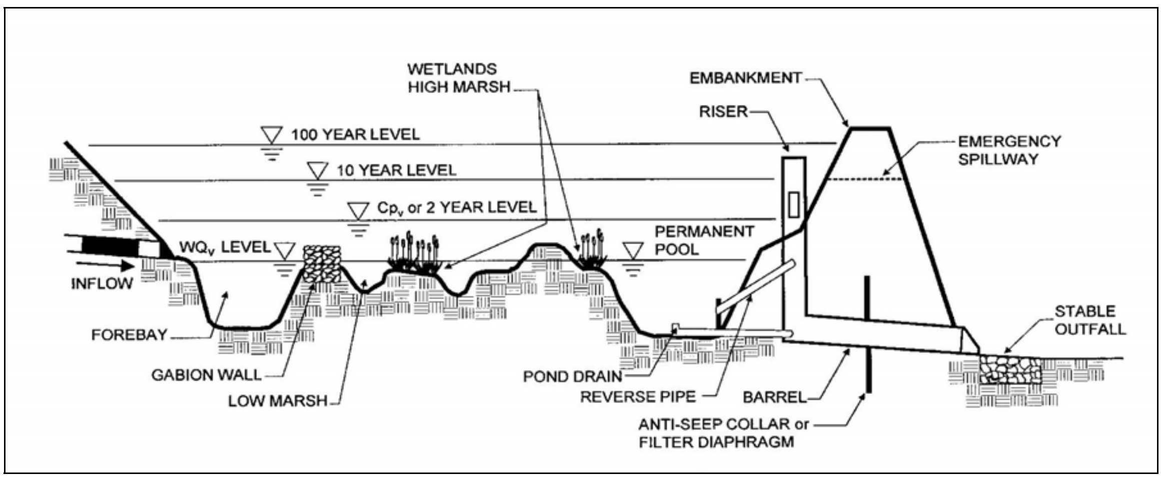
Pocket Pond


SUBMERGED
EARTH
BERM
AQUATIC BENCH
EMBANKMENT
FOREBAY
INFLOW
WEIR WALL
OUTLET
STRUCTURE
MICROPOOL
OUTFALL
MAINTENANCE
ACCESS ROAD
SAFETY BENCH
EMBANKMENT

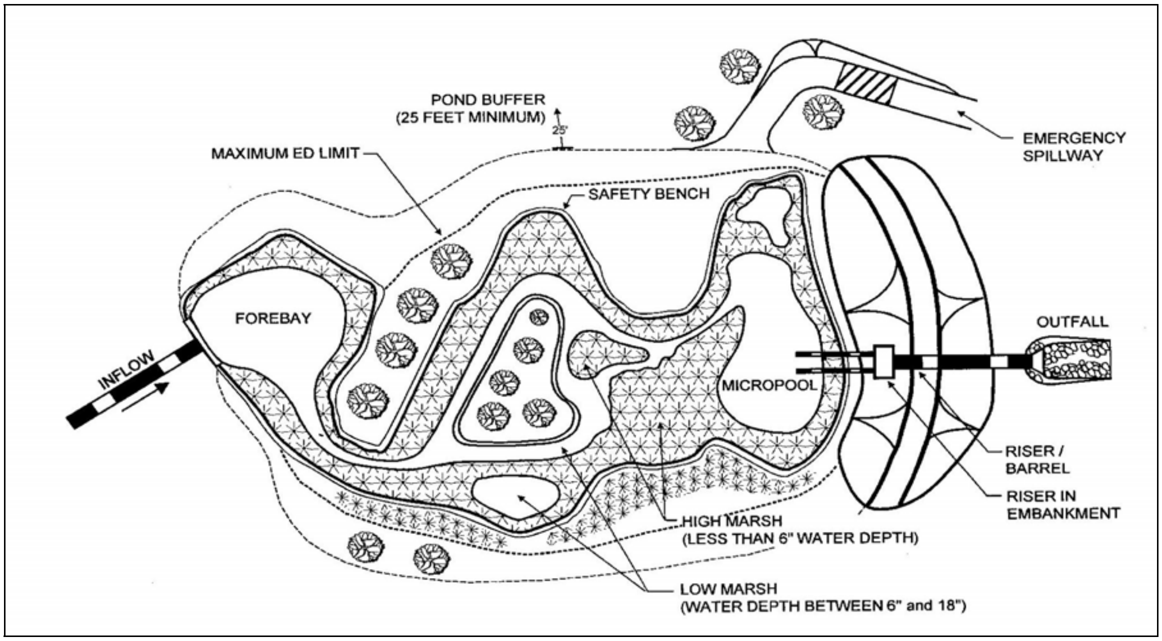

EMBANKMENT
HOODED
LOW FLOW
ORIFICE
100 YEAR LEVEL
10 YEAR LEVEL
Cp_v or 2 YEAR LEVEL
WQ_v ELEVATION
WEIR WALL
OUTLET
STRUCTURE
STABLE
OUTFALL
INFLOW
WET POOL
GROUND
WATER TABLE
FOREBAY

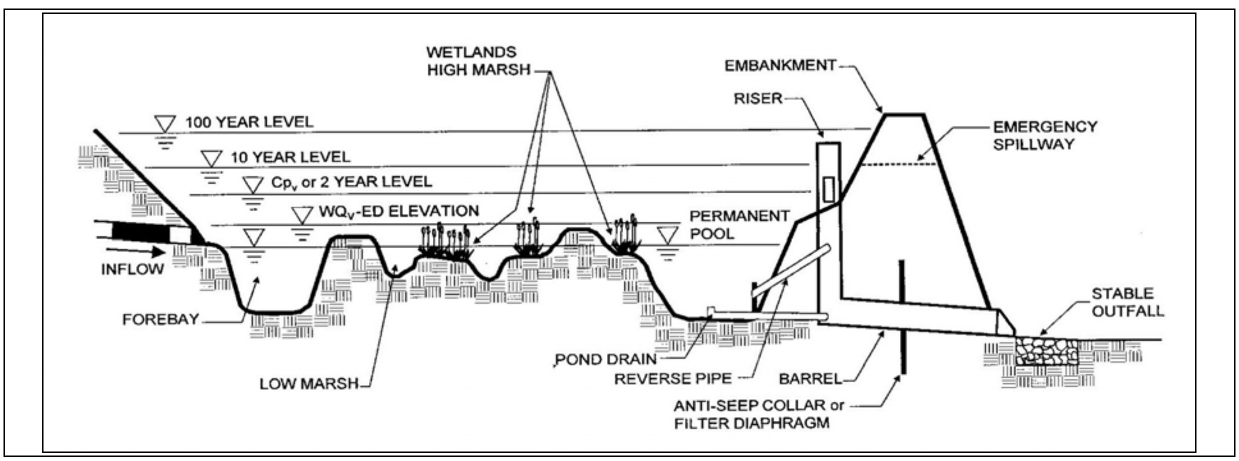
Shallow Wetland



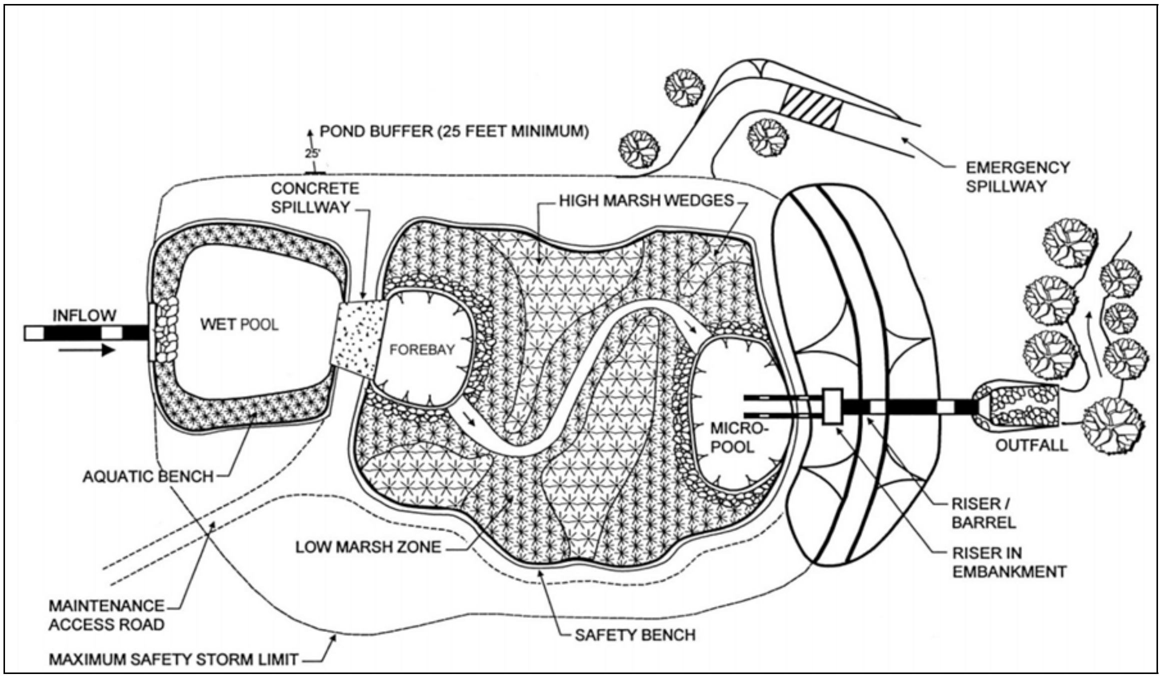


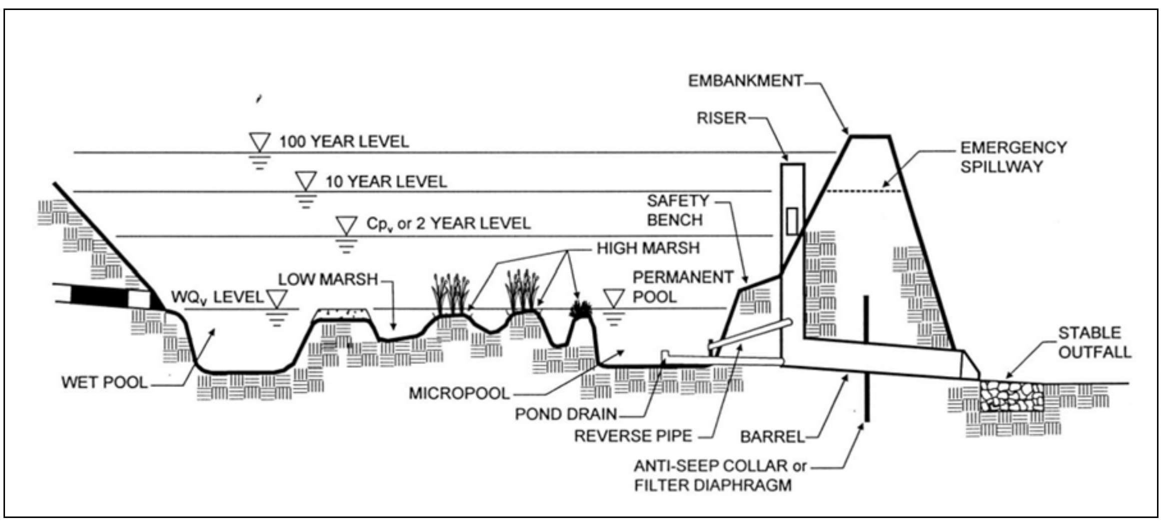
Extended Detention Shallow Wetland



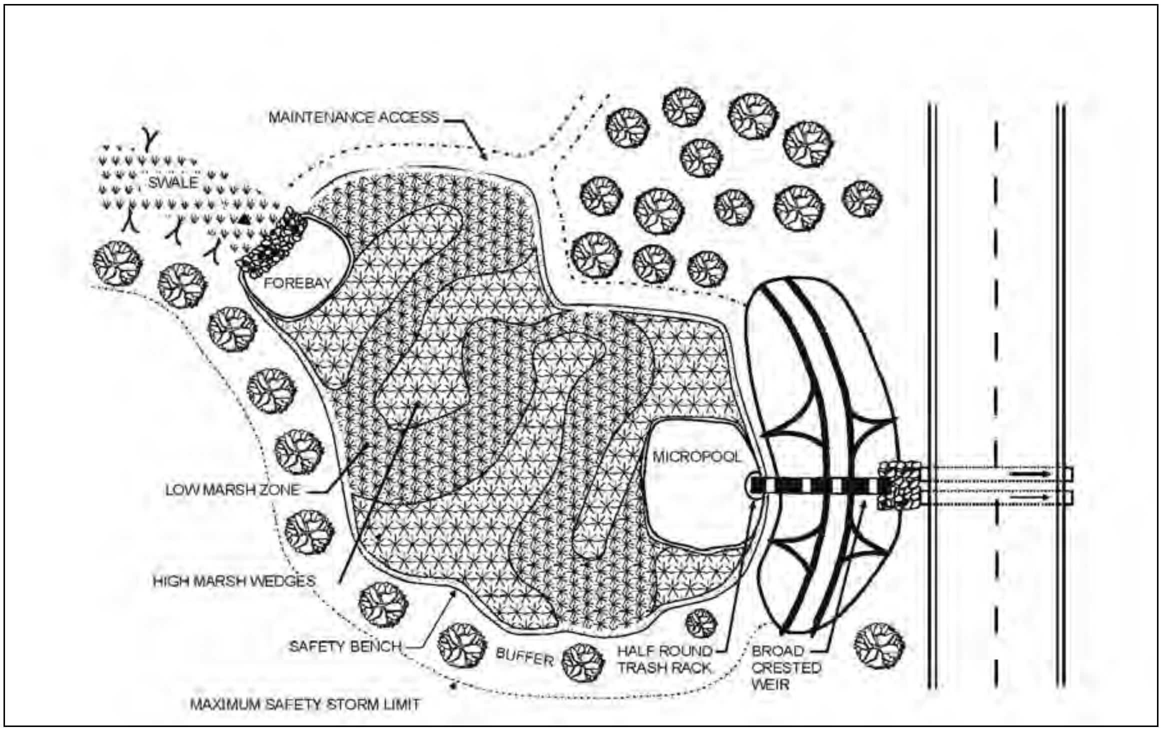


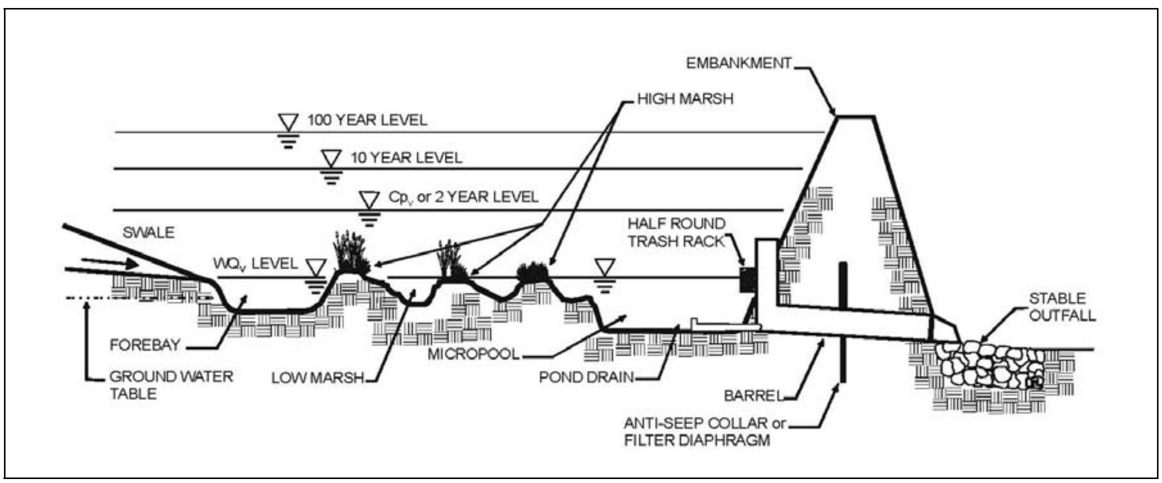
Pond/Wetland System



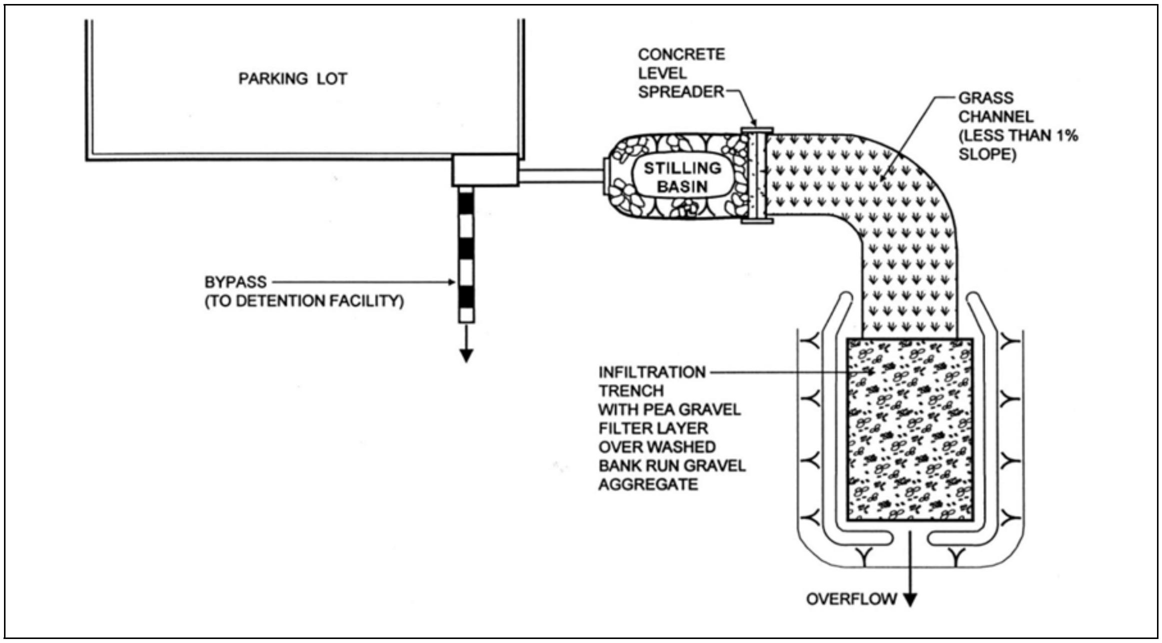


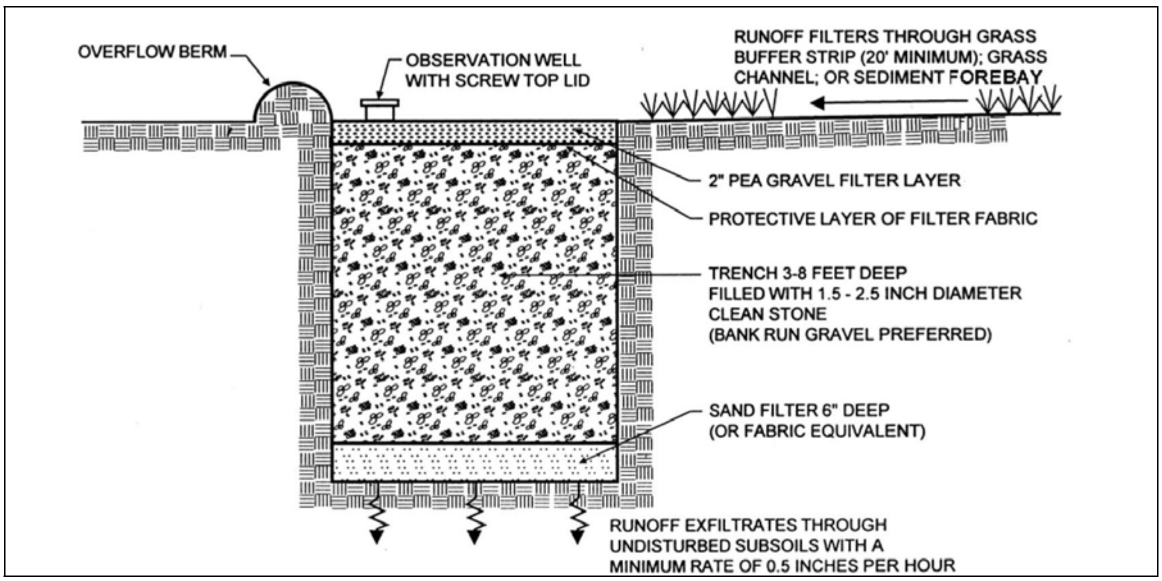
Pocket Wetland



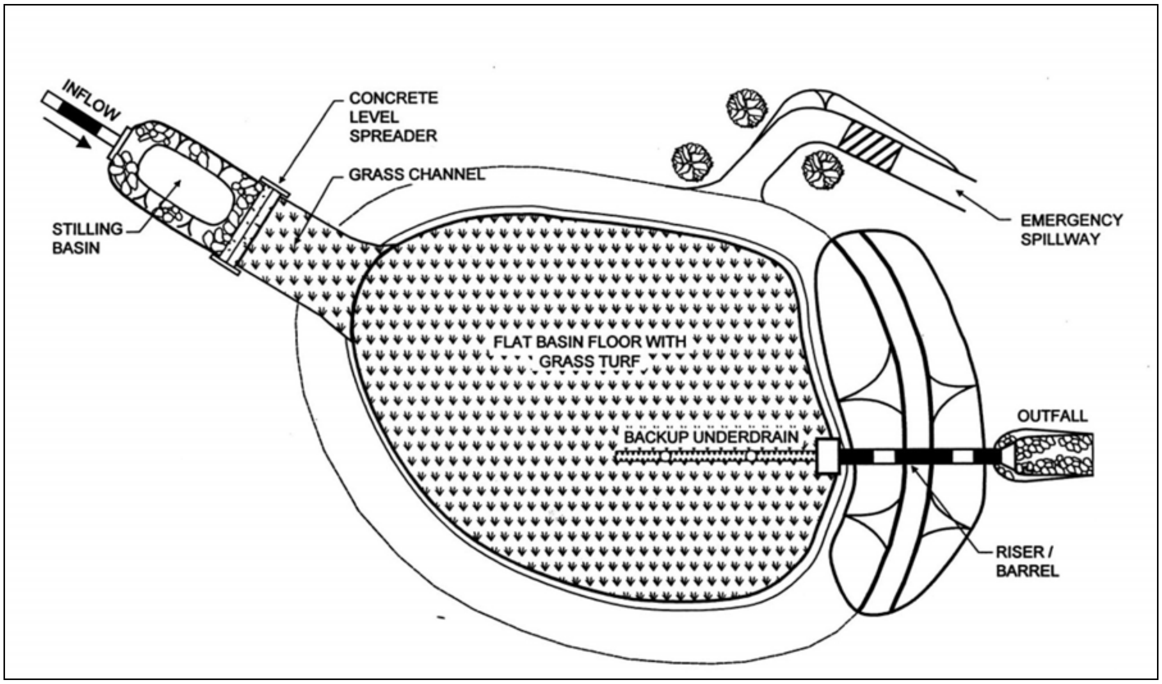


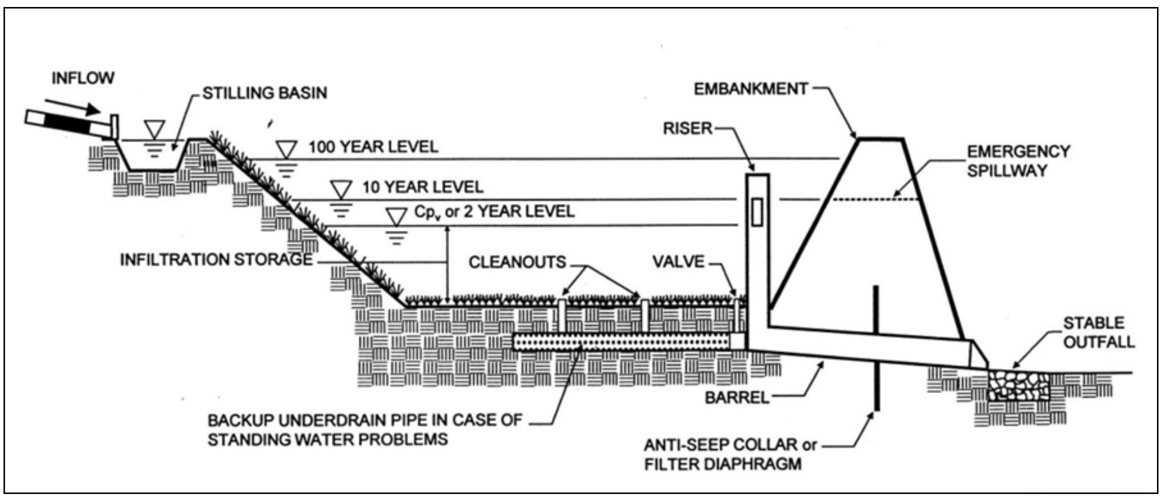
Infiltration Trench



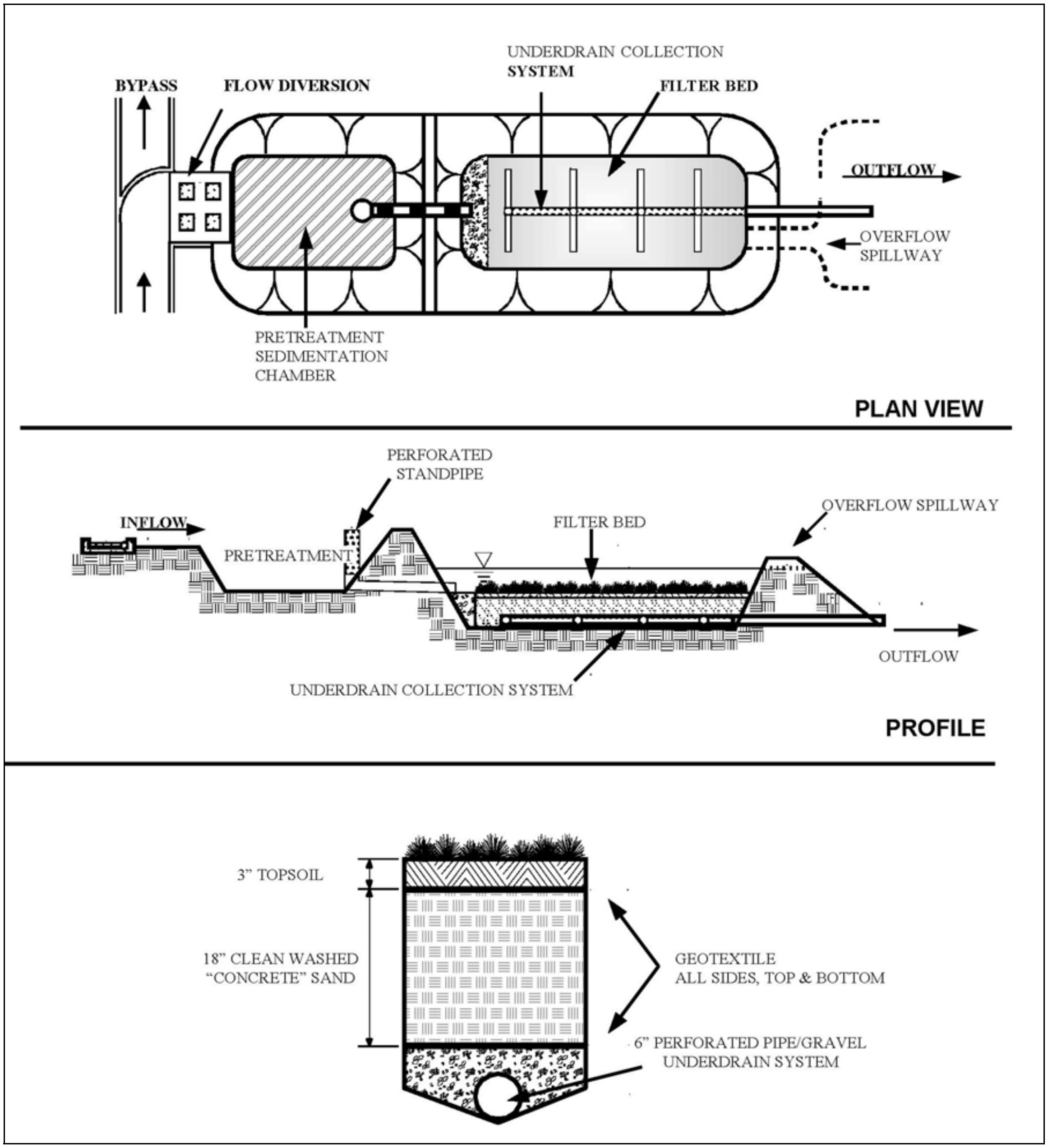


Infiltration Basin

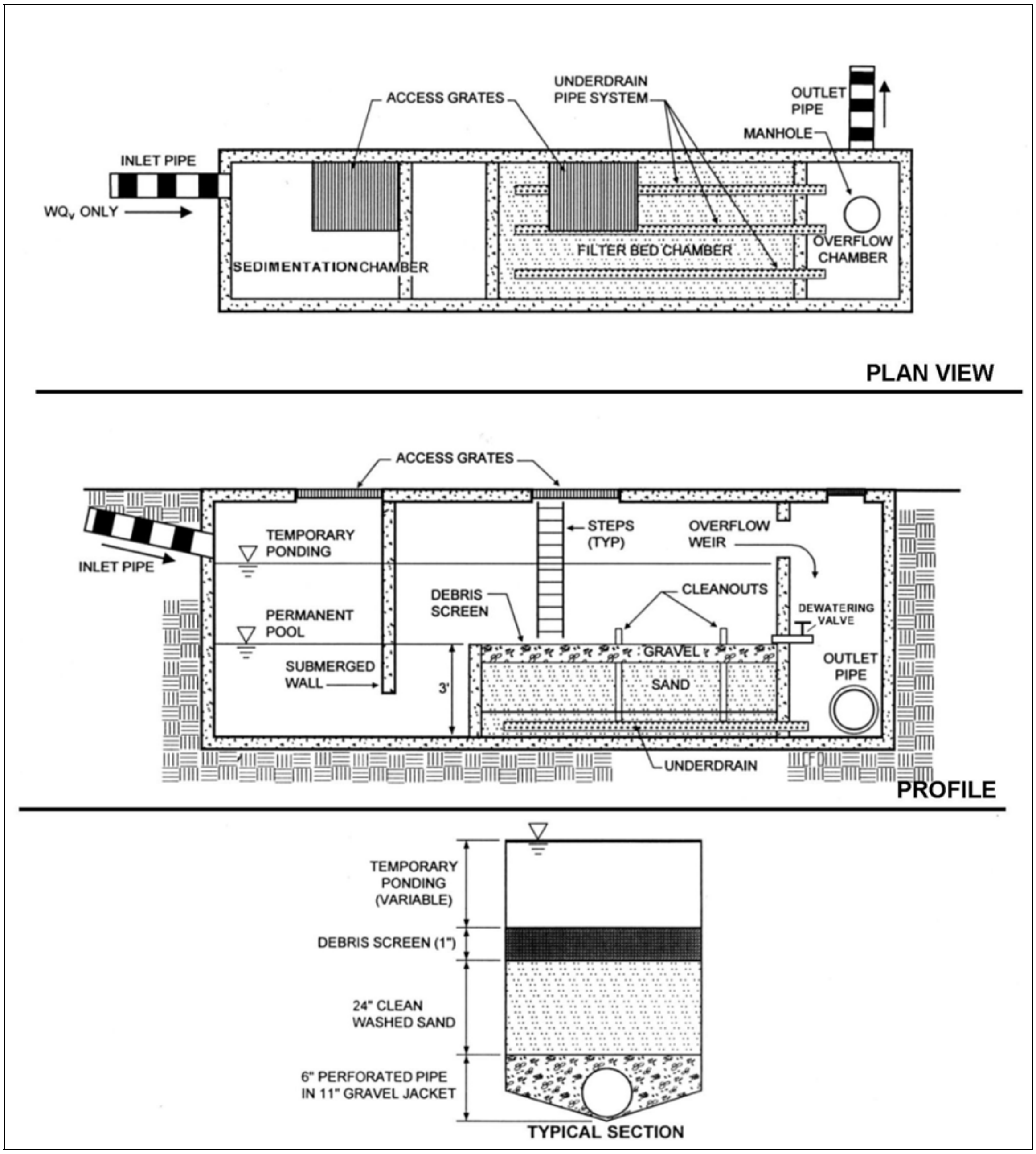




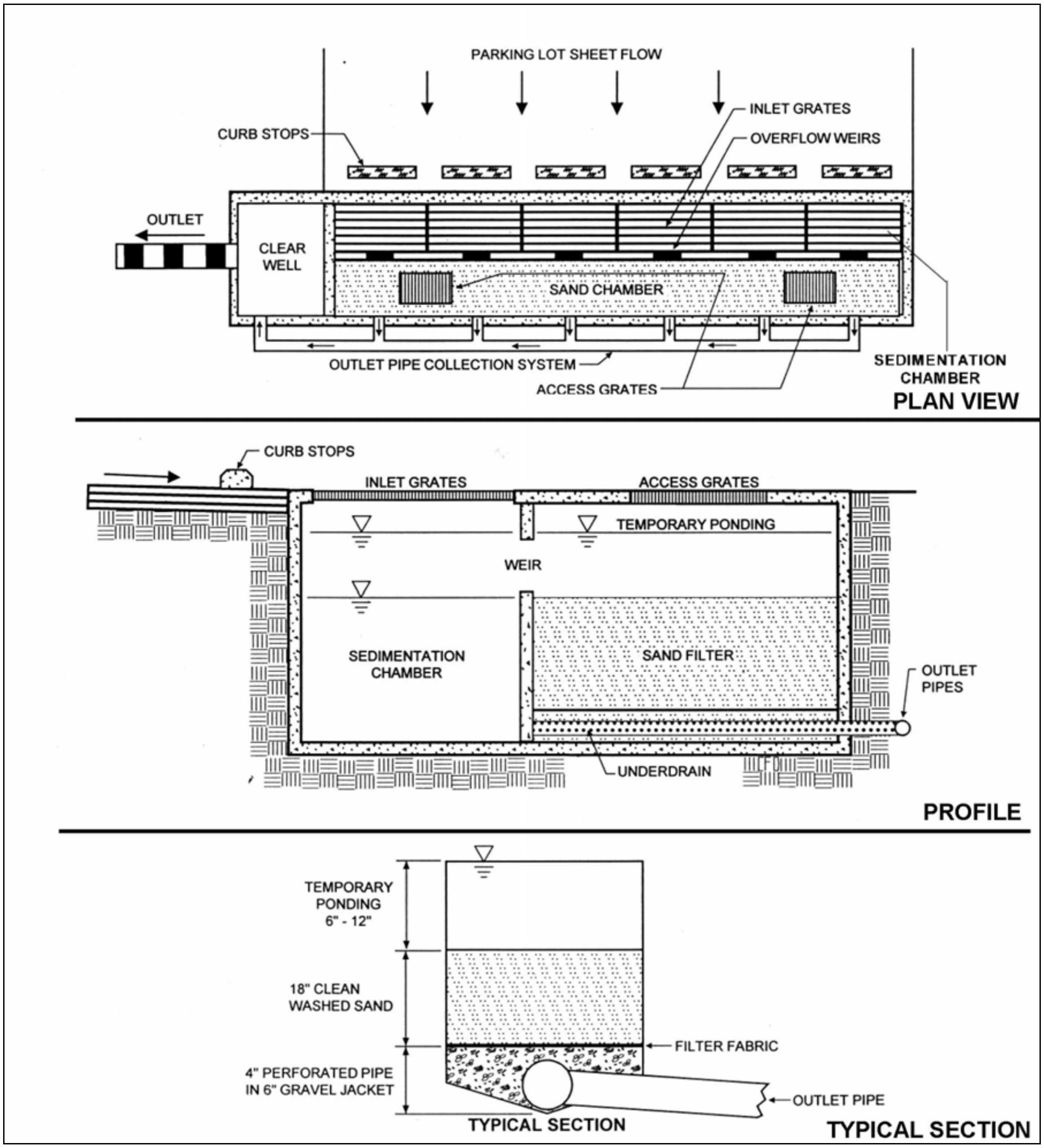
Surface Sand Filter



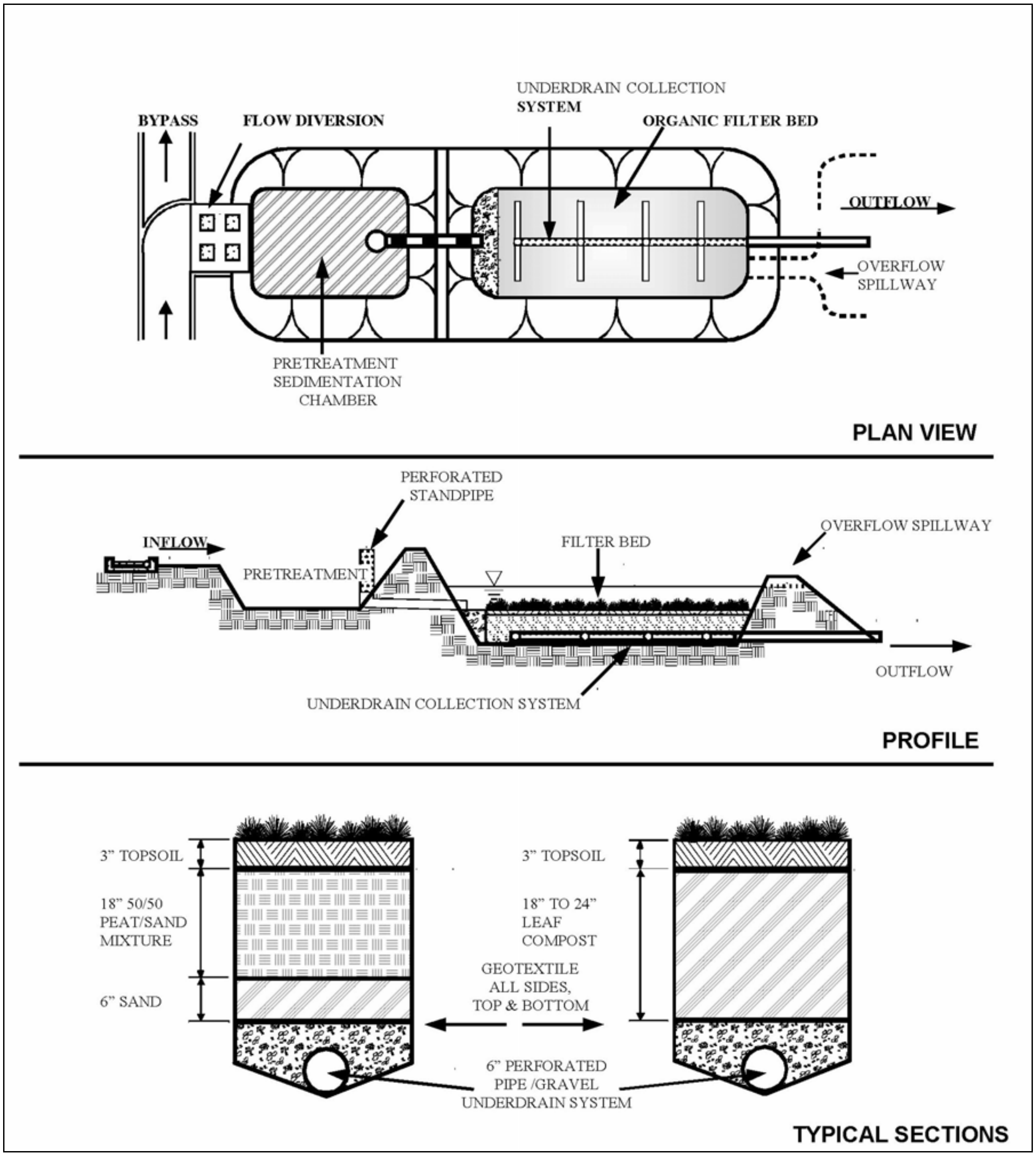
Underground Sand Filter



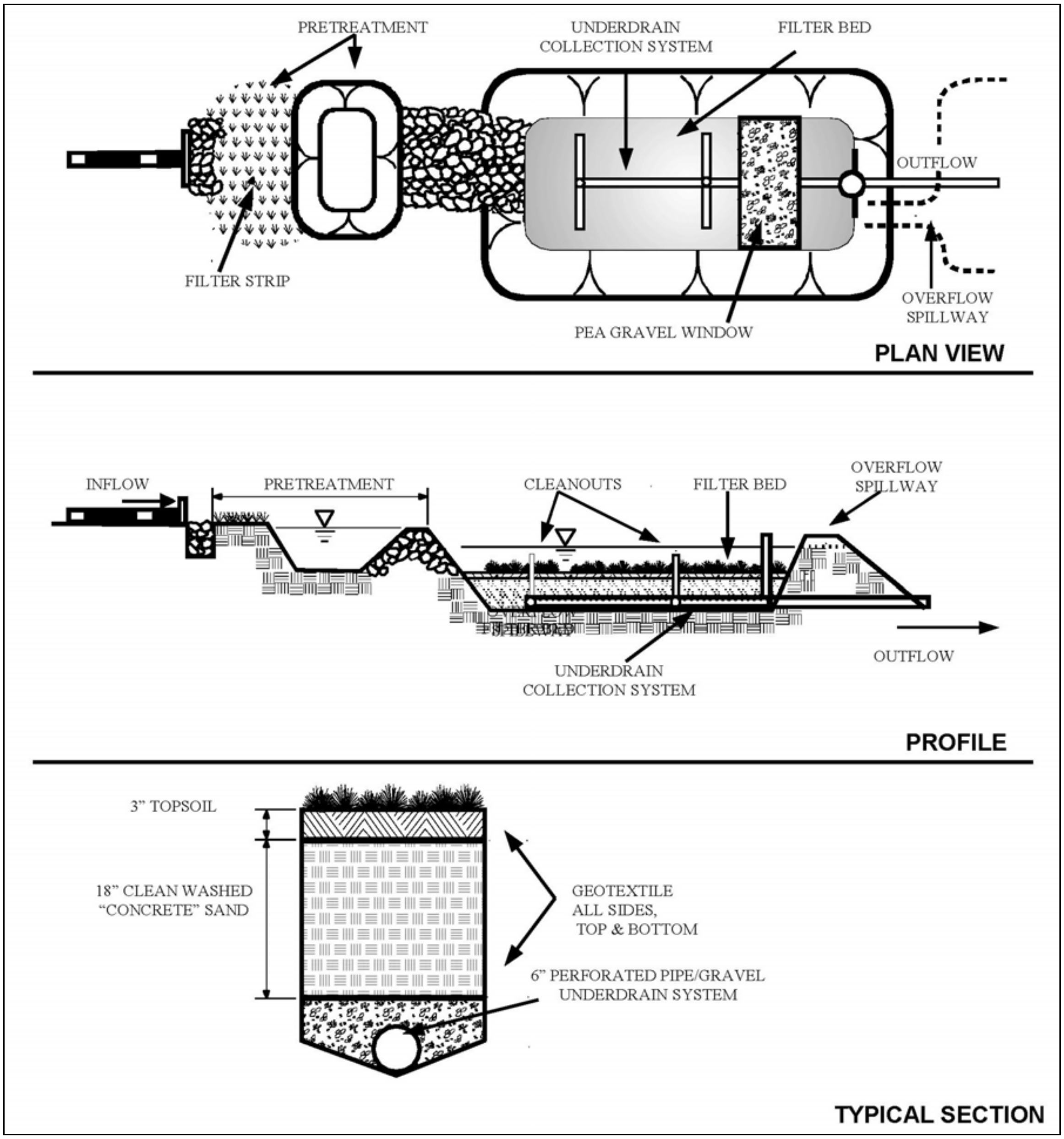
Perimeter Sand Filter



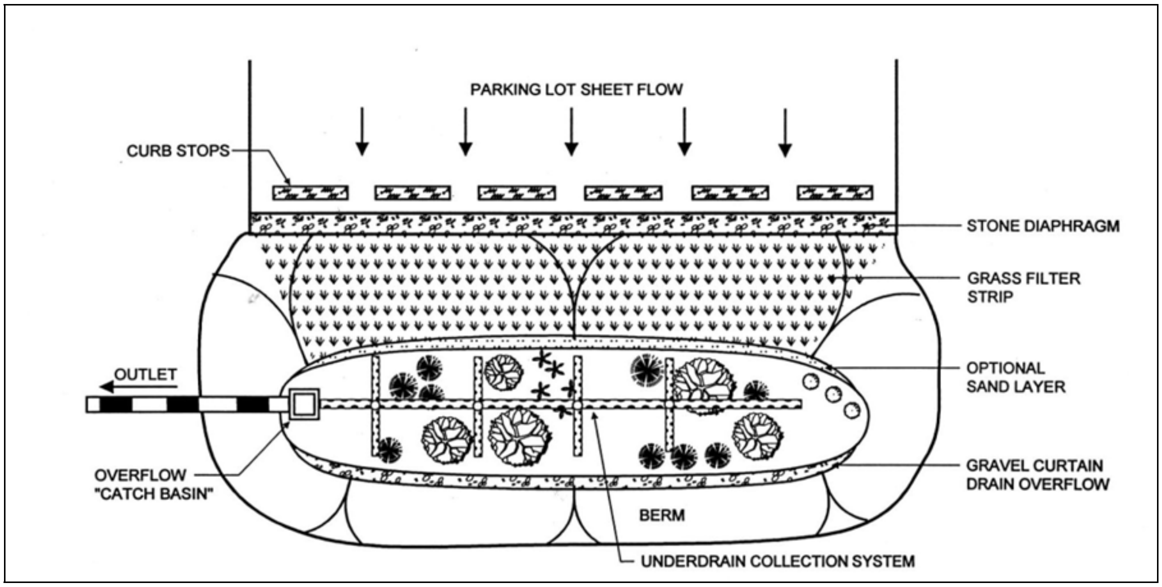
Organic Filter

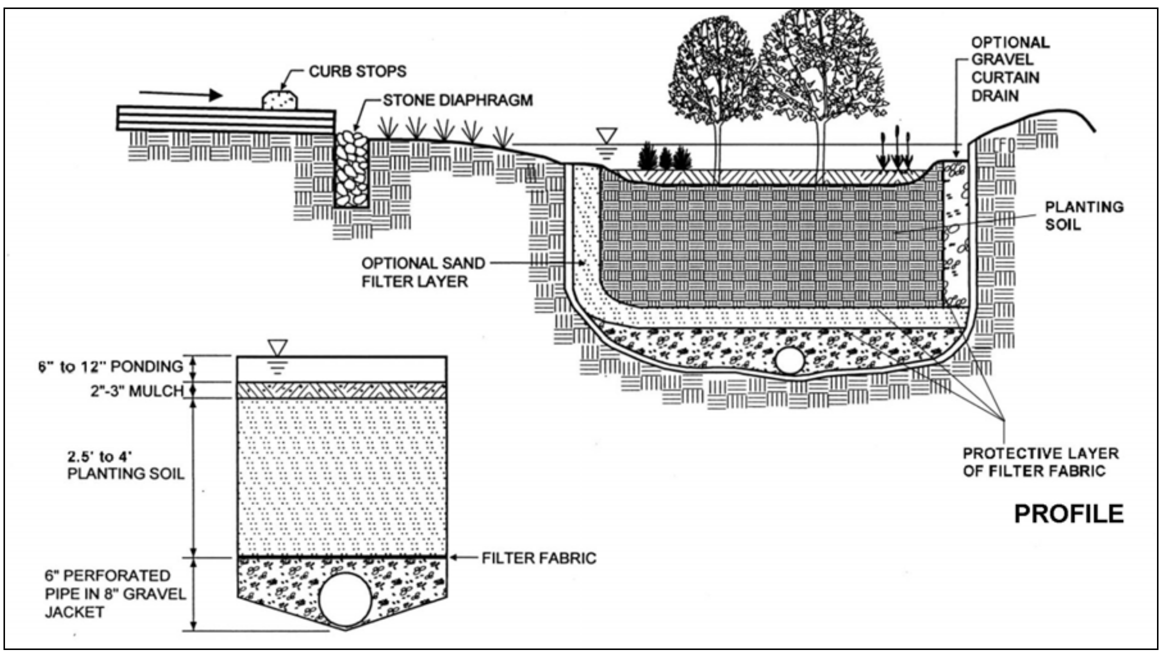


Pocket Sand Filter

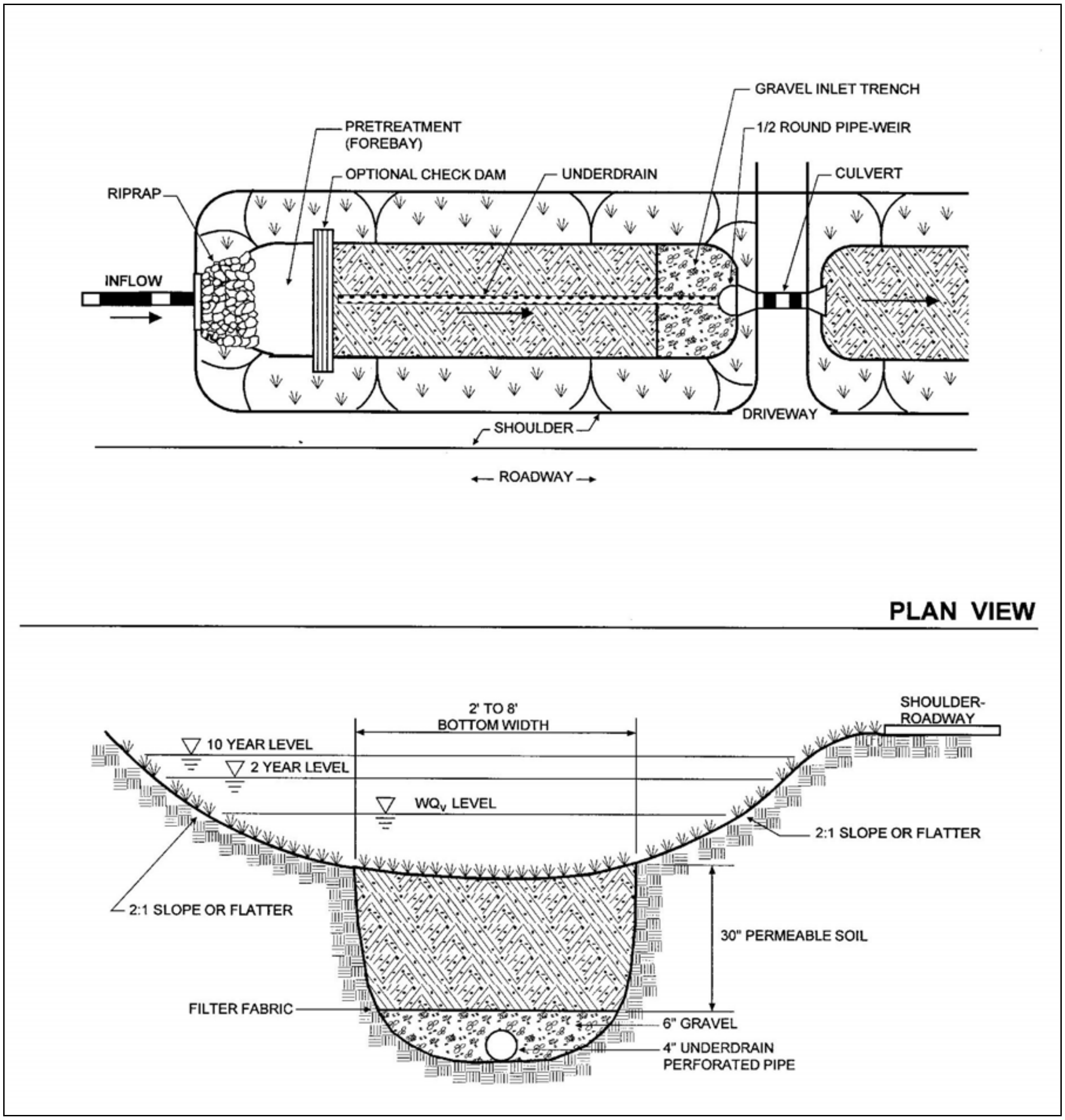


Bioretention

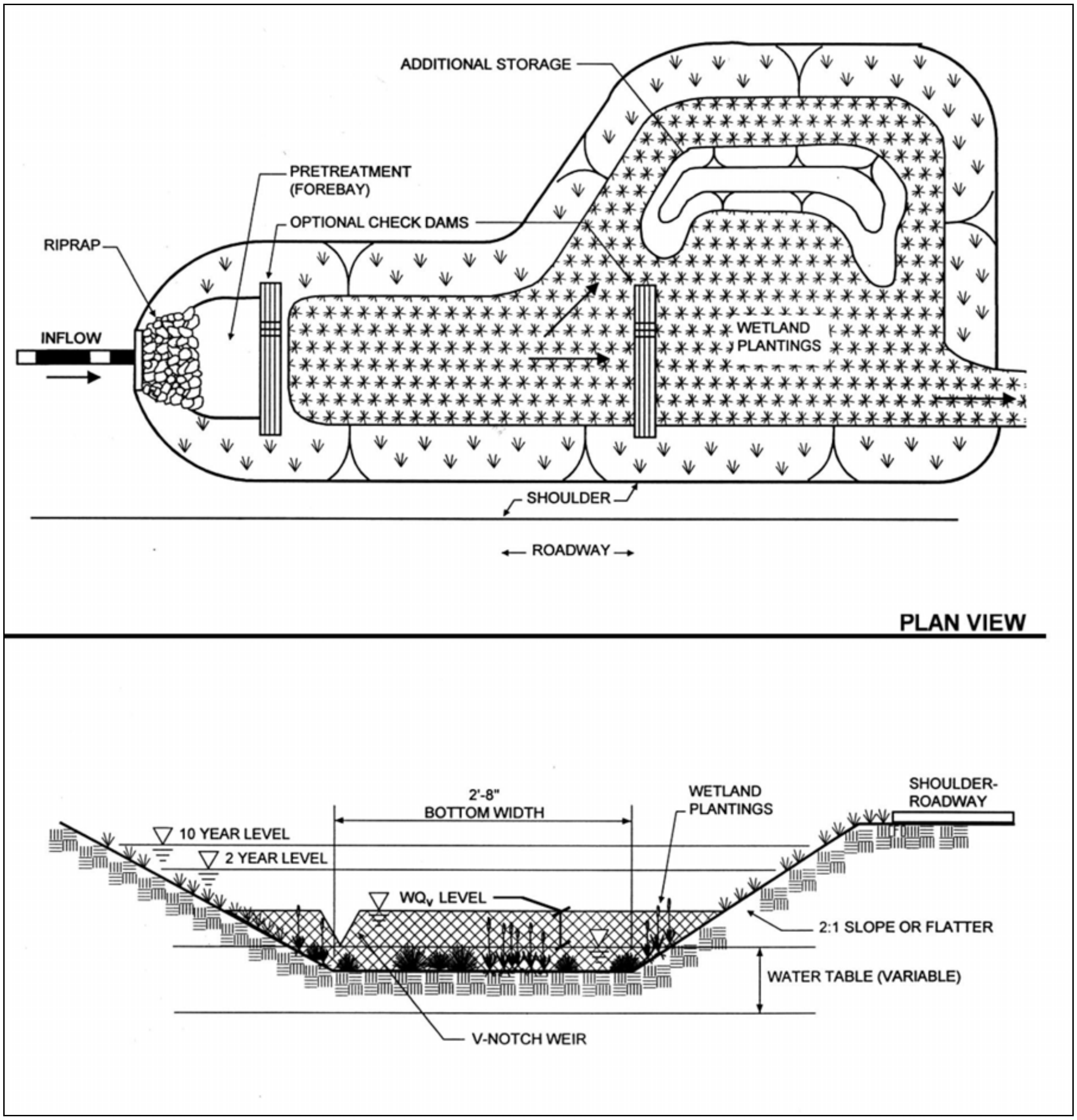




Dry Swale


GRAVEL INLET TRENCH
PRETREATMENT
(FOREBAY)
1/2 ROUND PIPE-WEIR
OPTIONAL CHECK DAM
UNDERDRAIN
CULVERT
RIPRAP
INFLOW
DRIVEWAY
SHOULDER
ROADWAY
PLAN VIEW
2' TO 8'
BOTTOM WIDTH
SHOULDER-
ROADWAY
10 YEAR LEVEL
2 YEAR LEVEL
WQ$_V$ LEVEL
2:1 SLOPE OR FLATTER
2:1 SLOPE OR FLATTER
30" PERMEABLE SOIL
FILTER FABRIC
6" GRAVEL
4" UNDERDRAIN
PERFORATED PIPE

Wet Swale



ADDITIONAL STORAGE
PRETREATMENT (FOREBAY)
OPTIONAL CHECK DAMS
RIPRAP
INFLOW
WETLAND PLANTINGS
SHOULDER
ROADWAY
PLAN VIEW
2'-8" BOTTOM WIDTH
WETLAND PLANTINGS
SHOULDER-ROADWAY
10 YEAR LEVEL
2 YEAR LEVEL
WQv LEVEL
2:1 SLOPE OR FLATTER
WATER TABLE (VARIABLE)
V-NOTCH WEIR

Appendix 3-D

Pictures of Standard BMP Features

(Blank)

Appendix 3-E

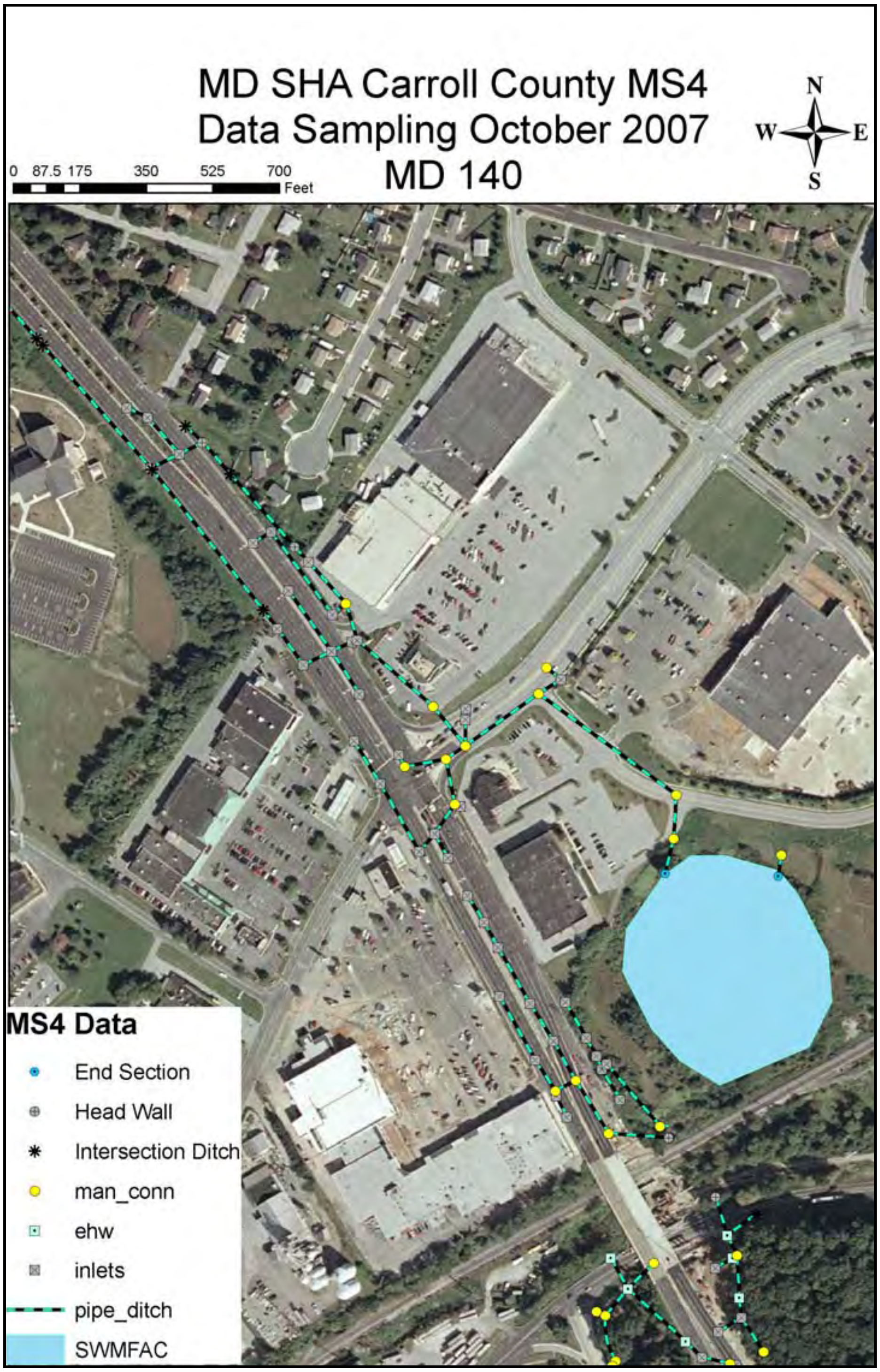
Invasive Species Document

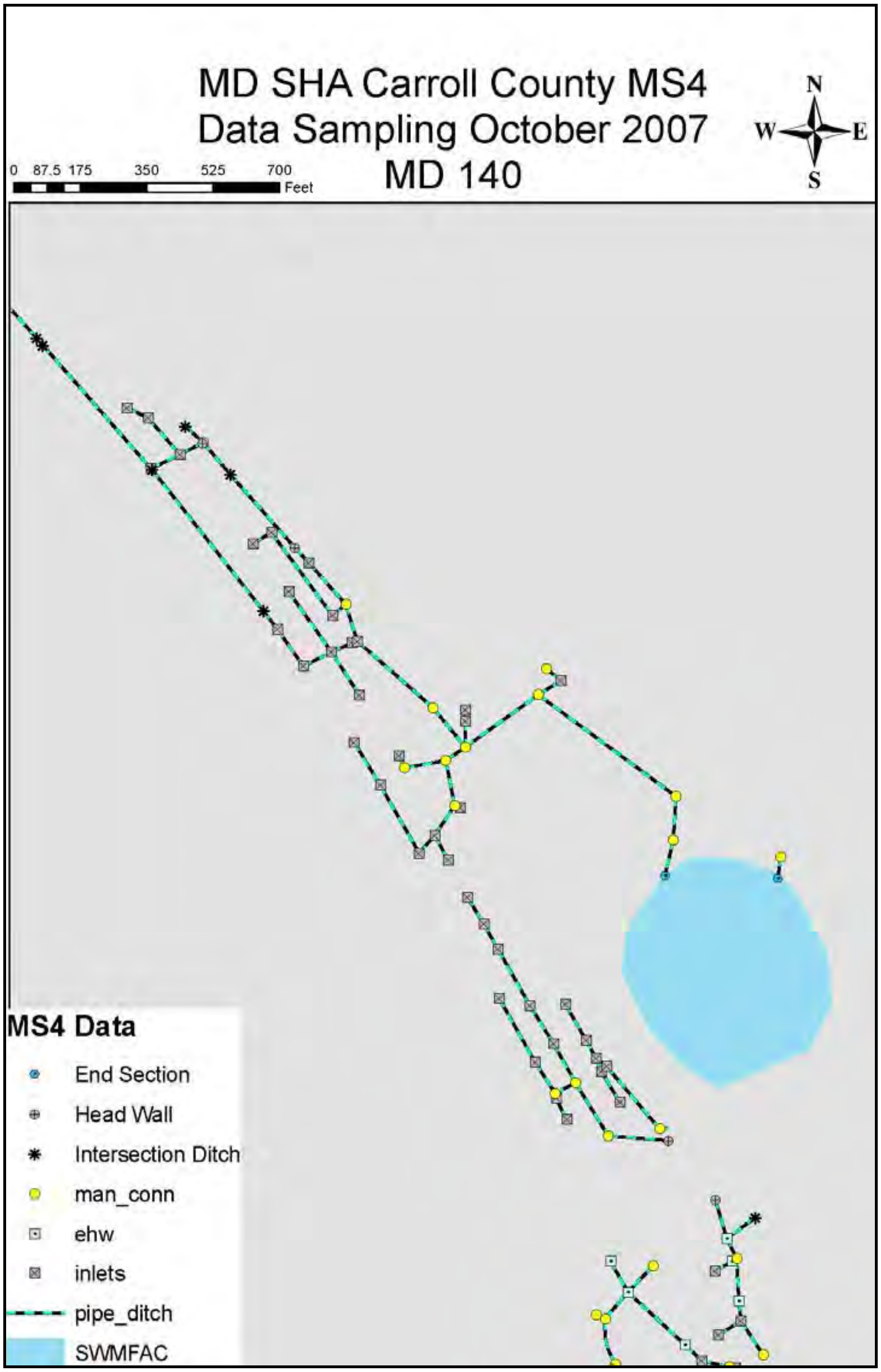
(Blank)

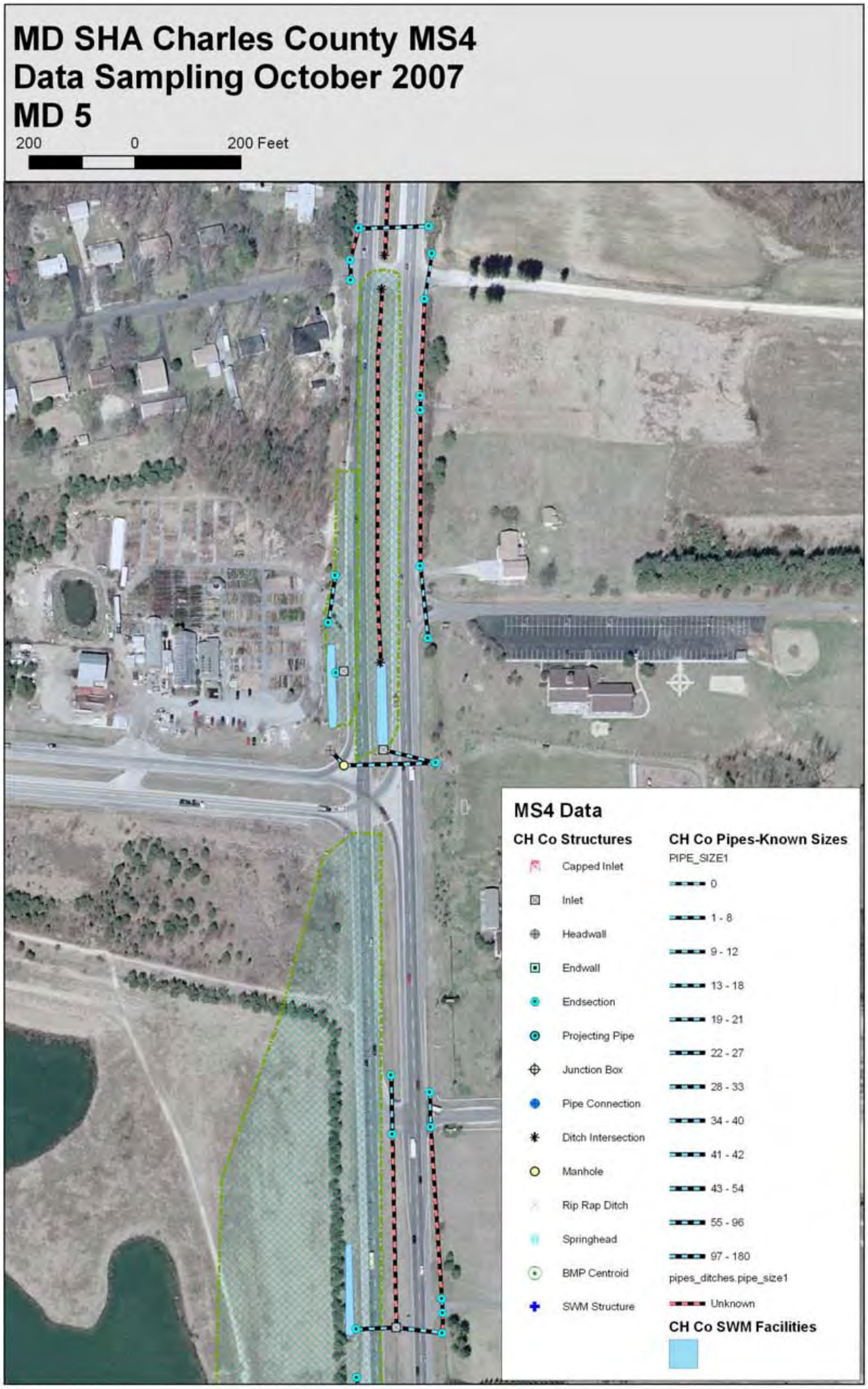
APPENDIX B:

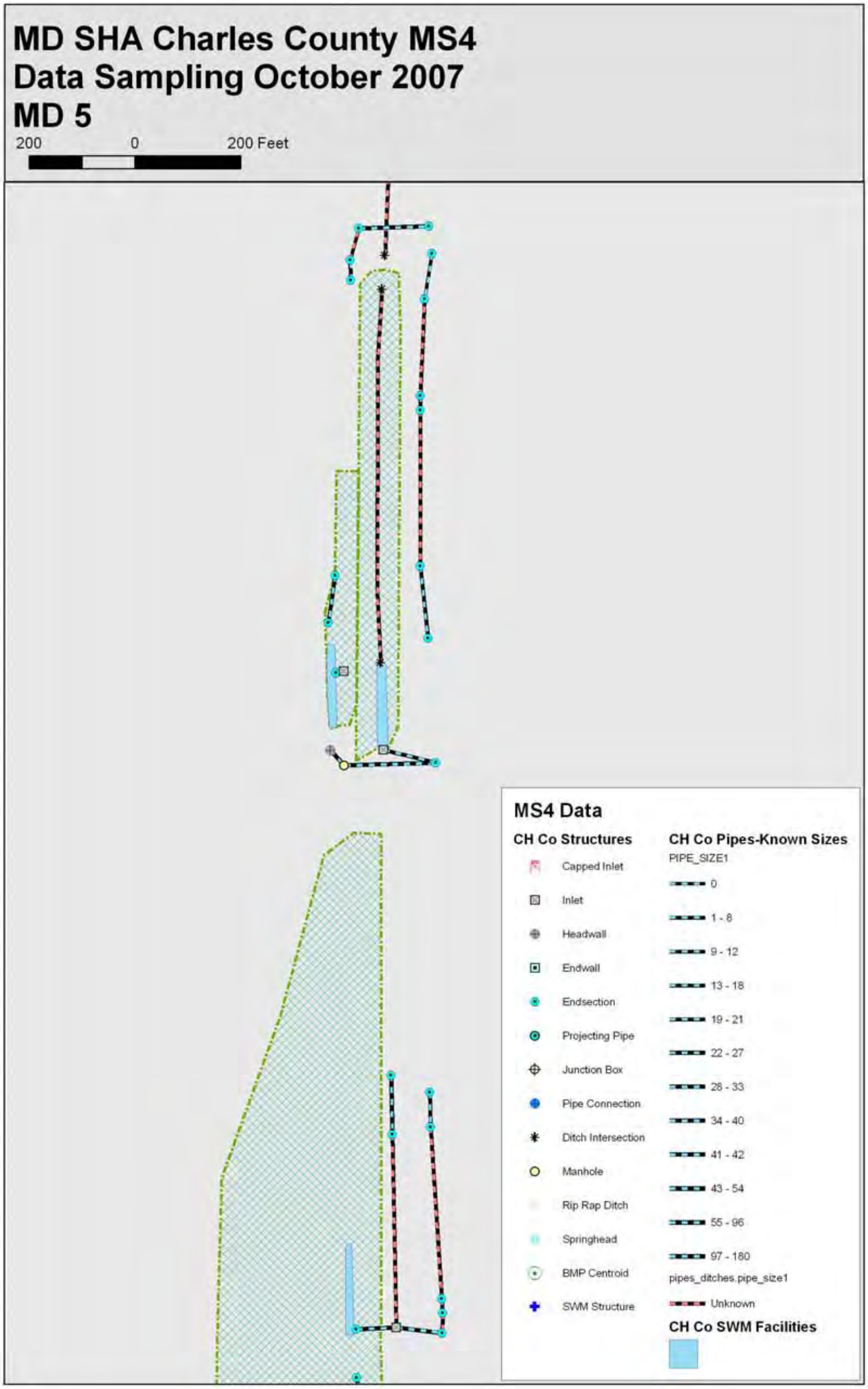
Source ID Examples

Carroll County
Charles County


MD SHA Carroll County MS4
Data Sampling October 2007
MD 140
0 87.5 175 350 525 700
Feet
N
W
E
S
MS4 Data
End Section
Head Wall
Intersection Ditch
man_conn
ehw
inlets
pipe_ditch
SWMFAC


MD SHA Carroll County MS4
Data Sampling October 2007
MD 140
0 87.5 175 350 525 700 Feet
N
W
E
S
MS4 Data
End Section
Head Wall
Intersection Ditch
man_conn
ehw
inlets
pipe_ditch
SWMFAC

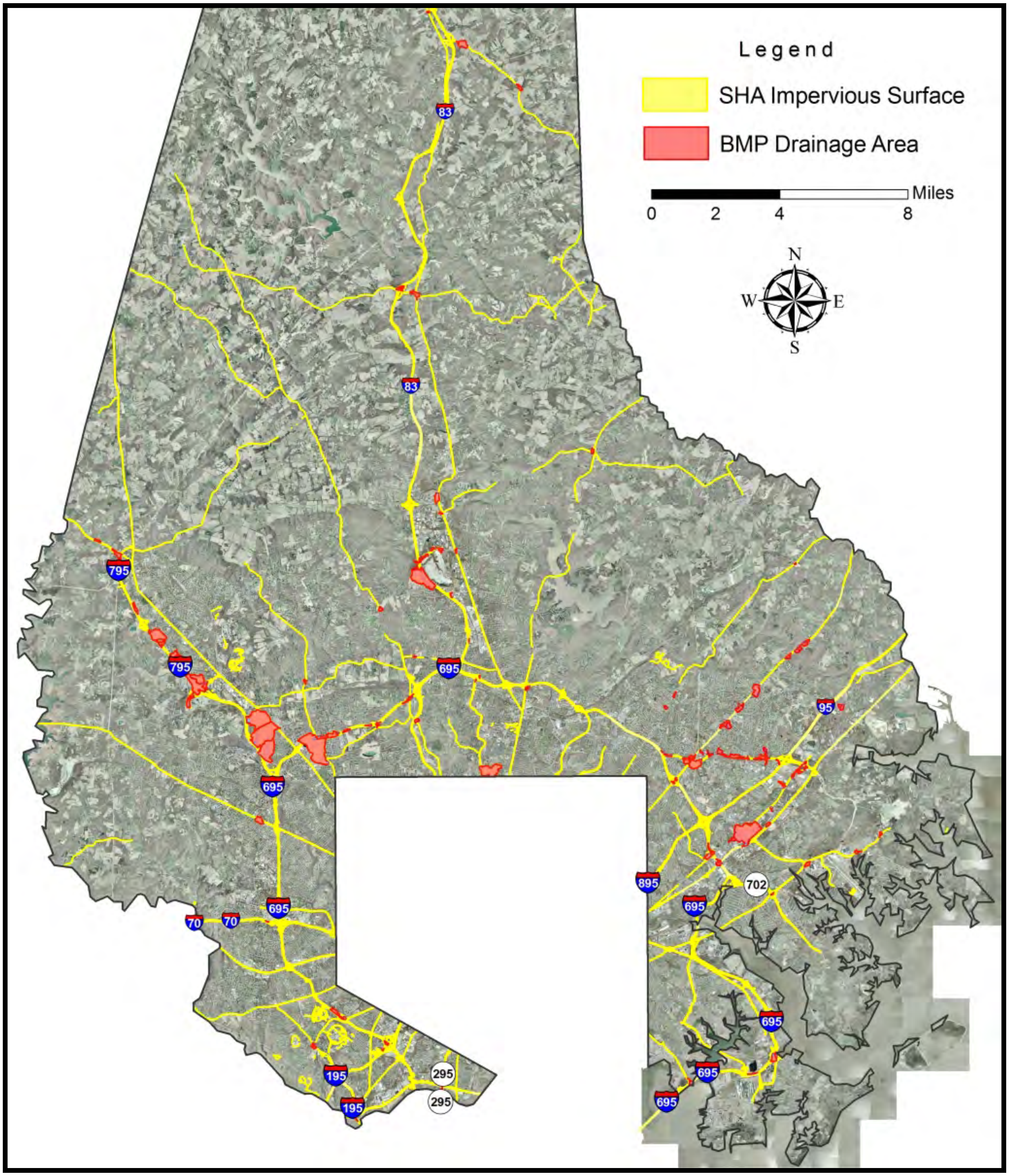

MD SHA Charles County MS4
Data Sampling October 2007
MD 5
200
0
200 Feet
MS4 Data
CH Co Structures
Capped Inlet
Inlet
Headwall
Endwall
Endsection
Projecting Pipe
Junction Box
Pipe Connection
Ditch Intersection
Manhole
Rip Rap Ditch
Springhead
BMP Centroid
SWM Structure
CH Co Pipes-Known Sizes
PIPE_SIZE1
0
1 - 8
9 - 12
13 - 18
19 - 21
22 - 27
28 - 33
34 - 40
41 - 42
43 - 54
55 - 96
97 - 180
pipes_ditches.pipe_size1
Unknown
CH Co SWM Facilities


MD SHA Charles County MS4
Data Sampling October 2007
MD 5
200
0
200 Feet
MS4 Data
CH Co Structures
Capped Inlet
Inlet
Headwall
Endwall
Endsection
Projecting Pipe
Junction Box
Pipe Connection
Ditch Intersection
Manhole
Rip Rap Ditch
Springhead
BMP Centroid
SWM Structure
CH Co Pipes-Known Sizes
PIPE_SIZE1
0
1 - 8
9 - 12
13 - 18
19 - 21
22 - 27
28 - 33
34 - 40
41 - 42
43 - 54
55 - 96
97 - 180
pipes_ditches.pipe_size1
Unknown
CH Co SWM Facilities

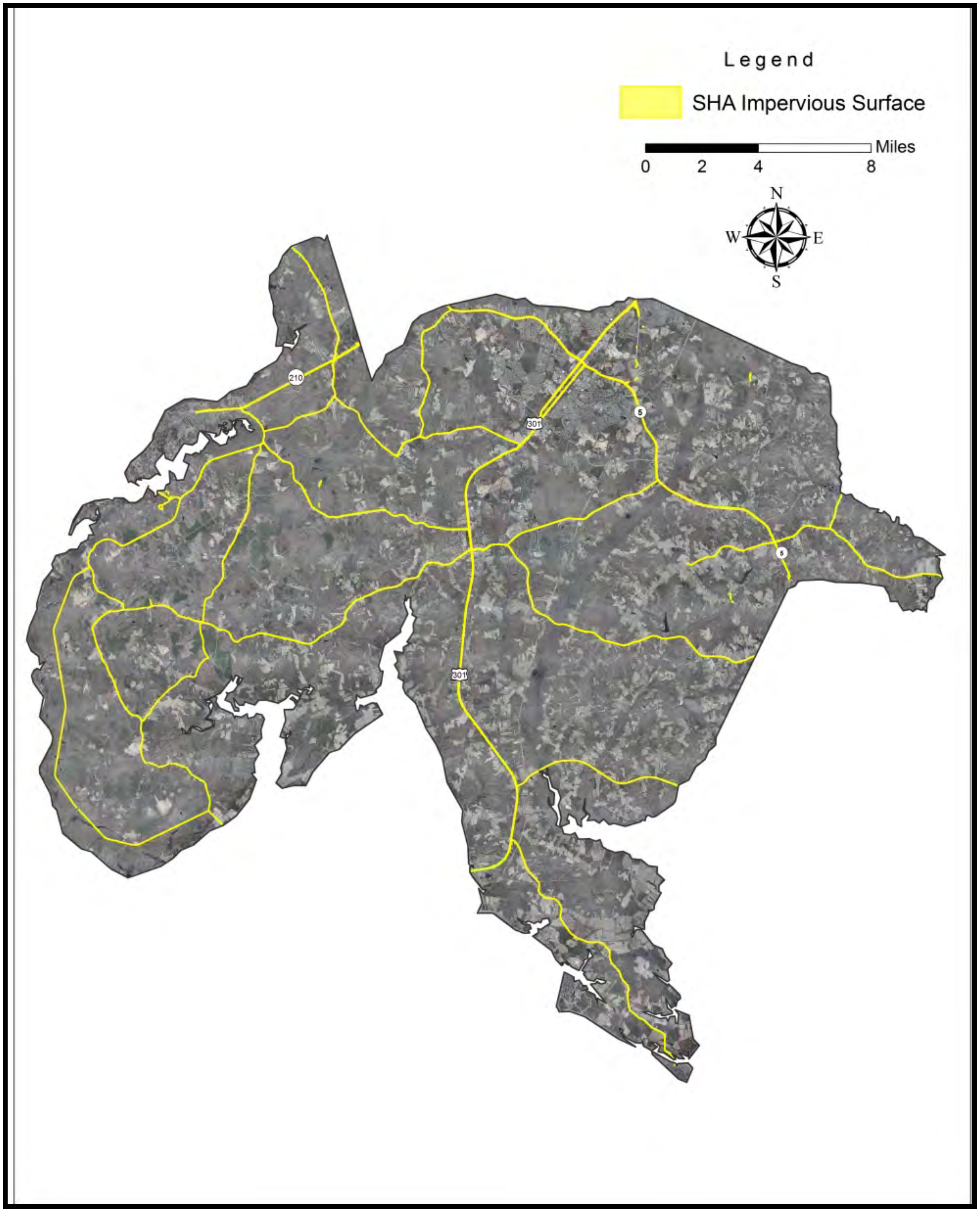
APPENDIX C:

Examples of Impervious Layers

Baltimore County
Charles County
Harford County
Howard County

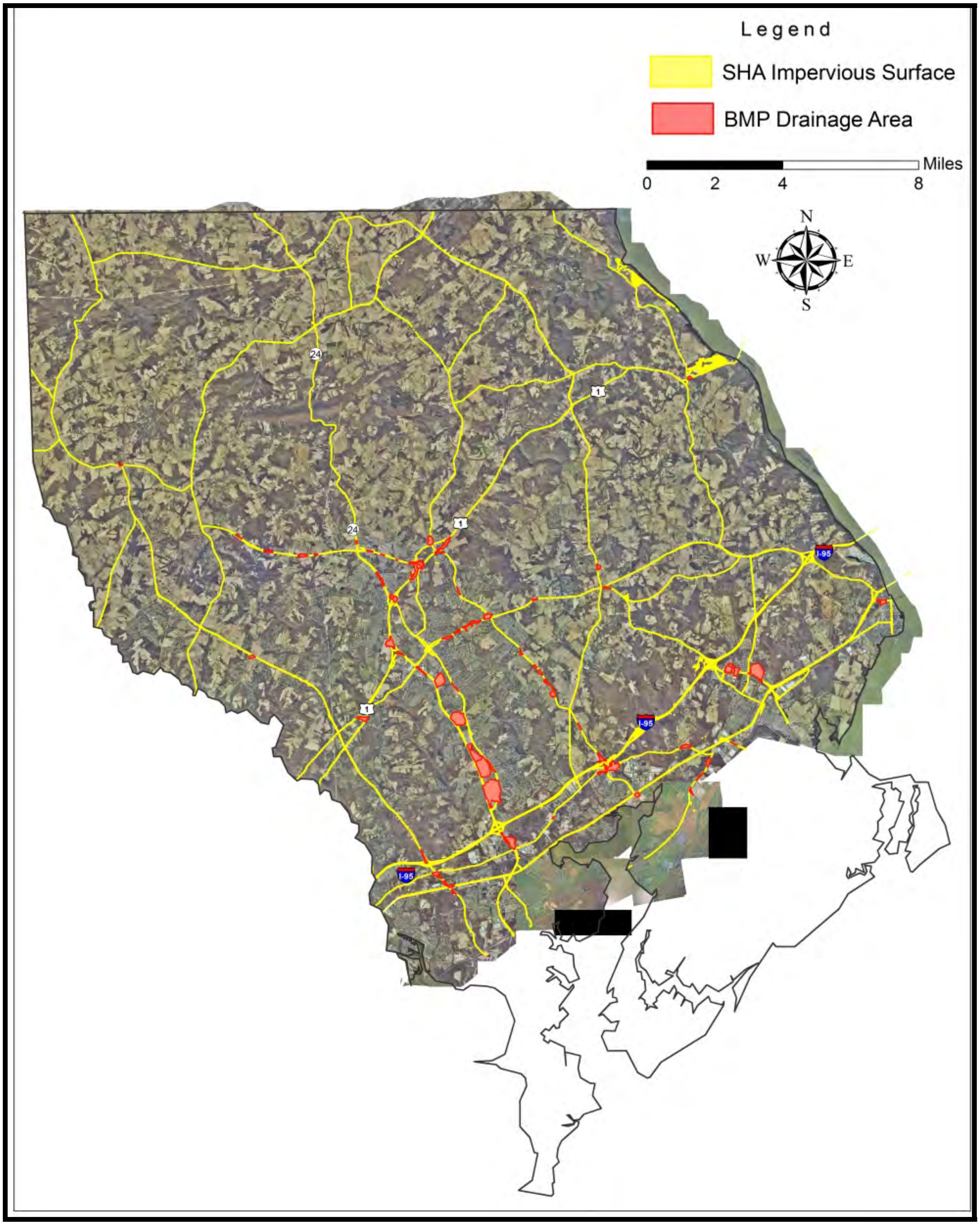


SHA-OWNED IMPERVIOUS SURFACES IN BALTIMORE COUNTY



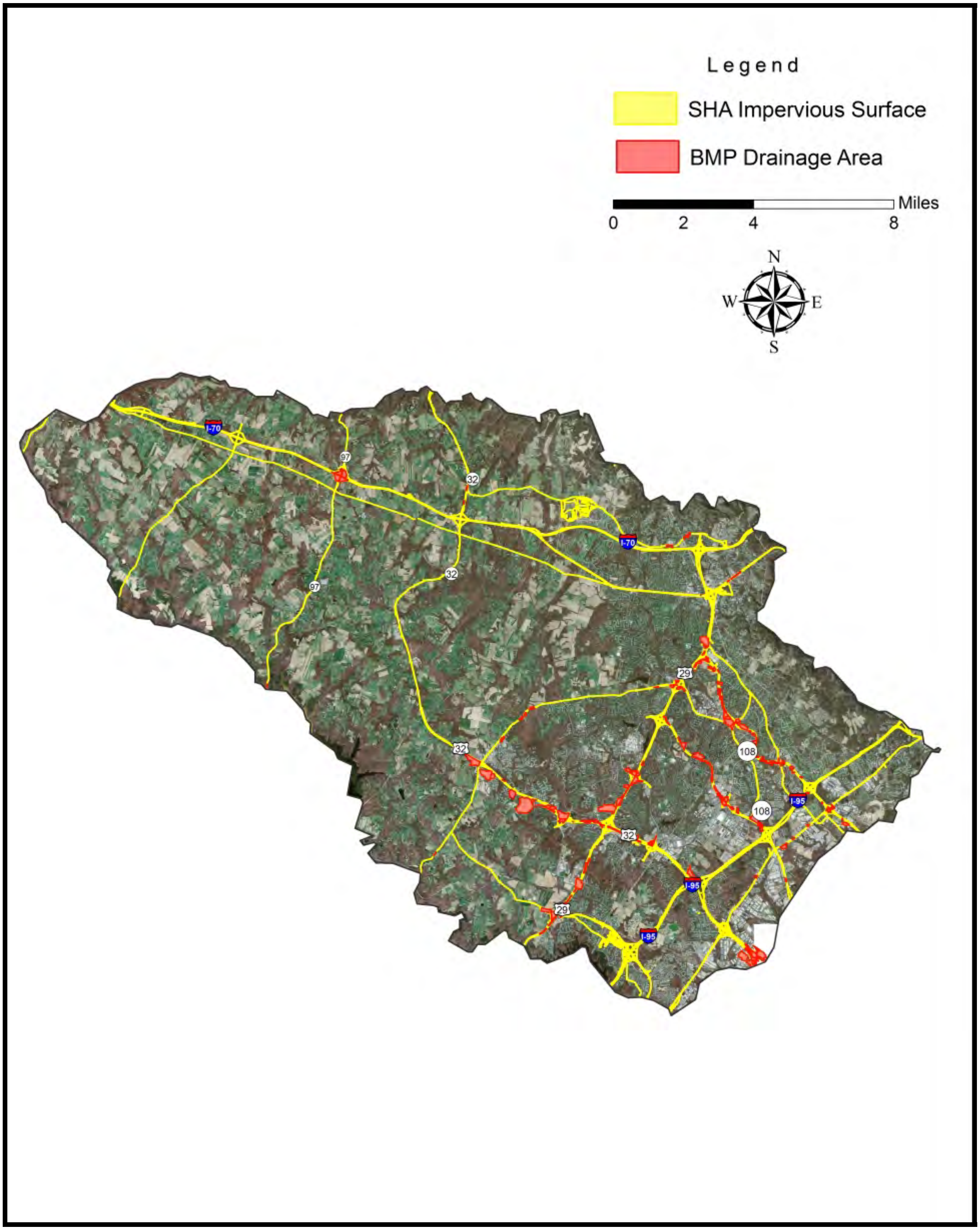
SHA-OWNED IMPERVIOUS SURFACES IN CHARLES COUNTY

Note: BMP Drainage Areas are not currently available for Charles County. The GIS for this county is currently being developed.



SHA-OWNED IMPERVIOUS SURFACES IN HARFORD COUNTY

Note: Photogrammetry for Aberdeen Proving Grounds is unavailable (southeast section of graphic). SHA will obtain impervious area coverage for this area through other means.



SHA-OWNED IMPERVIOUS SURFACES IN HOWARD COUNTY

APPENDIX D:

Draft: Impervious Surface Accounting Protocol

September 2007

Impervious Surface Accounting Protocol

September 2007

DRAFT

1.0 Introduction

Maryland State Highway Administration (SHA) is required under their National Pollutant Discharge Elimination System (NPDES) Program to quantify the amount of impervious area that they own and what percentage of that area is being treated by best management practices (BMPs). Impervious area is defined as surface cover that does not allow for infiltration of storm water into the ground. Examples of impervious area include concrete or asphalt roadways, sidewalks, buildings, and hard packed gravel driveways. BMPs include both structural BMPs such as ponds and bio-retention facilities as well as non-structural BMPs such as land conservation or disconnected roof drains. BMPs that treat SHA impervious area can be both SHA owned, joint owned, or private facilities.

The purpose of this document is to define the scenarios facing SHA and the accounting process that SHA will follow to adequately convey the amount of water quality treatment being performed to the Maryland Department of the Environment as part of the NPDES permit.

2.0 Stormwater Treatment

The construction of impervious area in watersheds has a detrimental effect on water quality which can be imparted in a number of ways.

- Deposited and leaked pollutants accumulate on impervious surfaces to be washed away during storm events.
- Impervious area hinders ground water recharge.
- Short times of concentration and reduced infiltration lead to high peak flows in streams and increased erosion.

The Maryland Department of the Environment *2000 Maryland Stormwater Design Manual* provides guidance for the construction of BMPs to address these issues. A Unified Stormwater Sizing Criteria is documented that addresses the different sizing criteria required for BMPs.

- Water Quality Volume – Storage to capture and treat the runoff from 90% of the average annual rainfall.
- Recharge Volume – Storage volume to promote ground water recharge.
- Channel Protection Storage Volume – The 24 hour extended detention of the one-year, 24 hour storm event to protect channels from erosion.
- Overbank Flood Protection Volume – Storage volume to prevent the frequency of out of bank flood events.
- Extreme Flood Volume – Storage volume to prevent an increase in flood damage and flood plain boundaries.

These five volumetric calculations for BMP sizing can be segregated into two basic categories. Water Quality treatment for the water quality volume and recharge volume, and water quantity treatment for the channel protection volumes. This is partially a misnomer as the quantity and frequency of flood events contributes to water quality; however, it facilitates the segregation of the concepts.

Water quantity management requires a hydrologic study of the watershed in which treatment is being performed. Stream flow is modeled through the calculation of hydrographs which statistically predict the magnitude and duration of runoff response to rainfall. Water quantity management must be designed holistically with a view of the entire watershed as timing of hydrographs is extremely important. As such, although impervious area is a key component to the hydrologic response of a study area, each study point should be analyzed with respect to adjacent contributing drainage areas.

The complexity and dynamic nature of water quantity management does not lend itself well to deriving the impacts on water quality. Therefore, for the purposes of the accounting protocols established in this report, focus will remain strictly on BMPs providing water quality management. The term “Stormwater Treatment” will refer to the management provided by BMPs for the MDE defined Water Quality Volume and Recharge Volume. The primary factor in the calculation of water quality volume is impervious area and therefore, this will be the currency for tracking the accounting of water quality treatment.

It should be noted that SHA owns many facilities that were designed and constructed prior to when the *2000 Maryland Stormwater Design Manual* revised the current standards and regulations. For the purposes of accounting impervious area treatment, it is assumed that the facilities are capable of treating the water quality of the impervious area draining to them.

3.0 Best Management Practices – Structural vs. Non-Structural

BMPs fall into two categories, structural and non-structural. Structural BMPs are engineered to fit design criteria, have a mechanism for providing treatment, and must be maintained to continue to provide treatment. There are five groups of structural BMPs and they are divided by the primary mechanism that they use to provide treatment.

- Ponds (Settlement)
- Wetlands (Plant uptake)
- Infiltration (Soil filtration to groundwater)
- Filtering (Filtering media)
- Open Channels (Settlement, plant uptake, soil filtration)

Non-structural BMPs are practices that are followed to promote water quality. They do not involve a mechanism that needs to be maintained to continue to provide water quality. They either exist or they do not exist. “Maintenance” is therefore putting protocols in place to ensure that they continue to exist in perpetuity. MDE’s current list of non-structural BMPs are as follows:

- Natural Conservation
- Disconnection of Rooftop Runoff
- Disconnection of Non Rooftop Runoff
- Sheet Flow to Buffers
- Open Channel Use

- Environmentally Sensitive Development

Some of these practices serve to reduce the overall project site area and thereby reduce the amount of treatment required. Others, like open channel and disconnected rooftops, reduce water quality treatment required by eliminating impervious area from the water quality calculations. Since the goal of this program is to quantify impervious area, these non-structural practices will need to be tracked and will be done so with the Water Quality Summary Sheet and Study Point Feature Class.

4.0 Water Quality Summary Sheet

SHA and MDE have an agreement in place for banking impervious area for water quality. On a project by project basis, SHA submits a Water Quality Summary Sheet (WQSS) that lists for each study point the change in impervious area due to new development, reconstructed impervious area, removed impervious area, loss of water quality treatment, and area treated by both structural and non-structural BMPs. A study point is defined as where stormwater runoff leaves SHA right-of-way. Projects can either credit or debit the water quality bank. SHA and MDE monitor the bank on a watershed basis and if the account trends too far into the negative for a watershed, special projects may be implemented to specifically provide BMPs to manage untreated impervious area.

The use of GIS will greatly facilitate the process of analyzing watersheds for improvement projects. Key to the analysis is the overall quantification of the amount of impervious area that SHA owns and how much of this area is being treated by BMPs. The incorporation of this data with the Water Quality Bank will provide SHA and MDE with a comprehensive program to monitor the accounting of impervious area.

5.0 Impervious Area Quantification – Feature Analyst

SHA requires an initial study to quantify the amount of impervious area that is owned and treated by BMPs. Several methods exist for this endeavor ranging from manual digitizing of data from aerial photographs or contract drawings to automated remote sensing applications using satellite or aerial photography. After some study of alternatives, SHA settled on using Feature Analyst with aerial photography. Feature Analyst is a sophisticated computer application that can delineate features of interest in digital imagery. It provides robust capabilities for feature extraction within the ArcGIS environment. Through a learning process, Feature Analyst is programmed to recognize spectral signatures of impervious area in aerial photography. Once Feature Analyst learns the characteristics of the imagery it is to analyze, it can quickly process the data and produce County wide results.

This process of producing an impervious area data set has been executed for the nine phase 1 Counties.

- Montgomery
- Frederick
- Prince George's
- Charles
- Carroll
- Howard
- Anne Arundel
- Baltimore
- Harford

The data is stored in an ESRI geodatabase with the following structure.

Simple feature class
IMPERVIOUS_AREA

OBJECTID	Object ID
SHAPE	Geometry
STUDY_PT_ID	String
SHA_OWNED	String
CAPTURE_METHOD	String
SOURCE_DATE	Date
COMMENT	String
SHAPE_Length	Double
SHAPE_Area	Double
SOURCE_DESC	String

STUDY_PT_ID is the unique ID of the study point to which the impervious area is associated. They have been left blank for the Feature Analyst process.

SHA_OWNED is a yes/no field indicating if the impervious area represented by the polygon is owned by SHA or not.

CAPTURE_METHOD indicates the methodology by which the impervious area polygon was generated. Currently the two acceptable values for this field are Feature Analyst and Contract Drawings.

SOURCE_DATE is the date on which the polygon was created or edited.

SOURCE_DESC is the description of the source from which the data was captured. In the case of impervious created from a CAD import this will be the Contract Number. In the case of impervious created by Feature Analyst then this would be the date of the orthophoto from which the impervious data was generated

COMMENT is a field available for any additional comments needed for the impervious area polygon.

With the initial capture of impervious area completed, a maintenance process must be put in place to update the data.

6.0 Impervious Area Quantification – Update Procedure

The primary mechanism for updating the impervious area data set will be from construction projects which perform modifications to the existing impervious area. It is assumed that these projects will require coordination with MDE regarding the proposed work and as such will have data conveyed via mapping and a WQSS. SHA engineers or consultants will be required to create the following items in addition to their regular documentation.

- Microstation file containing study points – File should contain points and text attributes indicating the point number.
- Microstation file containing drainage areas – Drainage areas should be to each of the study points. Study points should be contained within the drainage area.
- Microstation file containing post development impervious area – This area should be broken out per study point drainage area and correspond to the area indicated in Column C of the WQSS. Additionally, polygons should be segregated by SHA owned vs. non-SHA owned. That distinction is not required on the WQSS, but is required for reporting in the GIS.

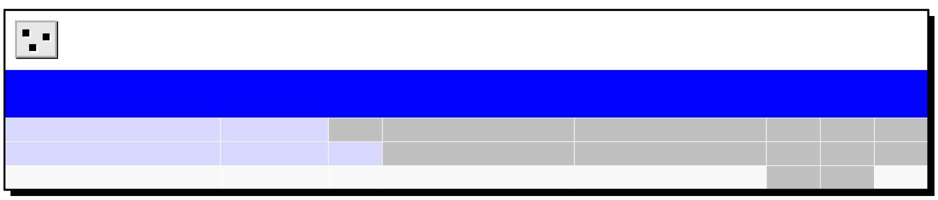
Impervious Area Model

The most involved process is the update of the Impervious Area data layer. This GIS centric procedure merges the new CAD polygon shapes with the existing impervious area feature class through the implementation of an Erase/Merge geoprocessing model. The core part of this model uses the erase geoprocessing tool which takes the new imperious polygons and uses their shapes to cut out the existing impervious areas that will be overwritten in a process similar to a cookie cutter. With the old impervious areas erased, the merge tool then imports the new impervious areas and creates a new, updated feature class that includes both old and new polygons as separate features. The stepwise diagram of this geoprocessing model is depicted in Figure XXXXX of the appendix. A general breakdown of the model processes is as follows:

1. Import the polygon data from CAD, isolating the level that contains the impervious area polygons.
2. Convert the data to a polygon feature class.
3. Create CAD impervious feature class and attribute.
4. Erase existing impervious features based upon updated impervious features extracted from the CAD file.
5. Merge new impervious features extracted from CAD file with erased impervious.
6. Manually review for orphan polygons.

Study Points

Study Points will be stored as a point feature class in the impervious area geodatabase. The structure of the table is as follows.



The STUDY_PT_ID is a concatenation of the MDE number from the WQSS and the study point number. An example study point number would be:

04-SF-1234-1

Where 04-SF-1234 is the MDE number and 1 is the study point number in that MDE project.

The Study Point Update model selects the study points from the CAD point feature class based on their level name and adds them to the existing study point GIS feature class. Since the study point ID is not assigned by MDE until after the CAD plans are submitted, the GIS attribution of the study point ID would need to be done manually in the feature class after it has been updated with the new points. Another option would be to have the numbers added as a tag in Microstation after they have been assigned but before importation into the Study Point Geoprocessing model. In this senerio, further development would be required to enable the geoprocessing model to import the CAD text attributes to the study point feature class. . A general breakdown of the model processes is as follows:

1. Import the study point data from CAD, isolating the level that contains the study points
2. Convert study point to point feature
3. Import CAD annotation, isolating the level that contains the study point labels, convert CAD annotation to point feature with CAD text as attribute.
4. Perform spatial join to assign the study point label to the study point location.

5. Update the feature class with the new study point features.
6. Perform attribution

Drainage Areas

The Drainage Area Update Model facilitates the update of the drainage area GIS feature class utilizing information extracted from submitted CAD drawings. This GIS centric procedure merges the new CAD drainage areas the existing drainage area features through the implementation of an Erase/Merge geoprocessing model. The core part of this model uses the erase geoprocessing tool which takes the new drainage area polygons and uses their shapes to cut out the existing draiange areas that will be overwritten in a process similar to a cookie cutter. With the old drainage areas erased, the merge tool then imports the new drainage areas and creates a new, updated feature class that includes both old and new polygons as separate features. The following steps outline the basic processes of this tool:

1. Import the drainage area data from CAD
2. Convert CAD polyline features to polygon feature class
3. Erase existing drainage area features based upon updated drainage area features extracted from the CAD file.
4. Merge new drainage area features extracted from CAD file with erased features
5. Update the drainage area feature class with the new drainage area features..
6. Manually adjust discrepancies.

CAD Standards and Practices

The successful implementation of these models will require strict adherence to SHA CAD standards. Currently SHA maintains a comprehensive set of standards that are implemented and accessed through the SHA CAD Toolbar developed by MSHA. These standards facilitate the standardization of CAD drawings submitted to MSHA by consultants and contractors. SHA CAD standards define the structure of the CAD file in terms of in terms of levels, line styles, colors, etc. However, many CAD practices fall outside the control of these standards but will effect the CAD to GIS conversion process. The following list contains suggested CAD practices so that compatible files are produced:

1. Drainage areas for each study point must be created as individual closed shapes in the Microstation design file.
2. Drainage areas should be drawn in Microstation as polylines and not polygons. This will reduce the occurrence of gaps and slivers during the conversion process to a feature class since Microstation does not provide a simple method to manage complex polygons with shared edges.
3. Snapping in Microstation should be utilized at all times to produce line work that does not contain over and/or under shoots
4. Study points should not be created as shared cells in Microstation

7.0 Account Reporting

There are two concurrent processes that assist SHA with accounting of impervious area; they are the water quality bank and the impervious area GIS. The water quality bank is a very precise record of project by project impacts of increases and treatment of impervious area. The impervious area GIS is a coarse representation of the impervious area that SHA owns so that watershed decisions can be made. The goal of this accounting process moving forward is to meld these two processes to improve both of them.

Over the course of time, the Microstation files from the engineers will improve the accuracy of the impervious area GIS. Reports generated for MDE concerning the amount of impervious area in Counties, watersheds, or SHA districts will become more accurate. The impervious area GIS contains fields that can link to the water quality bank records. Therefore, custom queries can extract information from the water quality bank for more detailed reports. Conversely, the water quality bank can now spatially represent the records that it is recording. Overall, SHA now has a powerful GIS tool to assist in making decisions that improvement of Maryland's water quality.

8.0 Exemptions, Waivers, and Variances

MDE will grant *exemptions* for projects related to stormwater management if they disturb less than 5000 square feet and less than 100 cubic yards of earth movement. In typical situations where an exemption is warranted, SHA requests permission for the exemption from MDE. This typically accompanies Erosion and Sediment control documentation and plan sheets. It is recommended that SHA follow the same protocol as discussed for large design projects related to the development of Microstation drainage area and impervious area data for incorporation into the GIS.

There are two types of waivers for stormwater management allowed by MDE on a study point by study point basis. Type A waivers are used to waive both water quality and water quantity management. Typically the only Type A waiver applicable to SHA projects is an A.1 waiver that applies when "the project shall return the disturbed area to a predevelopment runoff condition (no hydrologic change and/or redevelopment occurs)." This waiver is typically used for maintenance and safety projects where utility cuts or landscaping is required. In these situations, there is no change in impervious area and there would therefore be no need to change the accounting of impervious area either in the GIS or in the water quality bank. Type B waivers are used to waive quantity management and SHA is still required to treat and account for the impervious area for water quality.

Variances are permitted in the case of exceptional circumstances that make stormwater management an unnecessary hardship. The variance may permit the relaxation of water quantity management; however, SHA would still utilize the water quality bank to account for impervious area.

9.0 Access Permits

Review and approval of stormwater management for access permits is the responsibility of the local approving agency. SHA and MDE become involved when the access permit seeks to use existing or proposed BMP's within the SHA right-of-way. The small nature of access permit projects and the diversity of engineering firms/developers producing documentation may make the automated collection of impervious area difficult. Further review is necessary into the access permit process to establish a procedure for inclusion in the accounting of water quality.

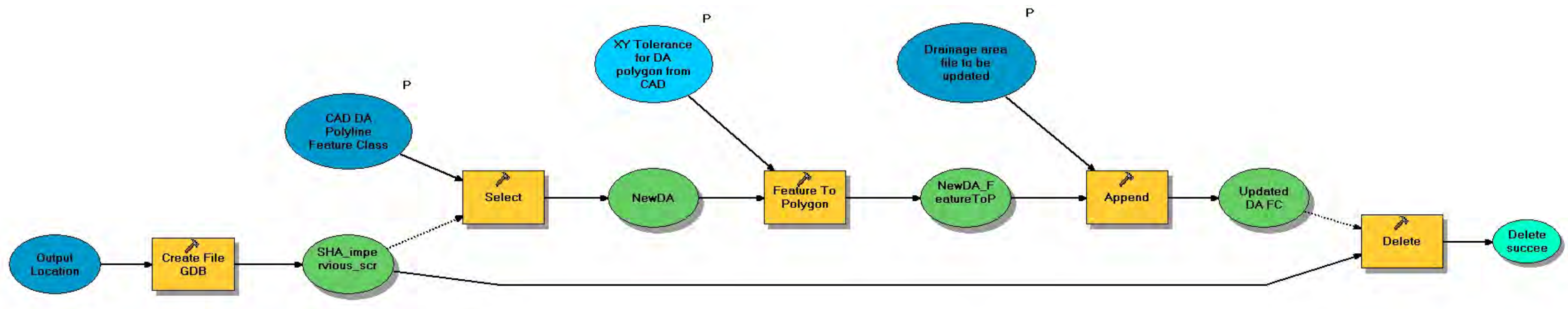
10.0 Private Development within SHA Right of Way

There are privately funded projects that are constructed within SHA right of way. Since they are privately funded and do not receive State or Federal funds, the responsibility for stormwater management approval is from the local approving agency. It is assumed that ownership of these projects is eventually turned over to SHA. When this occurs, it will be necessary to address each project on a case by case basis for inclusion into the accounting process for water quality and impervious area.

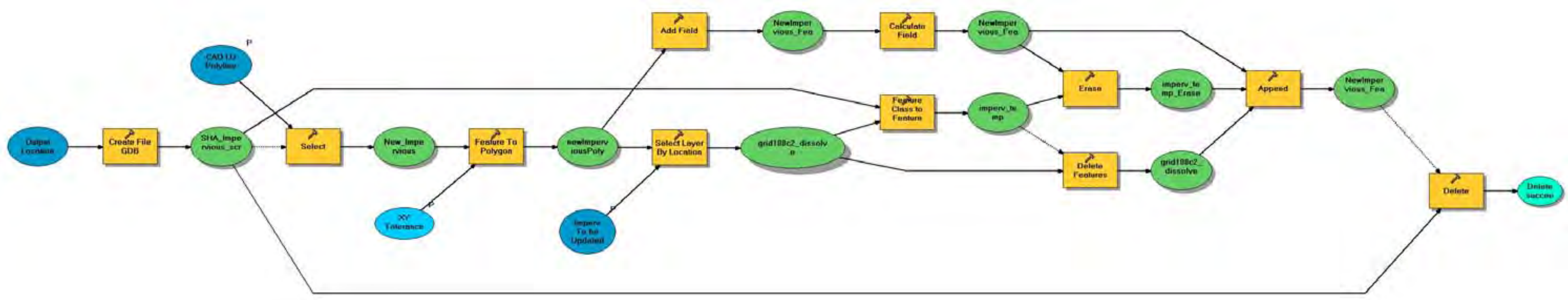
Update models

DRAFT

Drainage Area Update Model

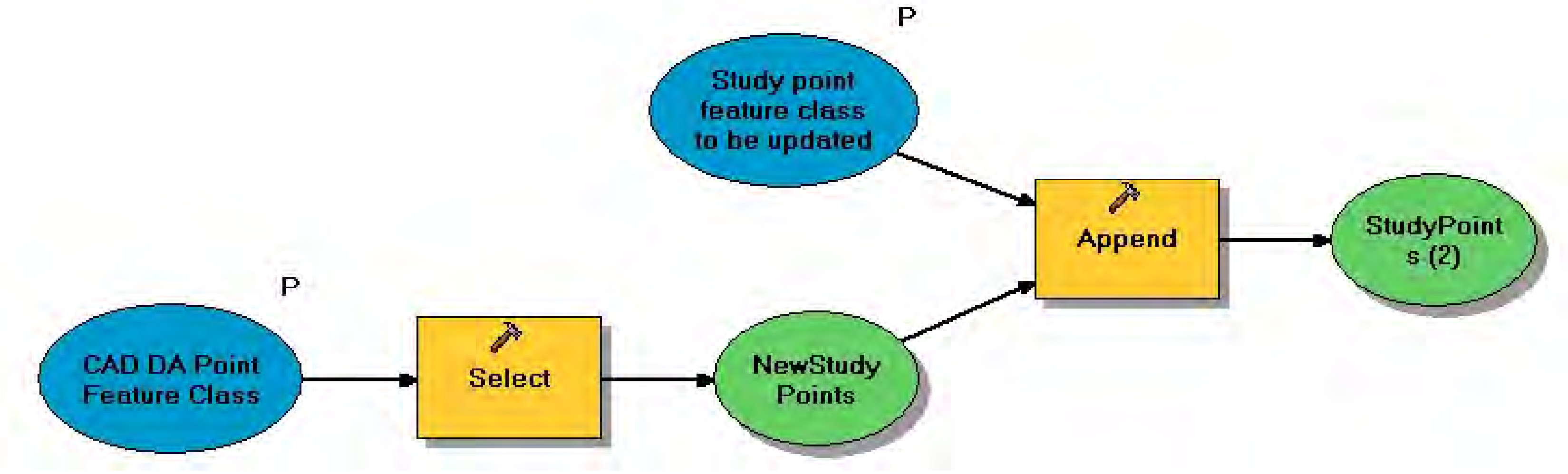


Impervious Surface Update Model



DRAFT

Study Point Update



APPENDIX E:

Grassed Swale Pollutant Removal Efficiency Studies – Part III

Progress Report

August 16, 2007

Progress Report: Grass Swale Pollutant Removal Efficiency Studies III

Project Duration:	August 2006 – July 2007
Project Sponsor:	Karen Coffman Highway Hydraulics Division Maryland State Highway Administration 707 North Calvert Street C-201 Baltimore, MD 21202
Project Coordinators:	Allen P. Davis, PhD, P.E Professor Nor Eliea Eluziea Jamil Graduate Student Department of Civil and Environmental Engineering University of Maryland College Park, MD 20742
REPORT DATED:	AUGUST 16, 2007

1.0 Introduction

Almost 50% of the total water pollution in the developed world comes from non-point source pollution (Novontny 1994). Non-point sources include overland runoff from agricultural, industrial and urban areas. In this study, the Maryland State Highway administration (SHA) is exploring the use of Low Impact Development (LID) technologies in managing complex stormwater management challenges. One of the LID technologies that have been used in many SHA designs is grass swales. Swales are shallow vegetated channels that capture stormwater and remove pollutants by filtration through grass and infiltration through soil. Swales are also relatively easy to design and maintain, and are aesthetically appealing, especially for highway use.

2.0 Objectives

Several studies have demonstrated grass swales as an effective LID technology by comparing water quality enhancements through pollutant removal efficiency. The focus of this study is to investigate the effectiveness of vegetated check dams on swale performance. This project has three objectives. The first is to study the overall efficiency of grass swales with native check dams on roadway runoff pollutant removal. Second, is to examine at the effect of shallow sloped grass pre-treatment area adjacent to the grass swale. Third, is to compare the results of the water quality parameters with the previous study by Stagge (2006) (grass swales without check dams). A goal of sampling one storm event per month is established.

3.0 Methodology

A research project has been constructed on Maryland Route 32 near Savage, Maryland that consists of two individual swales with different designs but nearly identical roadway drainage areas. The monitoring location is the same as the previous study (Stagge 2006). The two swales are constructed in the median of a four-lane (two in each direction) limited access highway which receives runoff laterally from the southbound roadway lanes (Figure 1). The first swale is constructed based on Maryland Department of the environment (MDE) guidelines, with a sloped grass pretreatment area between the roadway and the swale channel. The second swale, to the north, known as the SHA swale, was identically constructed but without the pretreatment area. The only condition that differs from Stagge's (2006) study is that two check dams are installed within each of the swales. These check dams consist of dense grass that could provide greater contact time for runoff through the swales, improve pollutant removal rates, and reduce the runoff flows.

Both swales convey to an inlet where water flow and quality measurements are made. Since swale input flow is distributed along its length, a third sampling area was designed to sample runoff directly from the roadway, known as direct, south of the swales. By this method, an input vis-a-vis output analysis can be done. Sampling occurs at a V-notch weir located at the end of each swale and flow rates were recorded by ISCO Model 6712 Portable Samplers to determine the effect of swales on stormwater quantity. Details of the sampler and sampling time can be found in Stagge's (2006) thesis.

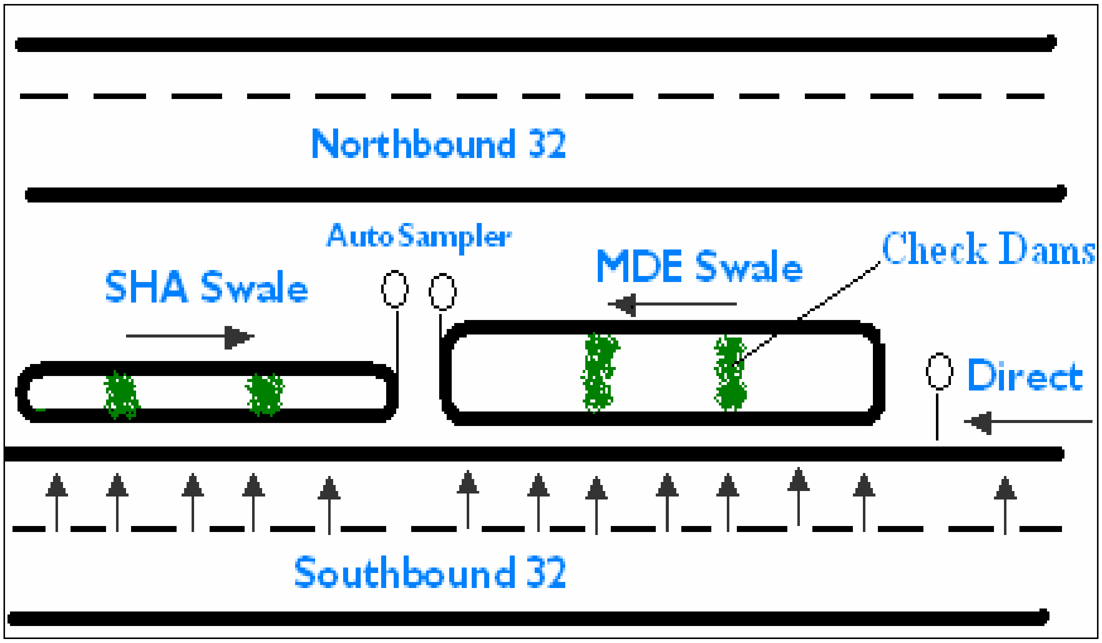


Figure 1. Diagram of site layout (Maryland Route 32). The arrows represent the highway runoff.

Sixteen storm events have been sampled and analyzed by Stagge (2006). The continuation of this project will try to achieve at least as many storm events in order to compare the results with the previous 16 storm events.

This study has 10 target pollutants for monitoring, total suspended solids (TSS), nitrate-N, nitrite-N, total Kjeldahl nitrogen (TKN), total phosphorus (TP), chloride (Cl), copper (Cu), lead (Pb), zinc (Zn), and cadmium (Cd). These pollutants are of greatest concern in roadway runoff because of their toxicity, water quality concern, and concern for anticipated total maximum daily loads (TDML) limits. All of the samples were picked up within 24 hours of collection and transported to the Environmental Engineering Laboratory, College Park, MD. All analyses were performed according to Standard Methods (APHA et al. 1995). TSS and nutrients analyses were immediately being done; 100 mL of sample was preserved for metal analyses using six drops of concentrated trace level HNO_3 and a 200 mL sample was preserved for TKN analysis using 12 drops of concentrated H_2SO_4. Metal digestion was completed within two weeks and analyses were carried out within 6 months.

4.0 Data Evaluation and Flow Calculations

For each event, three data sets will be collected:

1) Rainfall data in 2 minute intervals

2) Runoff flow rates at 2 minute intervals

3) The concentration of each pollutant for each sampling interval

In order to make the input/output comparison, the pollutant concentration was compared by using the normalized event mean concentration (N-EMC). The N-EMC represents the concentration that would occur if only the runoff from the roadway surface entered the swales and the resulting total storm event discharge was collected in one container. The N-EMC does not consider the dilution effect from rainfall that falls directly on the swales. Therefore, the N-EMC is calculated by dividing the total pollutant mass with the total runoff volume, minus the volume of rainfall that falls directly on the swale.

$$N-EMC=\frac{\int_{0}^{Td} Q(t)C(t)dt}{\int_{0}^{Td} Q(t)dt - As\int_{0}^{Td} i(t)dt} \qquad (1)$$

In this equation, Q is the measured stormwater flow rate, C is the pollutant concentration for each sampling event, T_d is the event duration, dt is the interval between samples, A_s is the total pervious swale area, and i(t) is the rainfall intensity.

In some cases, the calculated value for the N-EMC is negative; this shows that no dilution effect needs to be considered and the value of EMC is sufficient to be used in all of the data analyses.

5.0 Results and Discussion

5.1 Sampling Results to Date

Currently, 6 storm events have been sampled and analyzed (2/25/07, 4/4/07, 5/12/07, 5/16/07, 6/3/07, 7/4/07). One of the storms (5/12/07) was completely captured by the swales since there were no flow outputs from the swales. In some cases, there were issues of getting a full comparison of pollutant data due to technical problems on site and problems with laboratory equipment. Problems that occurred on site include check dam grass dying, check dams mowing, and a broken weir.

5.2 Hydrology Comparison

The rainfall that was received for the 6 events ranged from 0.17 to 0.65 inches (0.43 cm to 1.65 cm), excluding the snow storm event on 2/25/07. Hydrographs were created to observe the effectiveness of the grass swales in reducing the peak flow of each event and the time delay between both initial flow and flow from both swales. From the hydrograph, it can be seen that the direct channel flow mirrors the rainfall hyetograph (Figure 2). High peaks in flow for the direct channel correspond to high peaks in rainfall. In most of the events, significant runoff volume reduction was noted for flows through the swales. For example, in the event of 4 April 2007 (Figure 2), the peak flow from the direct was 45 L/s/ha and was reduced to 4.0 L/s/ha (MDE) and 8.4 L/s/ha (SHA). The ability for the grass swale to reduce the peak flow helps to manage the stormwater. The receiving water body will be less exposed to erosive flow compared to high flows of runoff that may enter it. Comparing both swales, runoff from the SHA swale reached the outlet earlier, apparently due to less contact time in the swale. For this event, the peak flow for the MDE swale was delayed for at least 4 hours and the delay was 5 hours for the SHA swale. However, having a secondary peak in the middle of the event can complicate the performance analysis, since it could affect the infiltration capacities of the swales.

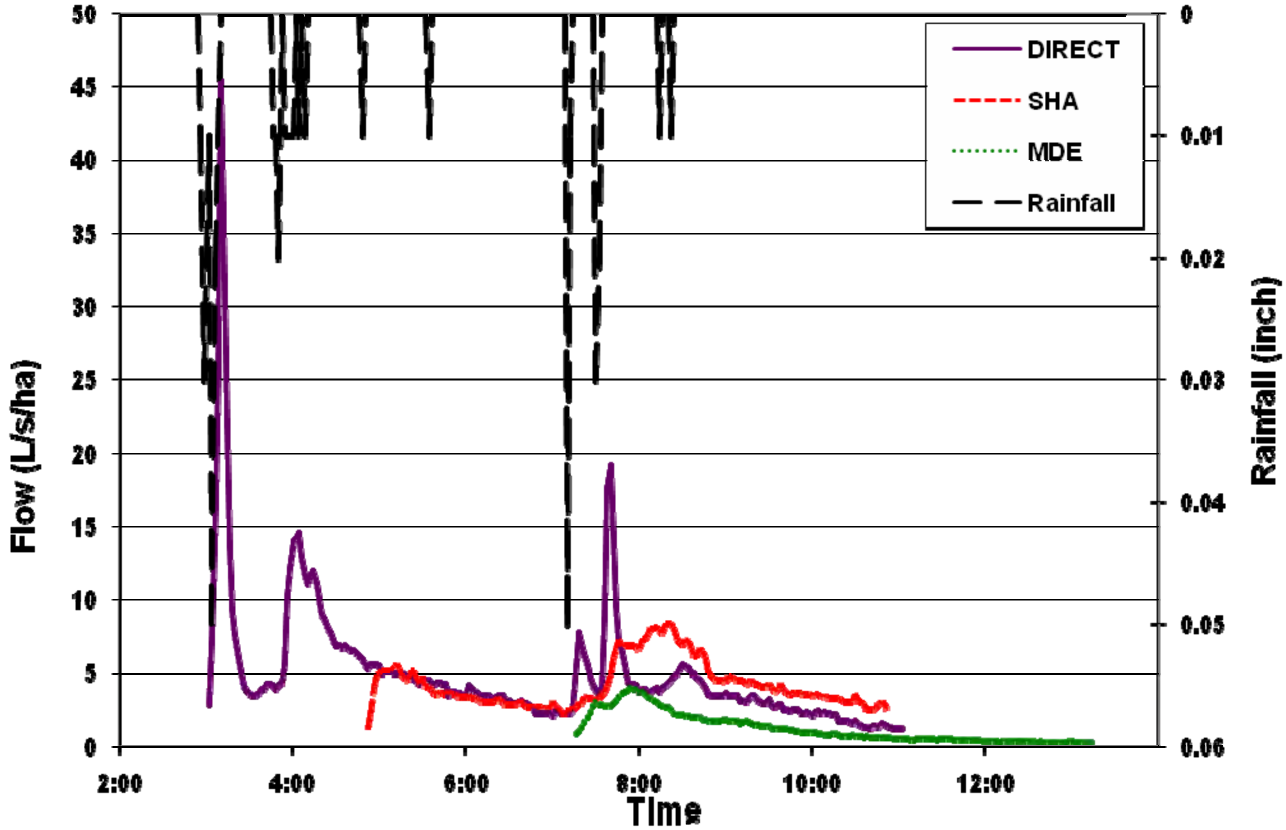


Figure 2. Normalized Flow for 4/4/07 Storm Event at Rt. 32 Swales

Another type of flow behavior is exhibited during storms with complete capture by the swales. This phenomenon will occur when the rainfall intensity is small and not enough to produce flow through the swales, but there is still flow through the direct channel, as demonstrated in Figure 3. In this event, the rainfall was just 0.17 inch (0.43 cm) and lasted for about 7 hours.

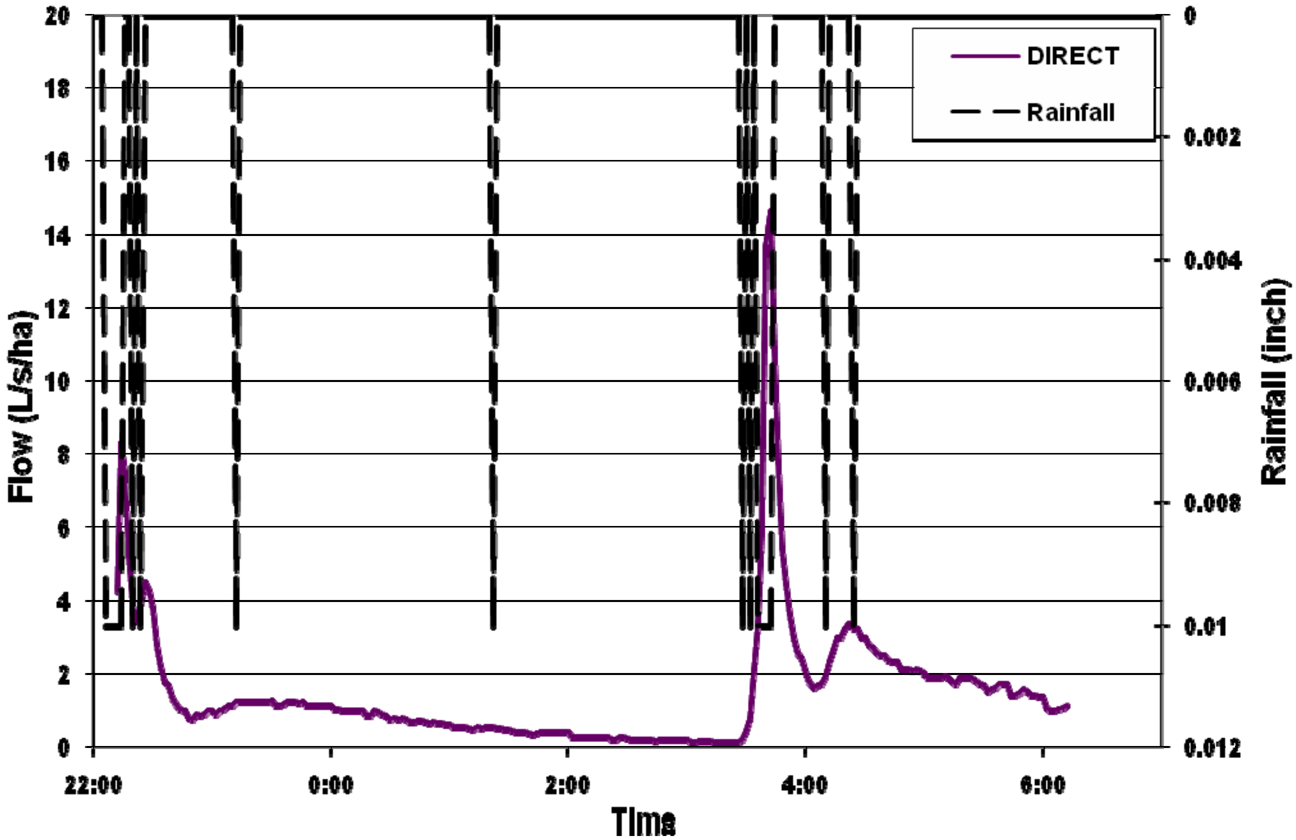


Figure 3. Normalized Flow for 5/12/07 Storm Event at Rt. 32 Swales

In the event of snow, the grass swales did not perform as they would for rain. The output produced more flow than the input because when the snow started to accumulate, the ground was freezing. When the rain started, the snow that covered the swales melted, flowing through the swale together with the runoff. Figure 4 show this phenomenon.

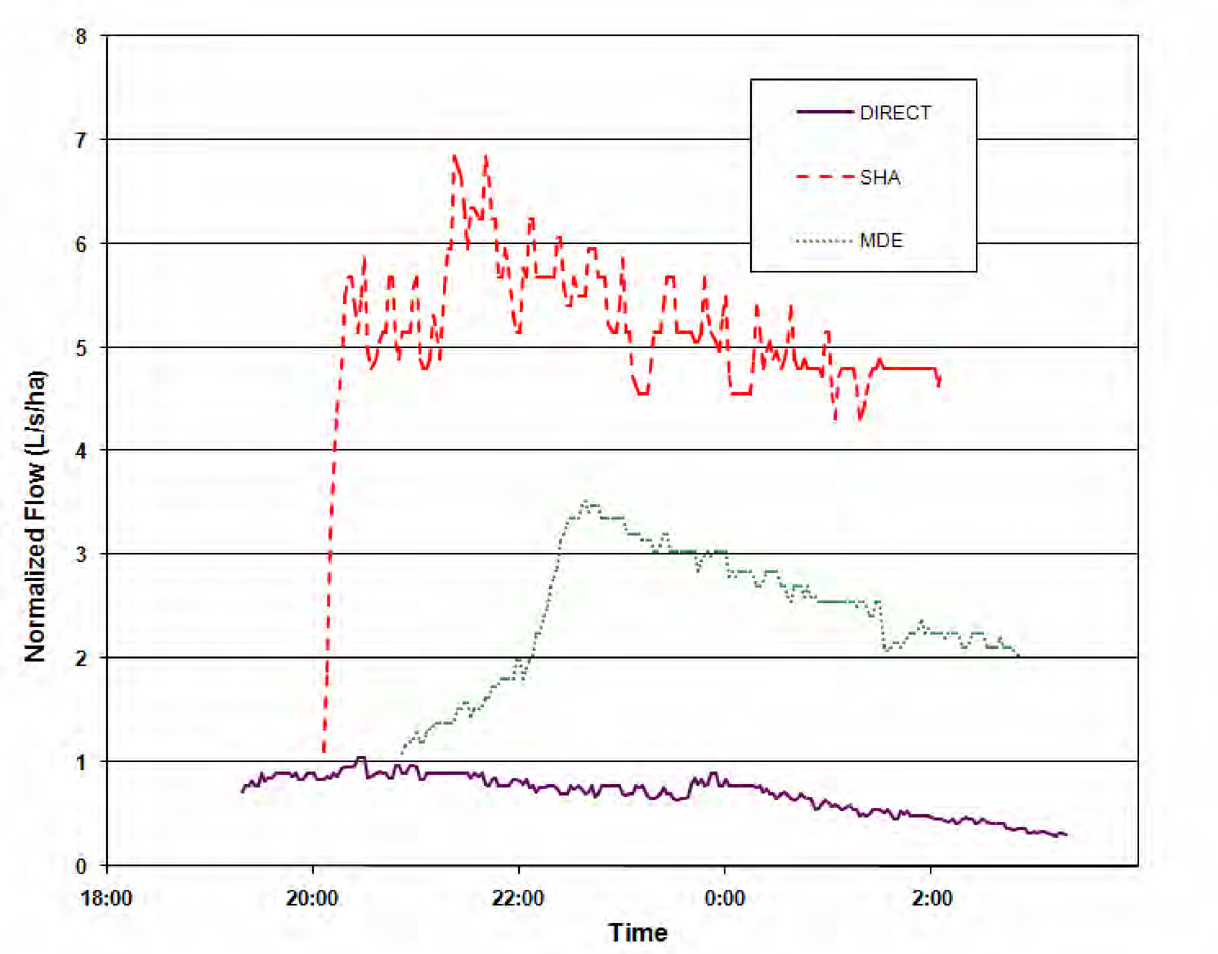


Figure 4. Normalized Flow for 2/25/07 Storm Event at Rt. 32 Swales

In order to have a better understanding about the ability of grass swales to reduce the peak flows, normalized peak flow (N-Peak Flow) probability plot were drawn by ranking the N- Peak Flow observed from each monitoring point from largest to smallest (Figure 5). From the plot, we can see that the N-Peak Flow median for the direct, SHA and MDE are 50 L/s/ha, 30 L/s/ha and 10 L/s/ha, respectively. This shows that there is slight difference in the swale performance. With this limited data, it seems that the pretreatment area does help to reduce the highway runoff.

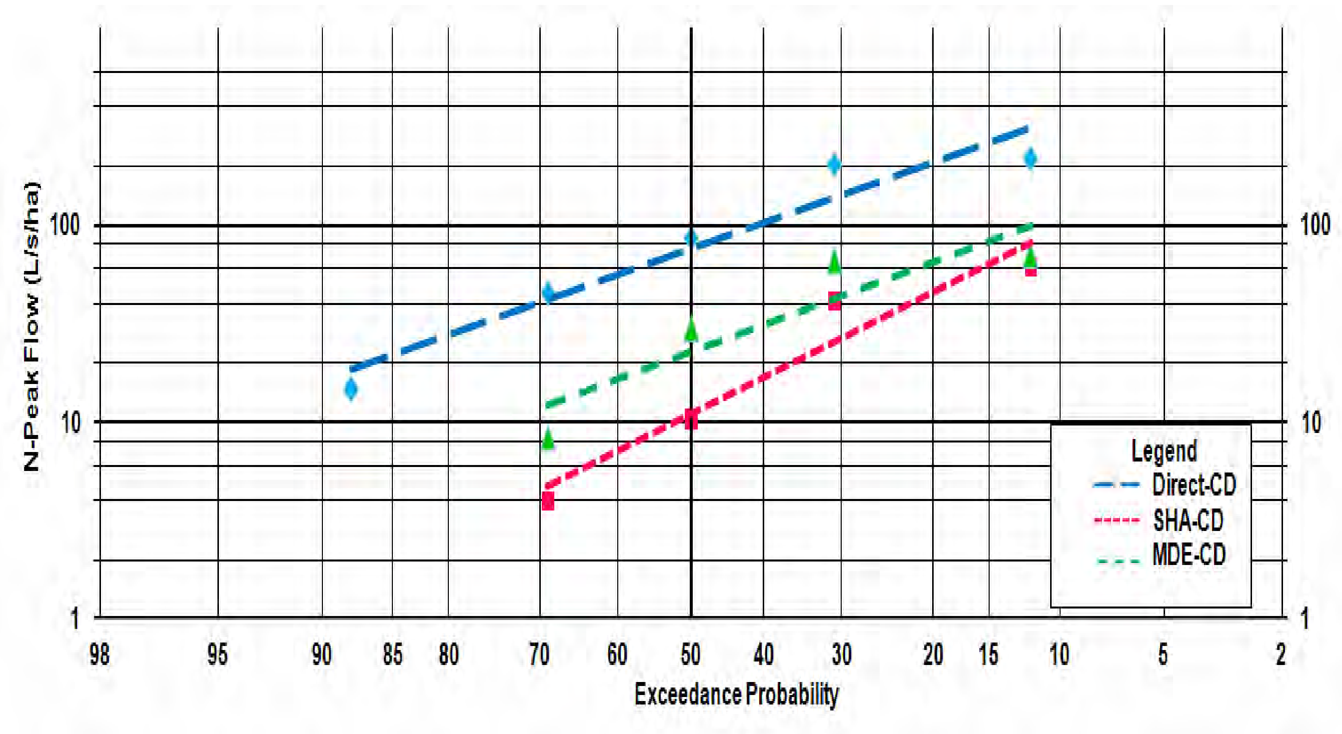


Figure 5. Probability plot for Normalized Flow at Rt. 32 Swales

5.3 Pollutant Observations

Ten pollutants were analyzed for each storm. Figures 6a-6i represent an example of data analyses for the 4/4/07 storm event. Nitrate analyses for this storm were not done due to equipment malfunction.

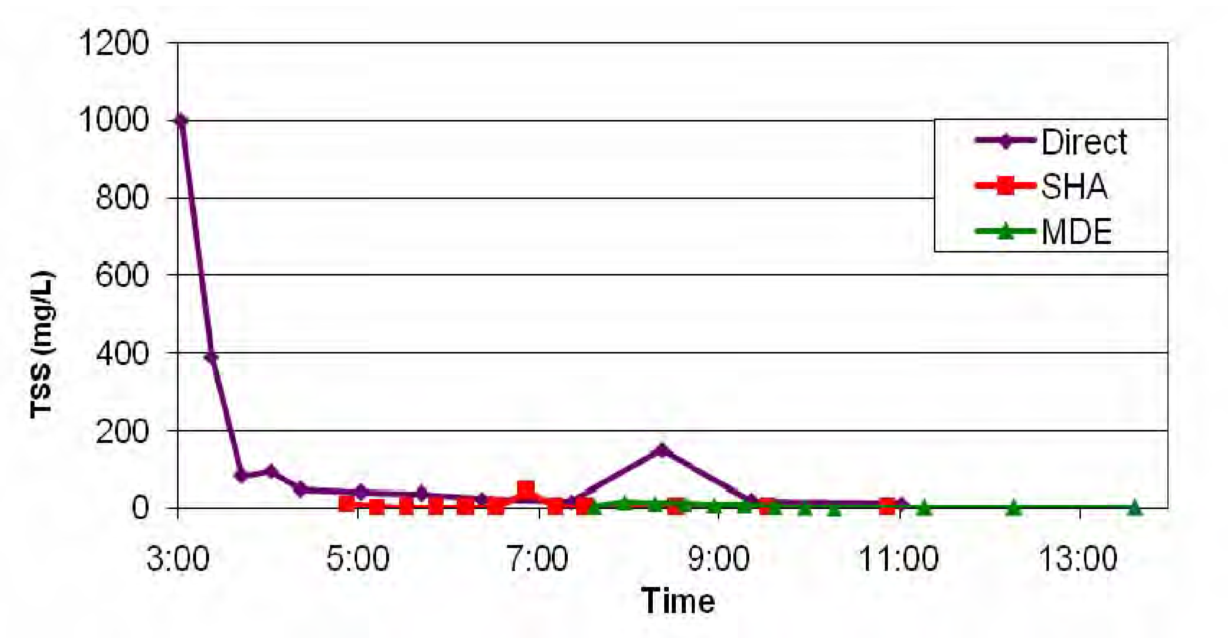


Figure 6a. TSS Concentrations (4/4/07) at Rt. 32 Swales

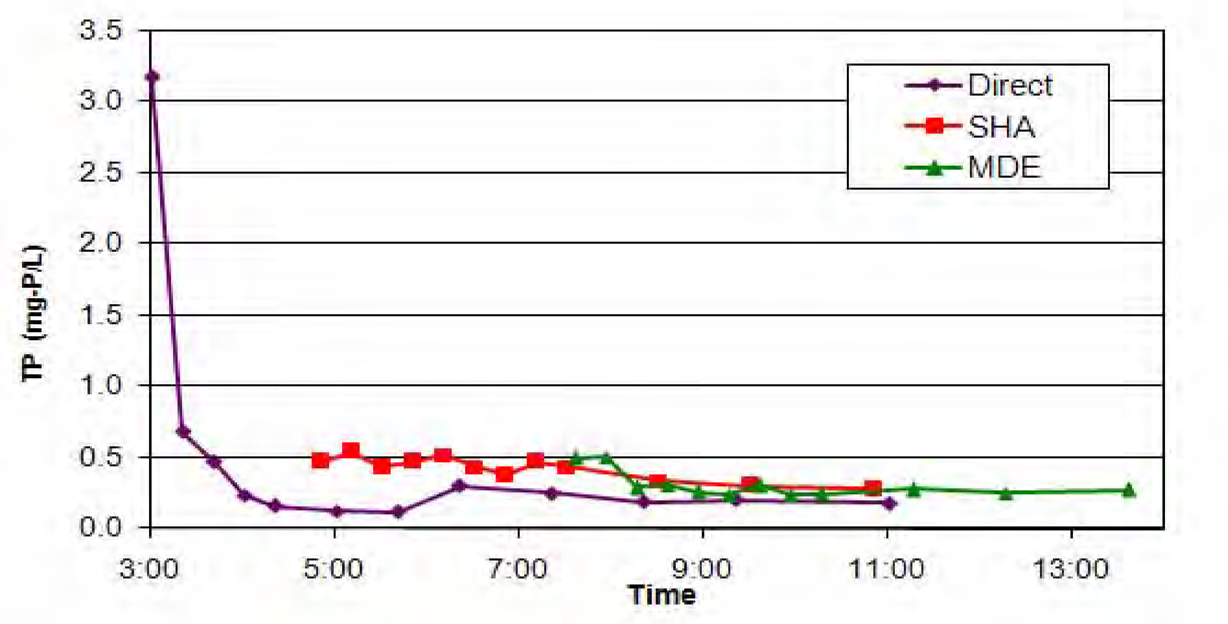


Figure 6b. TP Concentrations (4/4/07) at Rt. 32 Swales

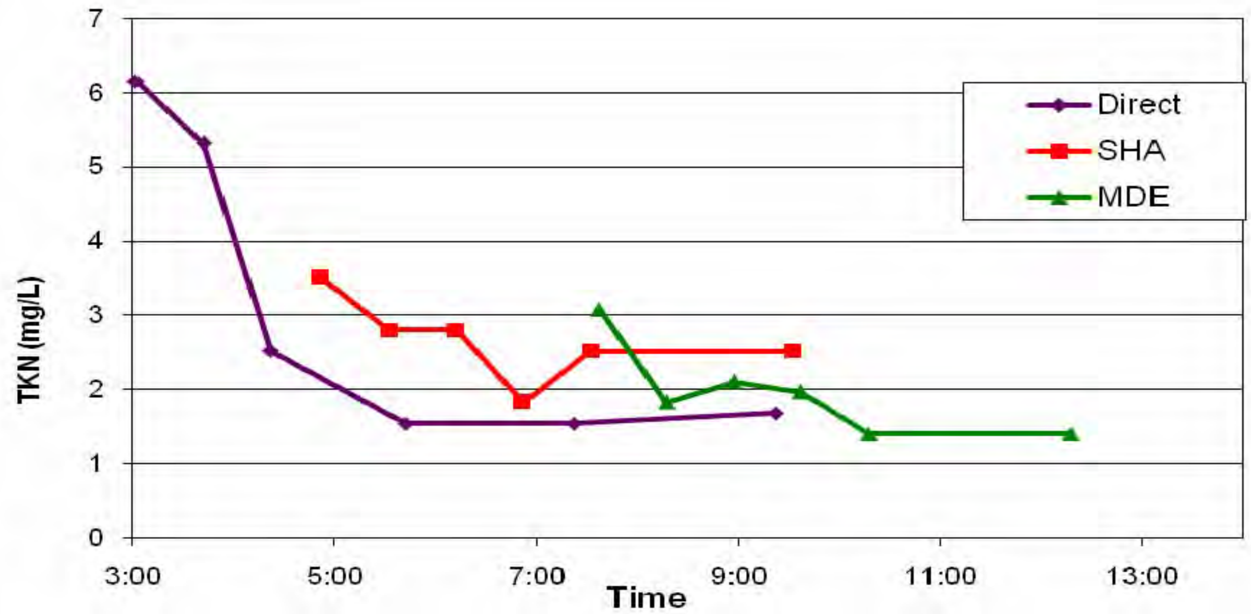


Figure 6c. TKN Concentrations (4/4/07) at Rt. 32 Swales

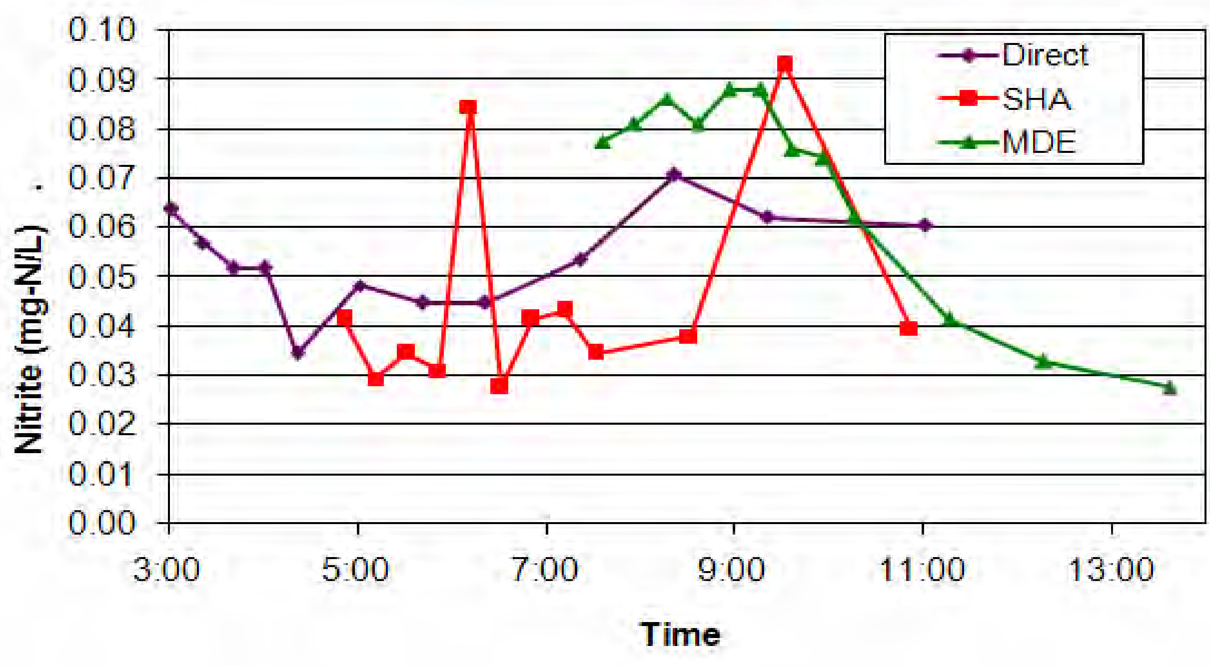


Figure 6d. Nitrite-N Concentrations (4/4/07) at Rt. 32 Swales

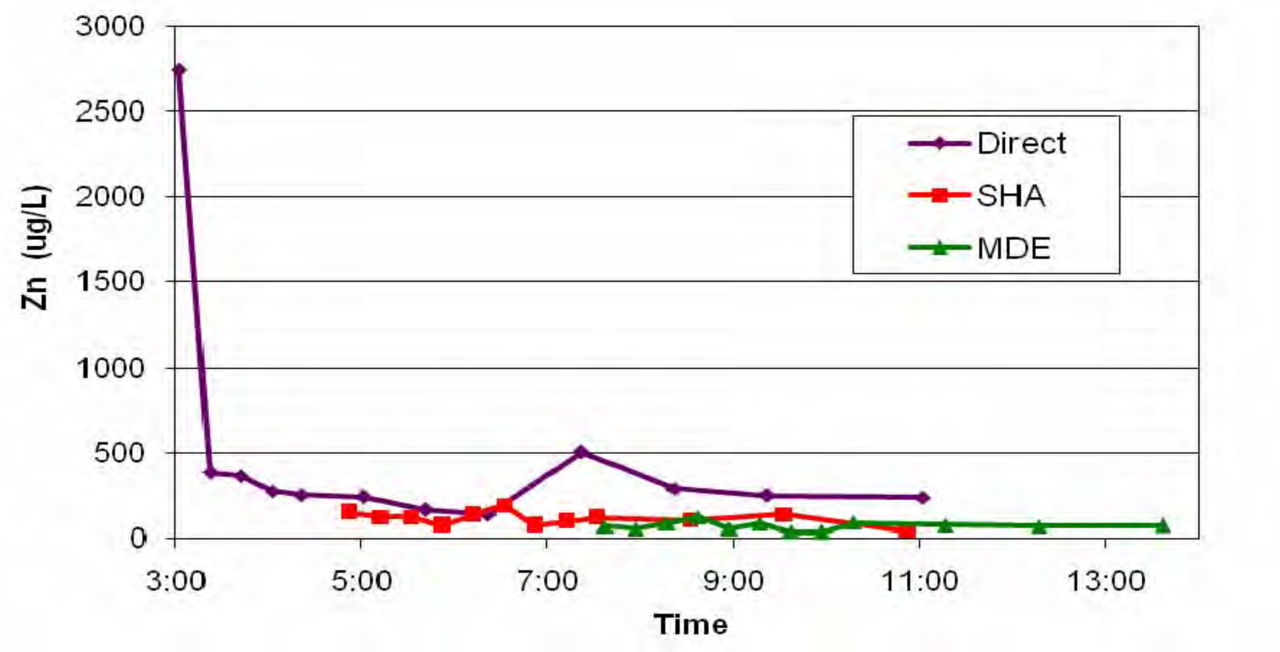


Figure 6e. Zn Concentrations (4/4/07) at Rt. 32 Swales

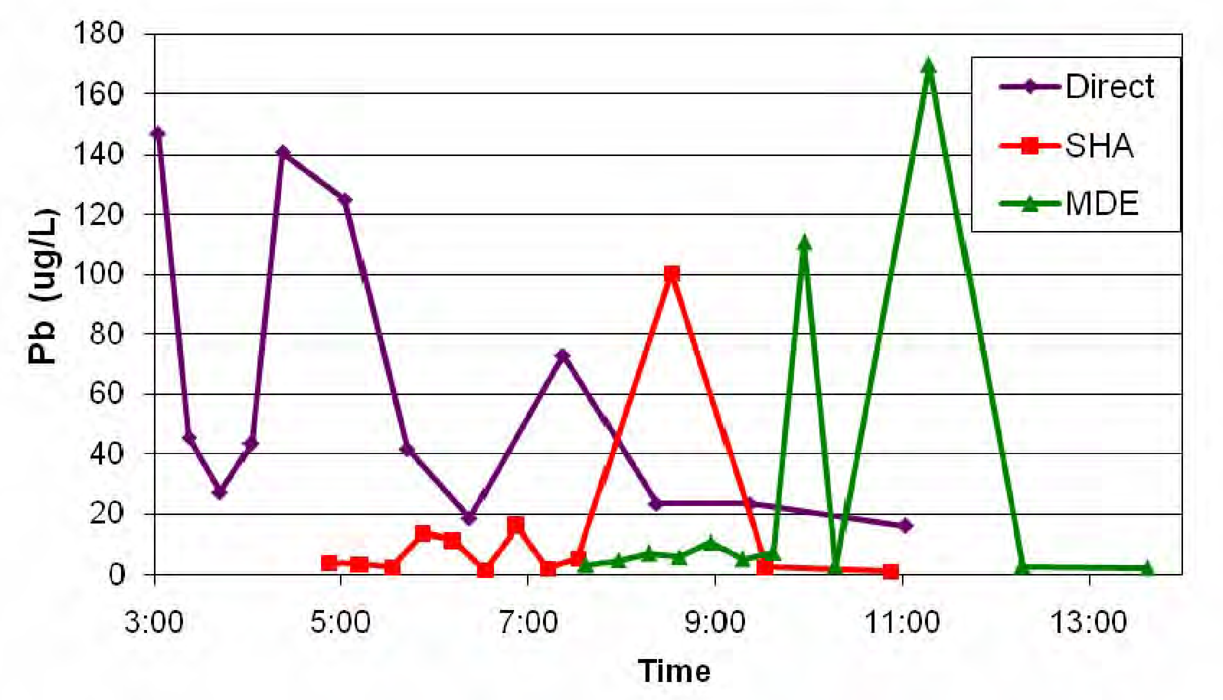


Figure 6f. Pb Concentrations (4/4/07) at Rt. 32 Swales

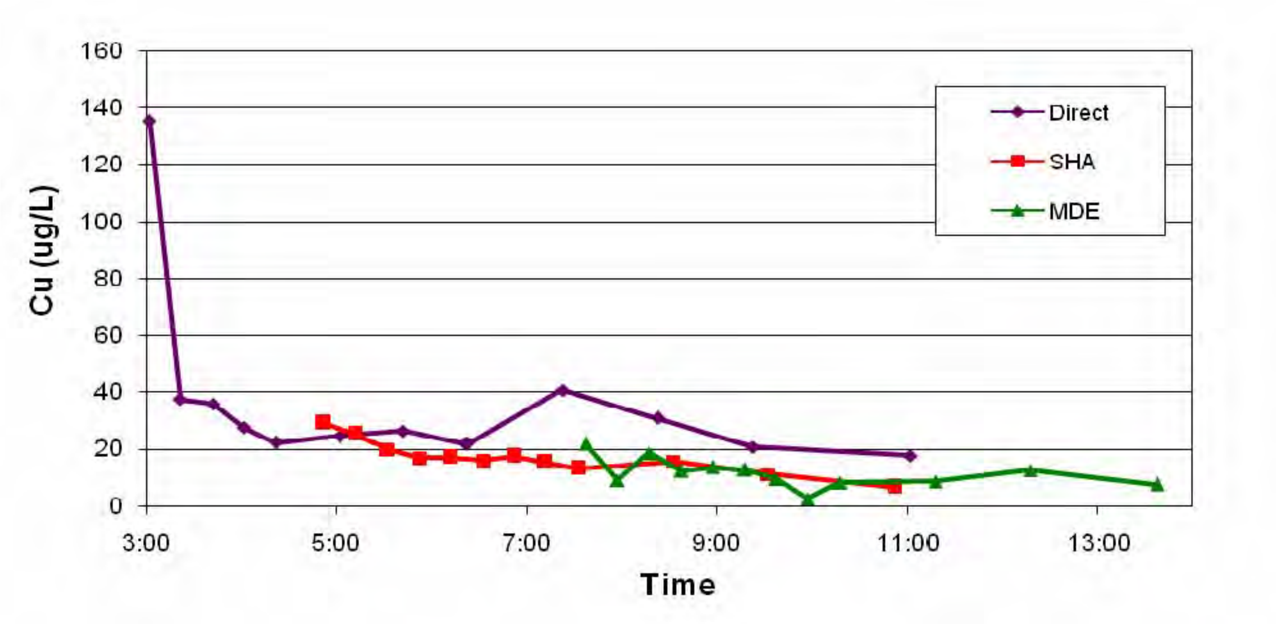


Figure 6g. Cu Concentrations (4/4/07) at Rt. 32 Swales

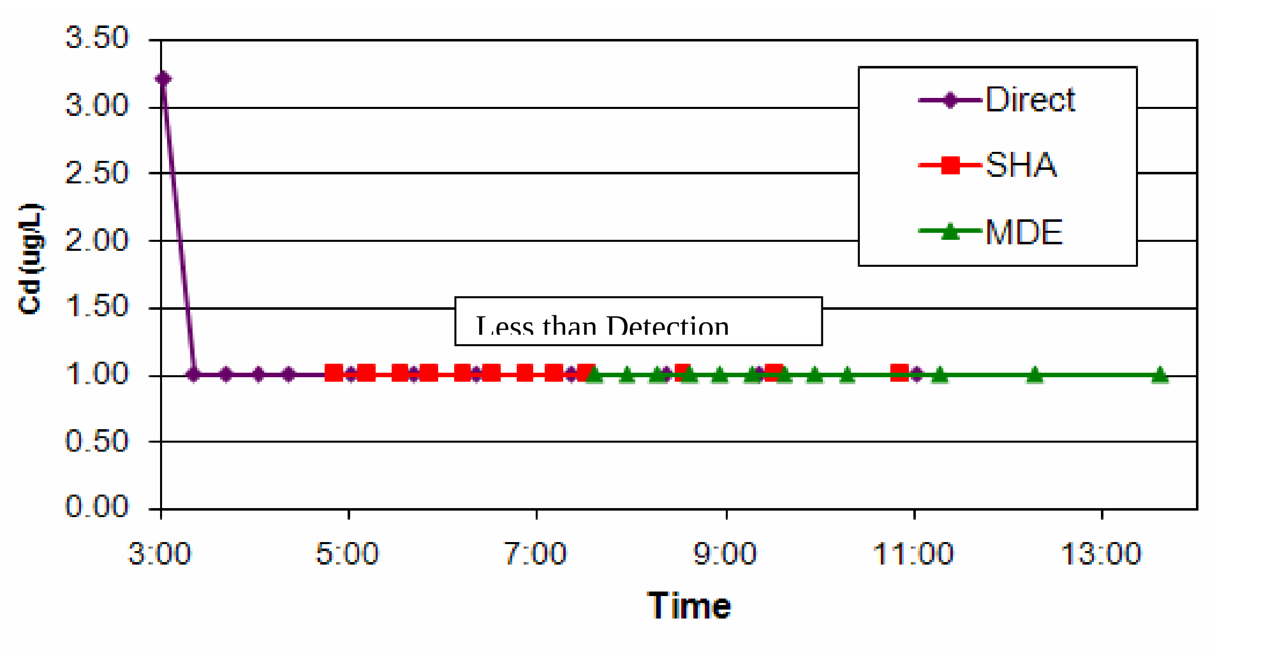


Figure 6h. Cd Concentrations (4/4/07) at Rt. 32 Swales. The detection limit (DL) for cadmium is 2µ/L. Value less than the DL are be plotted as ½ DL.

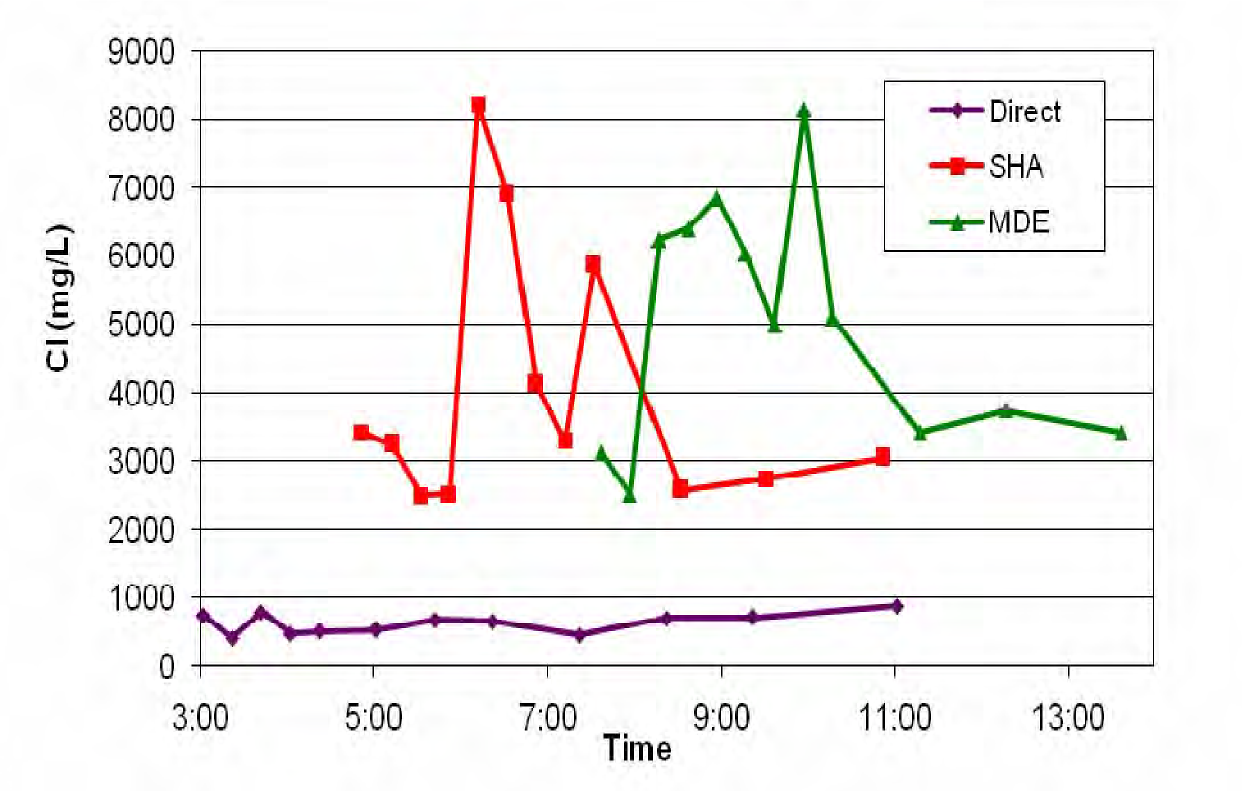


Figure 6i. Cl Concentrations (4/4/07) at Rt. 32 Swales

Each storm has different pollutant concentration shape but the patterns are similar. The differences are due to variability in input flows and pollutant concentrations. In order to analyze these data, two parameters, the N-EMC and Fractional Removal can be used to quantify and compare the effects of grass swales with check dams on highway runoff.

$$\text{Fractional Removal} = 1 - \text{Output Ratio} = 1 - \frac{N - EMC_{swale}}{EMC_{direct}} \qquad (2)$$

The N-EMC's for each pollutant are determined using Equation 1. Table 1 summarizes the N-EMC for each pollutant for each storm event. N-EMC values were used to construct the probability plots, Figures 7a-7j. The previous study data (Stagge 2006) were plotted on the same graph so that comparison could be made between the performance with check dams (Direct-CD, MDE-CD, SHA-CD) and without check dams (Direct, MDE, SHA). The swales with check dams were drawn using dashes and the swales without check dams were drawn using solid lines. All completely captured storm events resulted pollutant loads equal to zero and for these cases, a square with no fill is indicated on the plots.

	TSS (mg/L)			Nitrate (mg/L)			Nitrite (mg/L)			TKN (mg/L)		
Storm event	Direct	SHA	MDE	Direct	SHA	MDE	Direct	SHA	MDE	Direct	SHA	MDE
2/25/2007	7.80	1.80	3.00				0.09	0.06	0.05	0.40	0.54	0.50
4/4/2007	130.00	5.60	7.80				0.05	0.06	0.07	1.40	1.80	0.99
5/12/2007	42.00	0.00	0.00	5.60	0.00	0.00	0.35	0.00	0.00	1.80	0.00	0.00
5/16/2007	180.00	63.00	104.00				0.10	0.20	0.06	2.10	2.50	1.20
6/3/2007	70.00	13.00	41.00	0.95	0.47	0.14	0.03	0.03	0.00	0.43	0.54	0.60
7/4/2007	109.00	29.00	140.00	1.40	0.27	0.36	0.02	0.02	0.03	0.63	1.03	1.10

	TP (mg/L)			Cl (mg/L)			Lead (ug/L)			Copper (ug/L)		
Storm event	Direct	SHA	MDE	Direct	SHA	MDE	Direct	SHA	MDE	Direct	SHA	MDE
2/25/2007	0.32	0.56	0.44	7400.00	5000.00	3500.00	20.00	8.00	14.00	15.00	3.00	4.80
4/4/2007	0.40	0.48	0.31	610.00	4600.00	5200.00	61.00	33.00	25.00	32.00	19.00	22.00
5/12/2007	0.15	0.00	0.00	140.00	0.00	0.00	24.00	0.00	0.00	65.00	0.00	0.00
5/16/2007	0.13	0.95	0.30	17.00	360.00	280.00	500.00	61.00	29.00	140.00	57.00	26.00
6/3/2007	0.22	0.69	0.36	7.00	85.00	120.00	46.00	17.00	15.00	26.00	26.00	19.00
7/4/2007	0.22	0.56	0.42	49.00	33.00	43.00	16.00	6.00	16.00	42.00	14.00	27.00

	Zinc (ug/L)			Cadmium (ug/L)		
Storm event	Direct	SHA	MDE	Direct	SHA	MDE
2/25/2007	160.00	140.00	190.00	1.90	1.08	0.59
4/4/2007	420.00	140.00	76.00	0.31	0.21	0.13
5/12/2007	290.00	0.00	0.00	2.30	0.00	0.00
5/16/2007	2000.00	880.00	130.00	2.30	6.10	2.50
6/3/2007				0.26	0.21	0.21
7/4/2007				0.94	0.16	0.28

Table 1. N-EMC for each pollutant for each storm event at Rt. 32 Swales

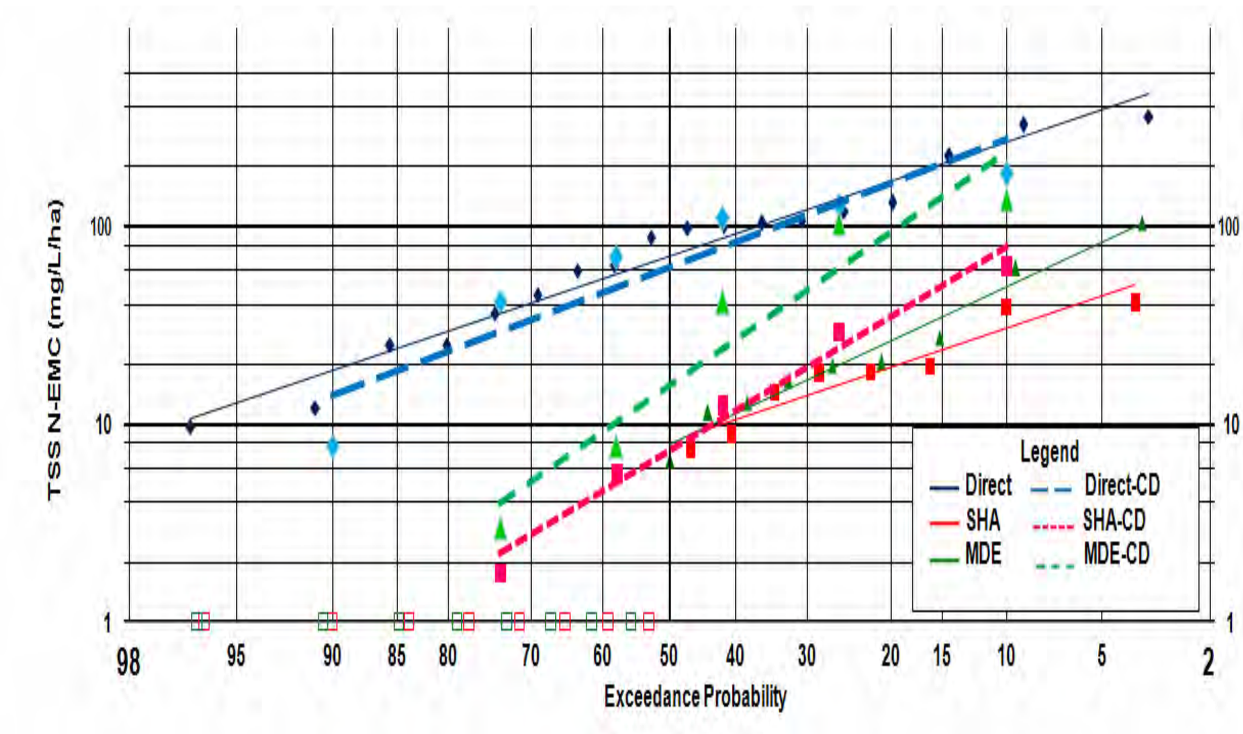


Figure 7a. Probability plot for TSS N-EMCs at Rt. 32 Swales.

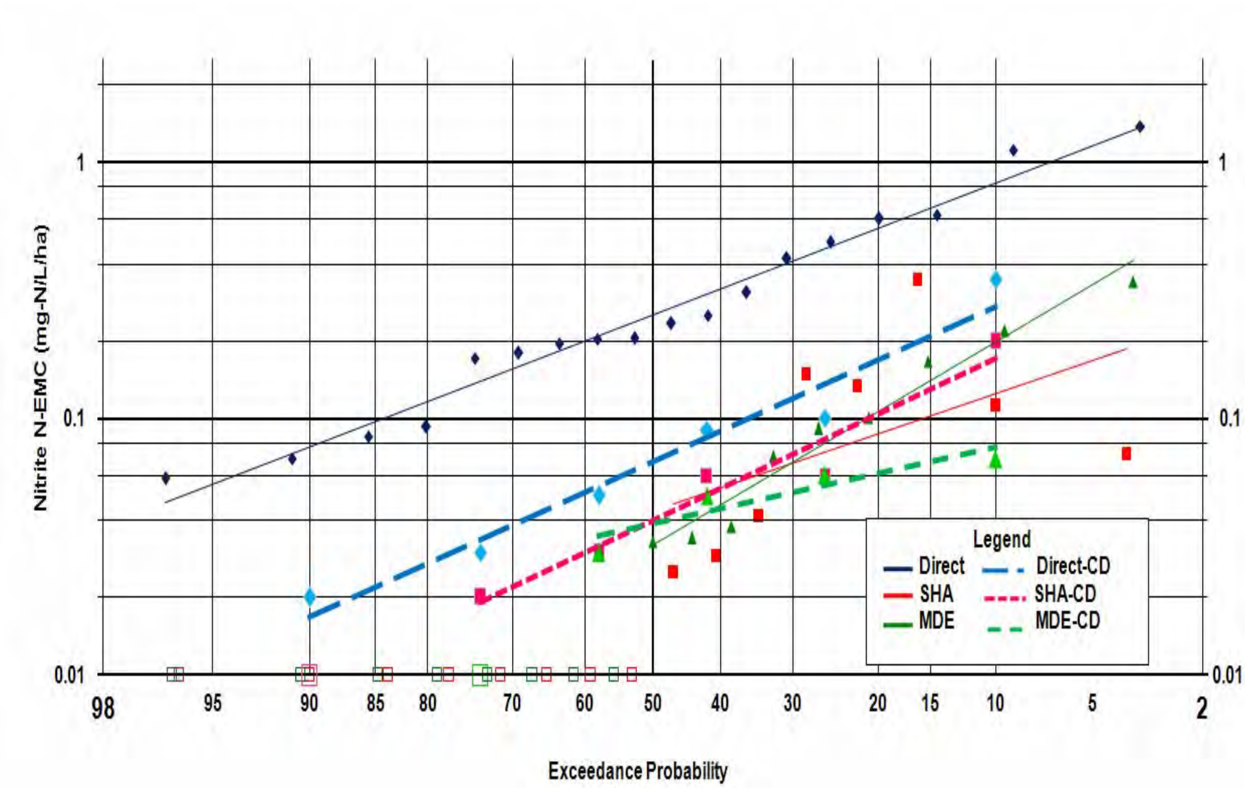


Figure 7b. Probability plot for Nitrite N-EMCs at Rt. 32 Swales.

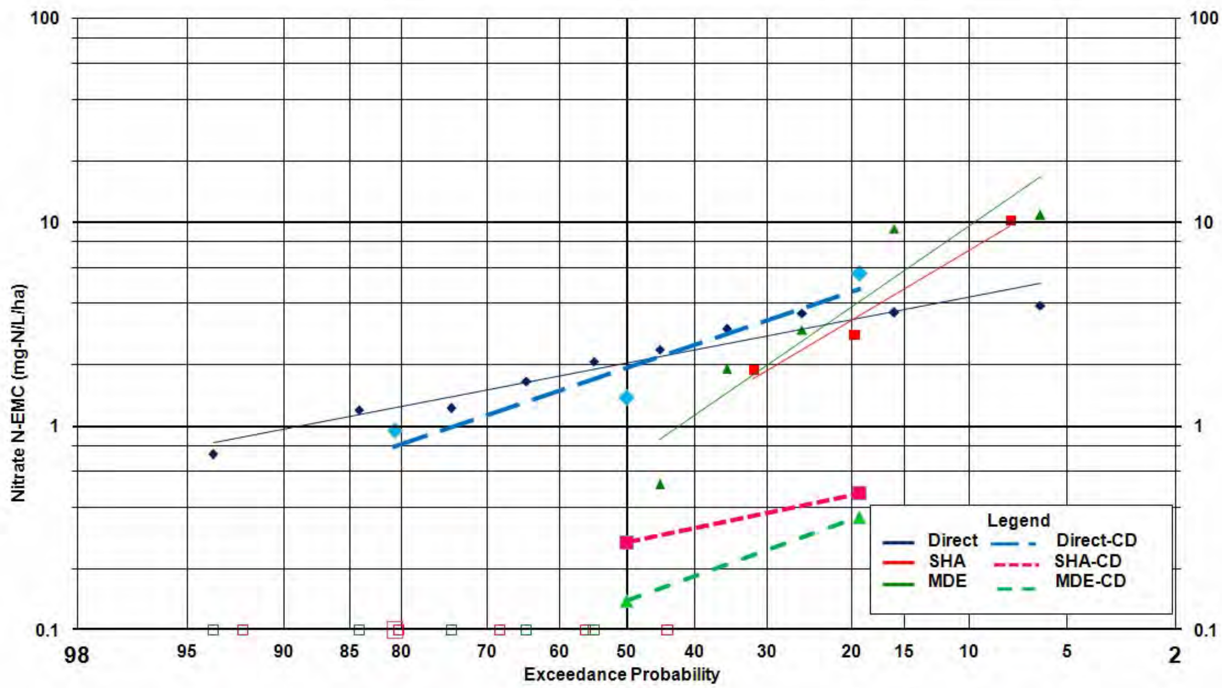


Figure 7c. Probability plot for Nitrate N-EMCs at Rt. 32 Swales.

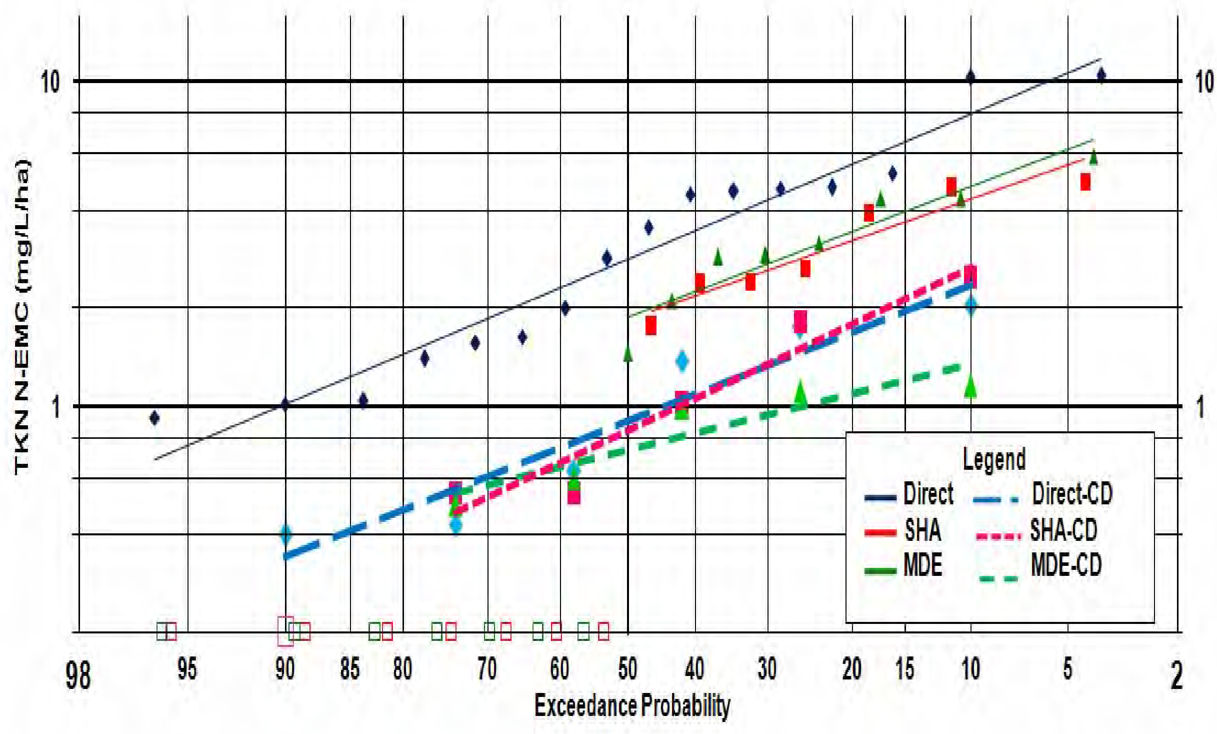


Figure 7d. Probability plot for TKN N-EMCs at Rt. 32 Swales.

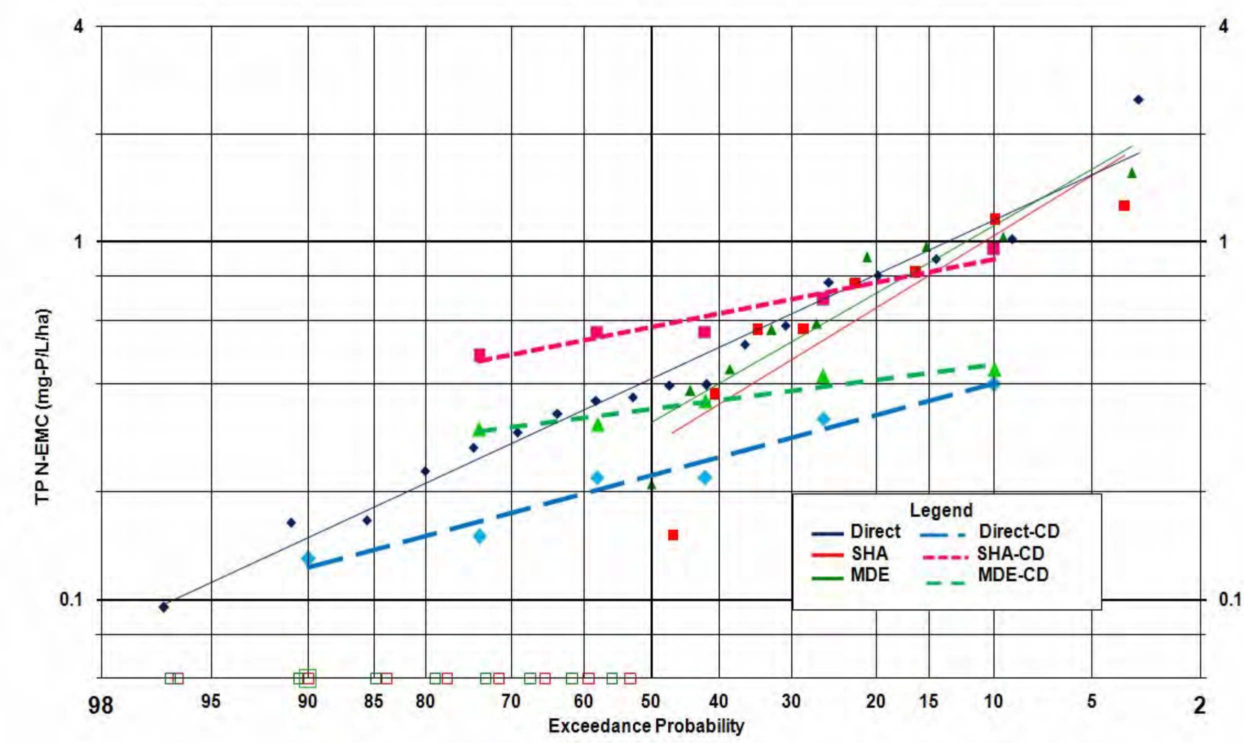


Figure 7e. Probability plot for TP N-EMCs at Rt. 32 Swales

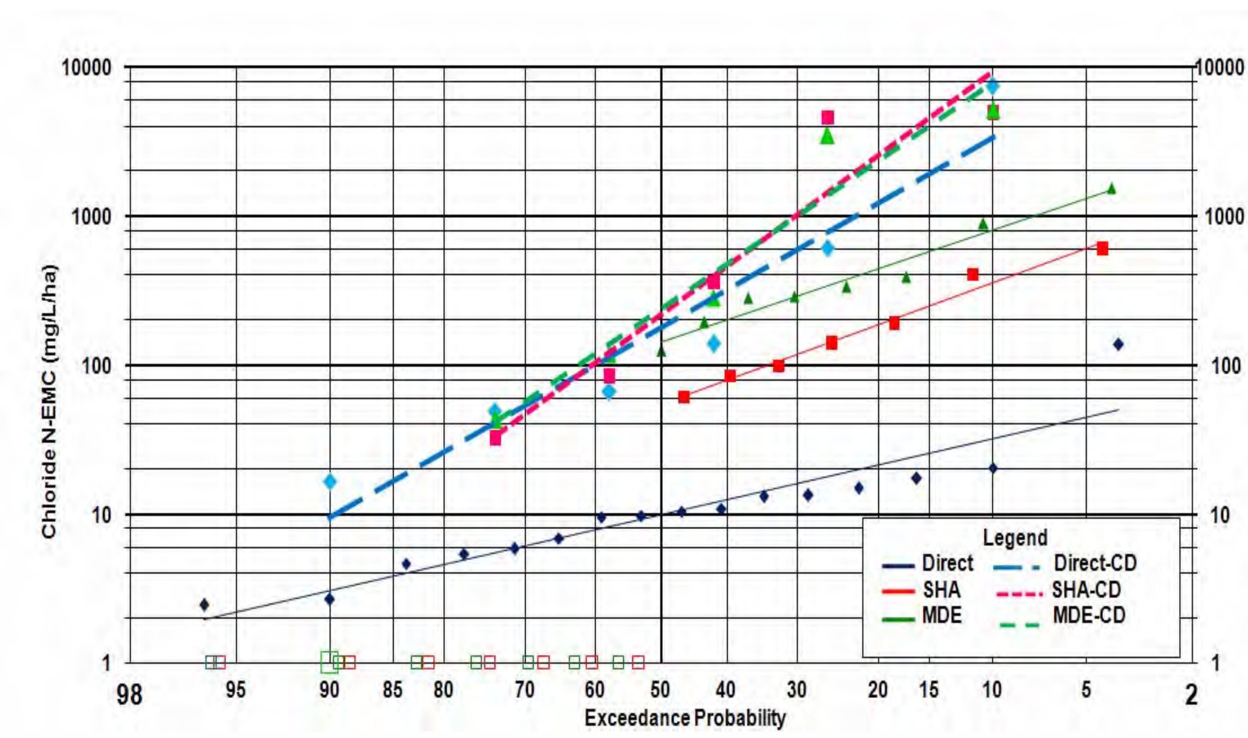


Figure 7f. Probability plot for Chloride N-EMCs at Rt. 32 Swales.

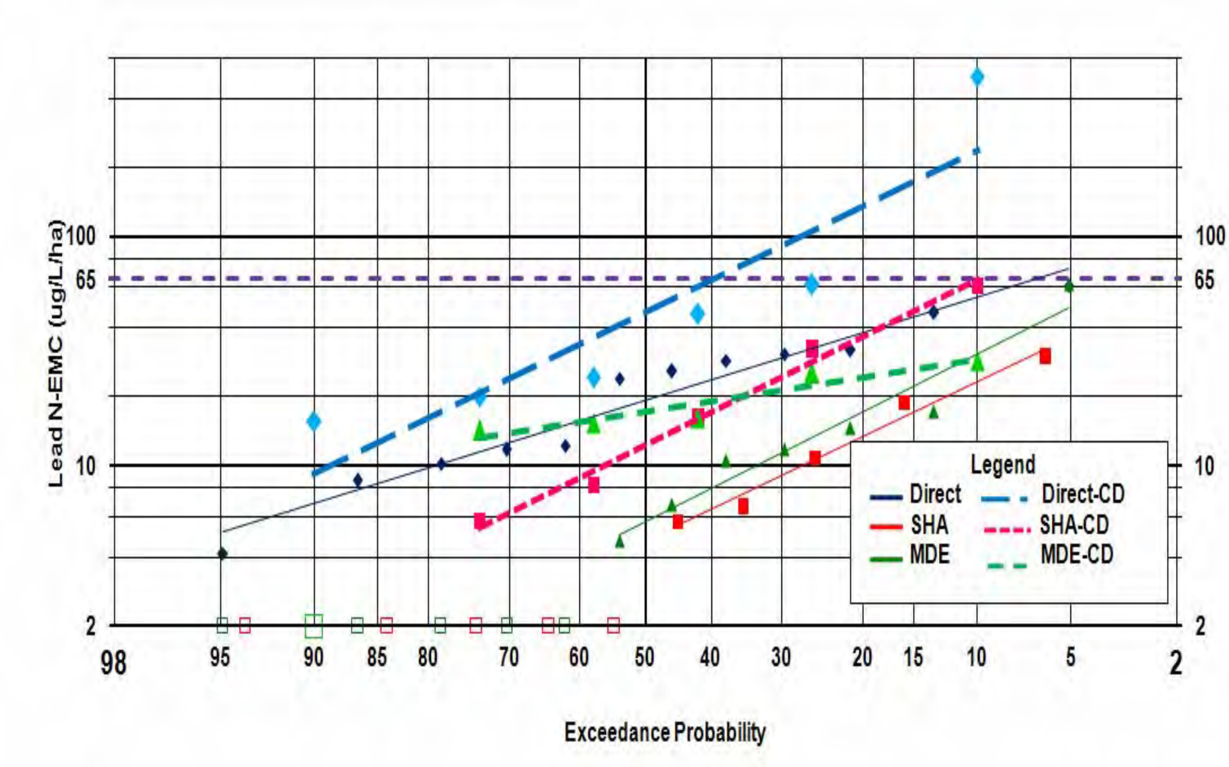


Figure 7g. Probability plot for Pb N-EMCs at Rt. 32 Swales.

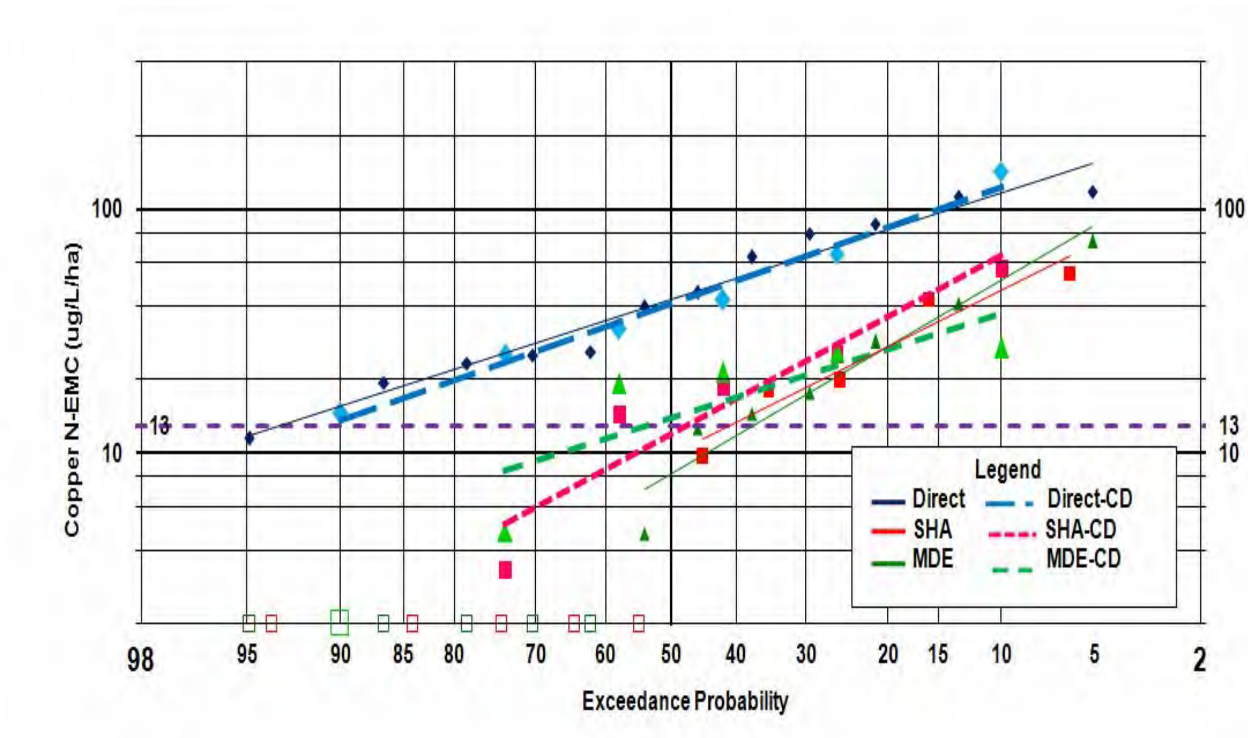


Figure 7h. Probability plot for Cu N-EMCs at Rt. 32 Swales.

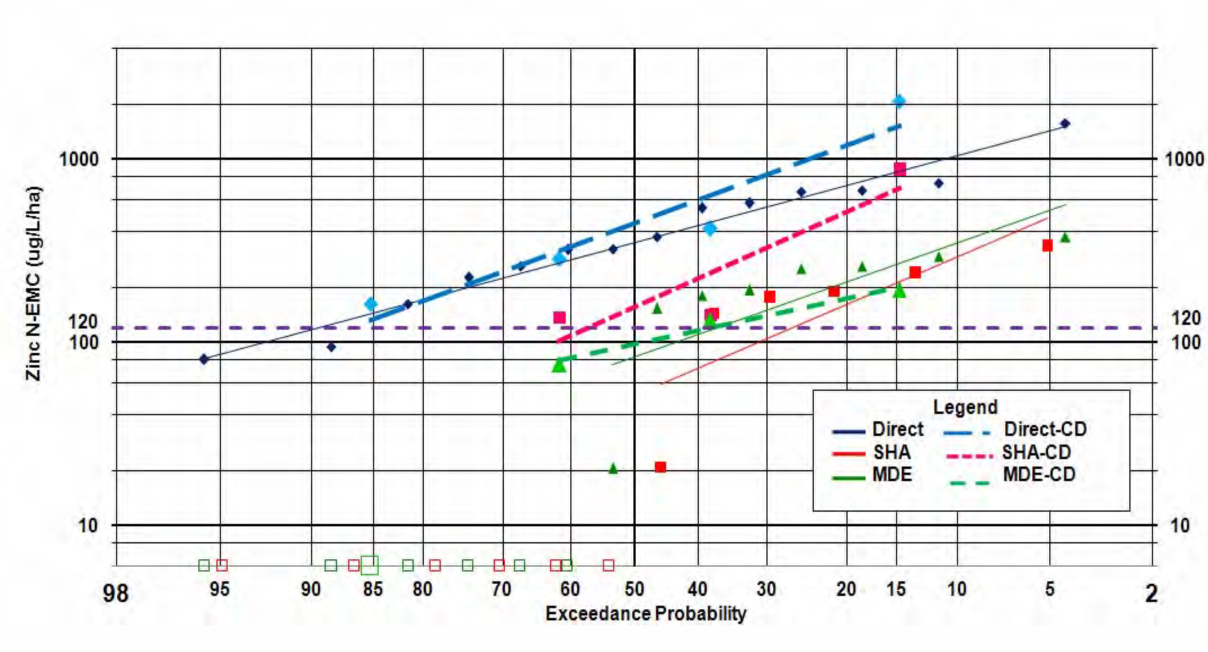


Figure 7i. Probability plot for Zn N-EMCs at Rt. 32 Swales.

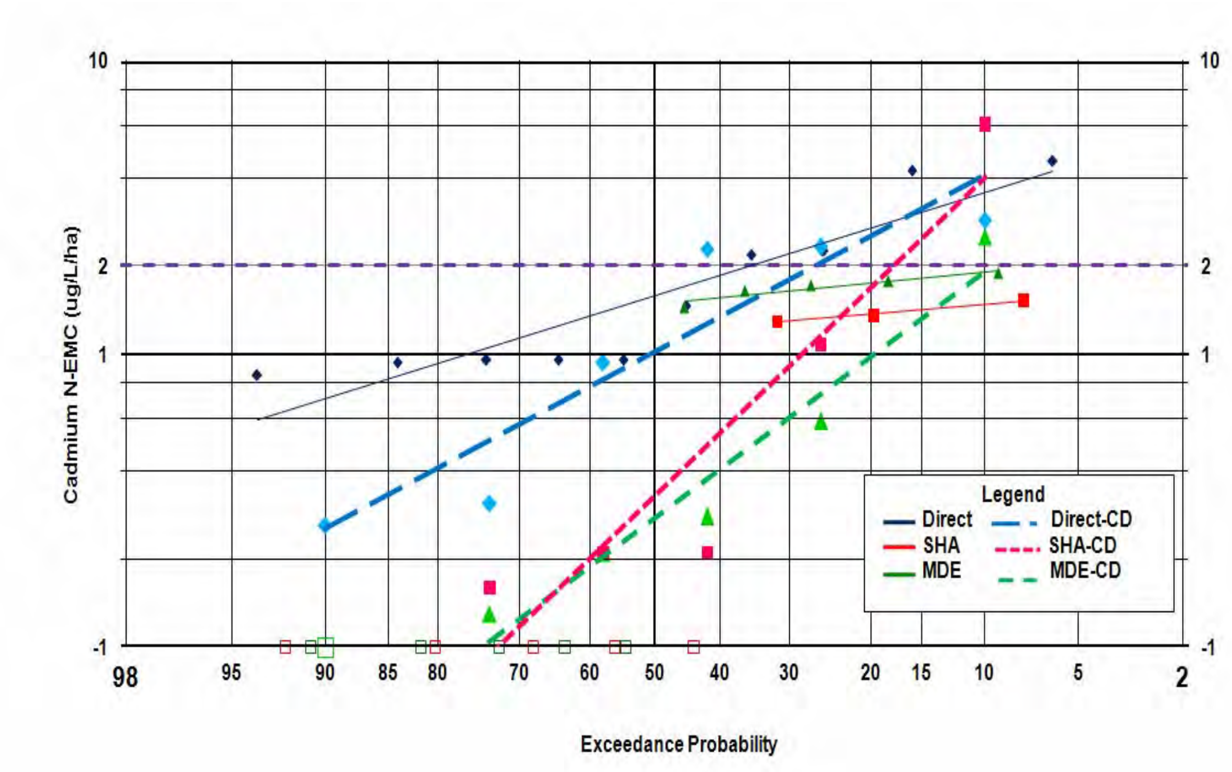


Figure 7j. Probability plot for Cd N-EMCs at Rt. 32 Swales.

The N-EMC varies over a wide range for each pollutant and it represents the flow weighted average concentration of each pollutant for each event. The difference between the input and output N-EMC represents the ability of the grass swale and check dams to reduce the pollutants. The median and percent removals for each pollutant are showed in Table 2. Those medians are based on the probability plots from Figures 7a-7j.

	TSS (mg/L)			Nitrate (mg/L)			Nitrite (mg/L)			TKN (mg/L)		
	Direct	SHA	MDE	Direct	SHA	MDE	Direct	SHA	MDE	Direct	SHA	MDE
Median	60.00	35.00	8.00	1.40	0.27	0.14	0.07	0.04	0.04	0.09	0.08	0.07
% Removal		42.00	90.00		81.00	90.00		43.00	43.00		11.00	22.00

	TP (mg/L)			Cl (mg/L)			Lead (ug/L)			Copper (ug/L)		
	Direct	SHA	MDE	Direct	SHA	MDE	Direct	SHA	MDE	Direct	SHA	MDE
Median	0.25	0.58	0.35	170.00	200.00	210.00	50.00	12.00	18.00	40.00	12.00	14.00
% Removal		-130.00	-40.00		-18.00	-24.00		76.00	64.00		70.00	65.00

	Zinc (ug/L)			Cadmium (ug/L)		
	Direct	SHA	MDE	Direct	SHA	MDE
Median	450.00	160.00	100.00	1.00	1.00	1.00
% Removal		64.00	78.00		0.00	0.00

Table 2. Median and Percent Removal for each pollutant at Rt. 32 Swales

As mentioned above, characteristics of each storm event vary and therefore, the use of fractional removal in runoff management has several drawbacks because it is not giving a clear picture on what is happening on the site. For example, high percent pollutant removal does not necessarily indicate an effective treatment practice because this parameter also depends on the input and vice versa. However, having a negative value for percent removal shows that the swale is exporting the pollutant into the runoff. This phenomenon can be seen for total phosphorus and for chloride.

Total Suspended Solid (TSS)

Summary statistics for the N-EMC from Table 2 shows differences between the mean values of the direct input and both swales outputs. This suggests that the swales act as filters and are effective for TSS removal. For comparison purposes, using a TSS concentration of 20 mg/L is use as a reference, the inflow concentration will theoretically exceed 20 mg/L during 85% of the storms but with check dam swales, the MDE swale exceeded 20 mg/L TSS during 45% of storm events and the SHA only exceeded 20 mg/L TSS during 30% of storm events. This result is actually higher than the previous findings since previously the MDE swale only exceeded 20 mg/L TSS during 28% of storm events. However, in the previous study (without the check dams), both swales behaved similarly but with the check dams, it seems that the swales show different performance of removing the TSS. SHA seems to works better than the MDE swale, but results are still preliminary.

Nitrogen (Nitrate, Nitrite, TKN)

Nitrogen is one of the nutrients that causes accelerated algal production. Nitrogen sources are derived from decomposing organic matter, animal waste, fertilizers and atmospheric deposition. Statistically, it is shown that the median percent removals decrease from nitrate to nitrite, and followed by TKN, ranging from 89% to 22% removal (N-EMC, Table 2). From the probability plot, significant reduction of nitrite is noted for both swales. Unfortunately, currently the data for nitrate is available only for 3 storm events. Interestingly, the results for these three pollutants shows that the MDE swales with check dams tend to perform better than the SHA swales with check dams. On the other hand, Stagge (2006) found that the SHA was better than the MDE swale. Having check dams together with the pretreatment area on the swales tend to show some improvement in the pollutant removal for nitrogen.

Total Phosphorus (TP)

All swales tend to export phosphorus into the runoff. Check dams on the swale do not show any improvement to water quality for phosphorus content.

Chloride (Cl)

The outputs of both swales have higher values of chloride than the input. This could be due to high amount of salt being added during the winter. The salt is slowly diluting out in every storm event. Both MDE-CD and SHA-CD swales do not show any differences in performance compared to the MDE and SHA swales in the previous study (Stagge 2006).

Metals (Zinc, Lead, Copper, Cadmium)

Monitoring metal concentrations in the runoff is important because heavy metals have toxic effects on aquatic life and humans. The aquatic toxicity limit establish by the Maryland Department of the Environment acute and chronic aquatic toxicity limit (MD Department of Environment 2005) is use as a guideline and it is plotted on the probability plots as a purple dashed line.

Among these four metals, zinc generally has the highest concentration and is found primarily in dissolved form (Dean et al. 2005). The toxicity limit for zinc is 120 μg/L (MD Department of Environment 2005). The probability plot shows that 85% of storm events will produce highway runoff that exceeds the limit. However, after treatment with check-dam swales, only 60% of storm events will exceed the limit of 120 μg/L. The MDE-CD swale shows better removal than the SHA-CD swale. This is different as compared to the previous results. Check dams on the swale provide extra retention time for the runoff and therefore, it could allow more time for adsorption and the pretreatment area apparently assists in the sedimentation of particulate - bound zinc.

The toxicity limit for lead is 65 µg/L (MD Department of Environment 2005) and 40% of storm events will exceed this limit. However, having swales to treat this runoff, the discharge criterion for lead is always achieved since none of the storm events exceeded this limit.

The results for swale removal capability for copper are similar to those from the previous study (Stagge 2006). Swales help to reduce the number of storm events that will exceed the toxicity limit of 13 µg/L (MD Department of Environment 2005), from 90% of the storm events to 50% of the events.

The toxicity limit for cadmium is 2 µg/L (MD Department of Environment 2005). The SHA swale with check dams exceeds the limit for 20% of the storm events compared to none when no check dams were installed. The swale performance is consistent for both studies.

6.0 Conclusions

At this point of the research project, 6 storm events can not provide an overall performance evaluation of the swales with check dams. However, from the results, it shows that the grass swales improve the water quality of the runoff and help to reduce the runoff peak. Both swales were effective in reducing all the pollutants except for total phosphorus and chloride. Compared to the previous study (Stagge 2006), the pretreatment area prior to the grass swale appears to make some difference in reducing the pollutant concentrations. The swale with the pretreatment area tends to have a better pollutant removal performance. Having check dams on this swale could contribute to that effect. More data are needed to evaluate this statistically.

7.0 References

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APPENDIX F:

Literature Review: BMP Efficiencies for Highway and Urban Stormwater Runoff

By University of Maryland

Literature Review: BMP Efficiencies for Highway and Urban Stormwater Runoff

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Project Date: September 26, 2007

The field of stormwater management for highway and urban areas is growing and changing rapidly. New regulations, increased environmental concern, and new technologies continue to alter the landscape. While the challenges are greater, more tools are also becoming available and more fundamental and practical knowledge about these tools is being collected.

The Existing Toolbox

Several stormwater technologies, or best management practices (BMPs), have advanced to the forefront of stormwater management through Low Impact Development initiatives. A list of common technologies is presented in Table 1. These technologies address both excess runoff flow and water quality.

Bioretention	Permeable Pavement
Grass Swales	Manufactured Filters
Tree Boxes	Green Roofs
Soil Enhancement	Stormwater Wetlands
Street Sweeping	Stormwater Ponds
Level Spreaders w/Filter Strips	Rain barrels / Cisterns Water Reuse

Table 1. Existing technologies for management of stormwater from roadway and developed lands

Reporting Parameters for Stormwater BMPs

Because of the considerable number of variables affecting BMP performance, a systematic and consistent method for reporting BMP monitoring data is necessary. By eliminating or citing all extraneous variables in performance, it is possible to compare data from multiple storms and BMP locations, thereby allowing trends in design and performance to be determined. To this end, the Urban Water Resources Research Council of the American Society of Civil Engineers developed a database software package called the National Stormwater BMP Database (Urbonas 1995, Clary *et al.* 2002). The stated purposes of this database are (1) to define a standard set of data reporting protocols for use with BMP monitoring efforts; and (2) to assemble and summarize historical BMP study data in a standardized format (Clary *et al.* 2002). The National Stormwater BMP Database can be accessed online at *www.bmpdatabase.org*. The first version of the BMP Database contained performance data on 71 BMPs. These initial 71 BMPs underwent a quality assurance screening process to validate the monitoring methods of the studies. Currently, the Database has performance data on 247 BMPs.

By explicitly stating operating variables, it is possible to draw conclusions about the effects of design criteria and to explain differences between BMP efficiency studies. While stating experimental design parameters presents the user with a better representation of BMP conditions, in order to fully understand the effects and efficiency of a BMP treatment technology it is important to analyze the data using multiple reporting methods. Each method provides a different measure of performance, and together they can offer an effective overall test on the effects of a BMP swales. If possible, it is preferable to use paired inflow and outflow sampling to provide storm specific data.

The most common methods of reporting data uses paired Event Mean Concentrations (EMC). The EMC is calculated as:

$$EMC = \frac{\int_0^{T_d} CQdt}{\int_0^{T_d} Qdt} \qquad (1)$$

The EMC represents the concentration that would result if the entire storm event discharge were collected in one container. EMC weights discrete concentrations with flow volumes; therefore it is generally used to compare pollutant concentrations among different events.

A percent removal is calculated using the formula:

$$PR = \frac{V_{in}\, EMC_{in} - V_{out}\, EMC_{out}}{V_{in}\, EMC_{in}}\, x100 \qquad (2)$$

Where PR represents percent constituent load removed, V_{in} represents storm runoff volume inflow into the BMP, EMC_{in} represents event mean concentrations of inflow volume, V_{out} represents storm runoff volume outflow from the BMP, and EMC_{out} represents event mean concentrations of outflow volume. Descriptive statistics such as mean, median, standard deviation, and coefficient of variation for percent removals allow a measure of average efficiency. This method has drawbacks, however, because in the case of a storm event with relatively low inflow concentrations, the percent removal would be low despite relatively clean outflow. In a similar sense, in the case of a high concentration entering the swale, there is a possibility for outflow from the swale to have constituent concentrations much higher than water quality target values, yet show high removal percentage. Because of this, it is also important to determine descriptive statistics, such as mean and standard deviation, for the EMC data without transformation. Tests such as the Student's t-test can be performed on both of these data sets to determine the significance of the BMPs paired removal percentage or EMC distribution.

The Student's t-test assumes a normal distribution for EMC values. However, studies of influent and effluent EMCs from BMPs have been shown to follow a lognormal distribution (Van Buren *et al.* 1997, Harremones 1988). This means that nonparametric tests on EMCs, which do not specify a distribution, may be necessary to fully determine the distribution. Nonparametric tests, such as the Mann-Whitney and Kolmogorov-Smirnov tests, should also be performed and reported in BMP efficiency studies.

Finally, BMP performance data should be presented in a graphical manner. These graphical representations should include time series scatter plots of influent and effluent concentrations, graphical nonparametric analysis such as box-and-whisker plots, and normal probability plots of log transformed water quality data showing influent and effluent EMCs (Strecker *et al.* 2001). While the latter two graphical methods do not show the pairing between influent and effluent concentrations for specific storm events, they do allow an overall comparison between the distributions of EMC values.

Logarithmic Data Plotting Another method for analyzing the pollutant removal capability of BMPs is the use of probability plots. This method is different from the above results because it does not use paired samples and instead characterizes the distribution of the data. In the case of a BMP efficiency study, it is important to compare the distribution of the input pollutant concentrations with the distribution of the output concentrations after treatment. This not only provides a method to compare removal, but also a method to describe any changes in the overall shape of the probability distribution.

The most common of these probability plots is the normal probability plot, in which the scale of the abscissa is stretched such that the spacing represents the cumulative normal distribution. Therefore, if the data are normally distributed, they will plot as a straight line. This method of plotting data on distribution-specific probability plot has historically gained the most acceptance by hydrologists in flood frequency analysis to determine the probability of exceedance for a given design flood flow. However, by applying the same probability plot methods to hydrologic and water quality data for BMPs, it is possible to determine flow parameter and effluent concentration exceedance probabilities and to easily and visually compare different BMPs and BMP performances.

The first step in applying the probability plot approach to BMP treatment is to characterize the distributions. The normal and the lognormal distributions were shown to be sufficient to describe pollutant concentrations as shown in a study by Van Buren *et al.* (1997), which examined an on-stream stormwater management pond in an attempt to characterize the change in concentrations through the BMP facility. Influent and effluent EMCs for every monitored storm were plotted on both normal and lognormal probability plots. If the EMCs plot in a straight line, they are assumed to fit that distribution. In this study, a visual fit was used, however goodness of fit tests in the literature are available for normal and lognormal probability plots (Gan *et al.* 1991, Looney and Gelledge 1985).

The results of the Van Buren *et al.* (1997) study agreed with the assumption of other studies, that the distribution of stormwater runoff concentrations are generally lognormally distributed (Harremoes 1988). Suspended solids and its associated constituents, including metals and nutrients, tend to follow a lognormal distribution. However, concentrations of dissolved constituents seem to follow the normal distribution (Van Buren *et al.* 1997).

Barrett Regression and Model Storm Event Yet another method for comparing performance of runoff BMPs was described by Barrett (2005). His research is based on the hypothesis that effluent concentrations are linearly correlated to influent concentrations. This method has the advantage of using paired storm data. Using this hypothesis, effluent EMCs were plotted as a function of the paired influent and a regression line was calculated and tested for statistical significance at the 90% confidence level. In the case that no statistically significant regression could be determined, the mean effluent concentration was used. The linear regression took the form:

$$C_{eff} = a\, C_{inf} + b \qquad (3)$$

where C_{eff} = predicted effluent EMC, C_{inf} = influent EMC, and a and b are the slope and y-intercept respectively. Using this regression equation, effluent quality can be calculated for any arbitrary influent quality. If the regression line is below the bisecting line, $y = x$ ($a < 1$), the BMP effluent concentrations are lower than influent concentrations and therefore, the BMP functions as a removal treatment. However, if the regression line is above the $y = x$ bisector ($a > 1$), the BMP exports the specified constituent.

Grass Swales

Little consistent information on water quality improvements for grass swales is available, in large part because of the complexity of swale operation. Swales receive flow laterally through vegetated side slopes, which can greatly improve incoming water quality. Infiltration throughout the swale surface area can reduce flow volume and improve quality. Thus, swales have several distributed points of water input and output, which can complicate simple performance analyses. Also, in the case of field studies, input concentrations and flow rates are variable depending on the storm event and roadway characteristics, further complicating comparisons between swale removal efficiencies.

Total Suspended Solids Much of the initial research involving grass swale treatment technologies focused on treatment of suspended solids, because this is a simple parameter to test for, and because TSS is a good indicator for other water quality parameters. Grass swales tend to be very successful in removing TSS, with EMC removal values reported as: 65-98% (Schueler 1994), 85-87% (Barrett *et al.* 1998), 68% (Yu *et al.* 2001), and 79-98% (Backstrom 2003). This range of removal efficiencies is likely caused by differences in storm characteristics and swale construction. However, there have been some mechanistic studies attempting to model and describe the removal of suspended solids.

Current studies (Deletic 2001, Backstrom 2002, Backstrom 2003, Deletic 2005) have employed both real grass and artificial grass swales in order to investigate the processes involved in suspended solid removal. In Backstrom's work (2003), short runoff events (0.5 hours) were simulated by pumping water mixed with sediment into the swale at one well-defined inlet point. Inflow rates varied within the range of 0.5-1.5 L/s. Studies were performed on small scale (5-10 m) field grass swales and also on plywood channels covered with artificial grass. Results from these small scale studies were then compared to a full sized, 110 m long, roadside swale with similar design parameters and lateral flow from the roadway.

These studies concluded that grass swales are successful at removing suspended solids in runoff; however the removal efficiency is based on input concentrations. Very small reductions of suspended solids are likely to occur in a grass swale if the inflow TSS concentrations are below 30-40 mg/L (Backstrom 2003). In the case of very low influent concentrations, an export of suspended solids is possible. This conclusion is corroborated by studies performed by Barrett (2005).

Backstrom (2003) also concluded that grass swale suspended solids removal is highly related to particle size and thereby related to particle settling velocity. This conclusion was drawn from a particle size distribution analysis of the suspended solids which showed that grass swales trapped larger particles more efficiently than smaller ones. The field grassed swale (110 m) particle size distribution showed that particles larger than 25 μm were generally retained in the swale, while particles in the size interval 9 to 15 μm were exported from the swale (Backstrom 2003). The smallest diameter particles, 4-9 μm were exported to a lesser extent. Particle size distribution tests on the smaller, more controlled swales allowed a more detailed analysis of differences in particle size between influent and effluent flows. In these tests, the influent particle distributions were relatively uniform for all events with a d_{50}-value of 9.2 μm and a d_{90}-value of 26 μm.

Marked differences were noted between the artificial grass laboratory swales and the field swales. The laboratory swales captured particles of all sizes down to the lower limit of the size interval and no correlation was noted between particle size and removal efficiency. The field swales, however, showed a visible relationship between particle size and trapping efficiency. Similar to the full scale swale, the smallest diameter particles were exported, while the larger particles were removed. Also, more removal of smaller diameter particles in the longer swales was apparent. The ability to remove smaller particles as travel times increase is indicative of sedimentation as the major removal method for suspended solids (Backstrom 2002). This study concludes that grass filtration plays a smaller role in removal of suspended solids in grass swale treatments.

Nutrients Nutrient removal is much more variable than suspended solid performance and good mechanistic studies are not available, given the small number of monitoring data sets. Sampling of two grass swales in Barrett *et al.* (1998) showed significant EMC removals of nitrate (37%) and TKN (39%). A similar study by Schueler (1994) showed mass reduction of nitrate ranging from -143% (export) to 45% and mass reduction of TKN between 9 and 48% for 3 swales with very different physical properties. A study of grass swales in a parking area in Florida showed that nitrate concentrations were unaffected by grass swale treatment, however, there was a significant load reduction due to storage and infiltration (Rushton 2001). This variability in grass swale performance for nitrogen removal shows that slight differences in storm type, vegetation characteristics and swale design can have significant effects on removal efficiency.

Phosphorus removal in grass swales is even more varied than nitrogen removal. Some studies have shown significant total phosphorus removal: 12-41% (Schueler 1994), 60% (Yu *et al.* 2001), and 34-44% (Barrett *et al.* 1998), while other studies have shown significant total phosphorus export (Wu *et al.* 1998, Rushton 2001, Barrett 2005). In the case of export, grass swales act as a source, rather than a treatment facility.

Researchers have hypothesized that this range of nutrient removal efficiencies is due to the fact that swales are an organic treatment method (Yu *et al.* 2001). Because the grass, decaying organic matter, and other vegetation, such as fallen leaves, contain these organic constituents, there is a significant likelihood of leaching these nutrients into flowing water. Also, variables such as mowing or fertilizing can be significant sources of nutrients in grass swales. Finally, as shown above, grass swales are much more successful in intercepting larger diameter solid particles, while nutrients like phosphorus tend to be either in dissolved form or bound to very fine sediment particles (Wu *et al.* 1998).

Heavy Metals Monitoring studies have shown that grass swales are successful at removing metals of concern in highway runoff: lead, copper, zinc, and cadmium. In most of these studies, lead and copper show moderate removal efficiencies that are slightly lower than the removal efficiencies of total suspended solids. Lead EMCs were reduced by 17-41% (Barrett *et al.* 1998), while total mass of lead was reduced by grass swales by 18-94% (Schueler 1994), and 59-87% (Rushton 2001). Similarly, total mass of copper was reduced by 14-67% (Schueler 1994), 34% (Backstrom 2003), and 23-81% (Rushton 2001). Zinc appears to be the most successfully removed metal constituent with studies showing 75-91% removal by EMCs (Barrett *et al.* 1998) and total mass removals of 47-81% (Schueler 1994), 66% (Backstrom 2003), and 46-79% (Rushton 2001). Finally, much less information is available about cadmium removal in highway runoff, as this constituent is generally present in very small amounts. However, monitoring studies have shown a wide range of removal values for cadmium, 12-98% by mass (Schueler 1994).

Positive metal removal through grass swales is corroborated by evidence showing trace metal accumulation over time in the sediment of the grass swales (Schueler 1994). All four metals, lead, copper, zinc, and cadmium, were shown to accumulate in the swale; however, their distributions are very different, highlighting differences between the metals. Copper and zinc distributions are concentrated on the surface and in the upper layers of soil of the grass swales. However, lead is much more evenly distributed throughout the deeper layers of sediment (Rushton 2001). This shows the greater likelihood of resuspension of soil particles with associated copper and zinc, to a lesser extent. This possibility was shown in research by Backstrom (2003), who found an increase in copper concentration leaving 2 grass swales. This mobilization was attributed to a buildup of colloidal bound copper prior to the monitoring period and later resuspension during the monitoring period. In the case of small storms with low influent concentrations, the swale acted as a source for all trace metals, exporting higher mass than present in the influent (Backstrom 2003).

Chloride No current performance data are available regarding the removal of chloride by grass swale treatments. However, studies of chloride concentrations in receiving water streams in Maryland, New York and New Hampshire have shown that while some seasonal differences in chloride concentrations occur throughout the year, this deviation is relatively small (Kaushal *et al.* 2005). This means that the common input source of chloride, roadway deicing agents used during the winter, is not sufficient to explain rising chloride concentrations. Therefore, a sink must exist between the roadway surface and the receiving waters that slowly exports chloride throughout the year. Grassy, roadside areas, like grass swales, are therefore likely repositories for chloride sources, acting as both a sink and a source.

The Barrett Model. Regression analysis for 6 grass swales treating highway runoff in southern California over 39 storm events was completed by Barrett (2005). For grass swales, a significant regression fit was found for all constituents except for orthophosphorus. Barrett compared BMP performance for a design storm with given influent concentrations. Comparisons were drawn for effluent EMCs and also, by multiplying influent and effluent EMCs by their respective flow volumes, a load reduction was calculated. On average, Barrett found a reduction of 47% of runoff in grass swales.

A design storm event with influent EMCs averaged from all monitored storm events (114 mg/L TSS, 0.97 mg/L nitrate, 0.12 mg/L orthophosphorus, 122 μg/L zinc, and 18 μg/L copper) was calculated. Using this design storm, the average runoff reduction, and the regression equations for grass swales, Barrett determined the expected effluent concentrations and load reductions for total suspended solids, nitrate, orthophosphorus, dissolved zinc, and dissolved copper. The results of this design storm indicate that grass swales are efficient in the removal of suspended solids and metals, while nutrients show variable results and potential export of constituents. Grass swales showed a significant reduction of suspended solids concentrations (from 114 mg/L to 58.9 mg/L) and loadings (75%), although this removal was not as great as other monitored BMPs (Barrett 2005). Nitrate effluent concentrations for the design storm were higher than influent (increase from 0.97 mg/L to 1.25 mg/L), yet showed load removal (40%) caused by infiltration, while orthophosphorus is exported by grass swales in both concentration and total mass loading.

Finally, zinc and copper were removed successfully, with load reductions between 60 and 80%. The mass reductions for metals associated with grass swales and filter strips are among the best of the monitored BMP technologies.

Grass Swale Efficiency and Hydrology Because grass swales are based on water flow, the hydrology involved in this treatment process requires investigation. The standard highway swale is designed to move runoff from the largest storm events away from the roadway. Because of this, highway swales are not designed for smaller storm events (0.2 – 1 in) that produce the majority of annual runoff through the swale (Schueler 1994). Grass swale pollutant removal effectiveness is dependent on the vegetation reducing the peak velocity, while infiltration reduces total runoff volume, and the longer travel time allows for chemical, biological, and other hydrologic processes to take place.

Percent runoff volume reduction has been reported as: 30-47% (Rushton 2001) and 33% (Backstrom 2003). This reduction is due to infiltration into the swale soil. Besides reduction of total volume, grass swales tend to smooth flow peaks. The reduction of flow peaks was characterized by the normalized peak discharge factor (PDF), defined as the ratio of peak discharge of runoff to total rainfall amount (Wu *et al.* 1998). The grass swales in this study showed a reduction of PDF by 11-22% when compared to the direct highway runoff (Wu *et al.* 1998).

The hydrology of grass swales can be characterized and compared using the Rational formula and the corresponding runoff coefficient, C:

$$q_p = C\ i\ A \qquad (4)$$

where q_p represents peak discharge (L/s), A represents drainage area (ha), i represents rainfall intensity (cm/hr) and C is a unitless coefficient. Wu *et al.* (1998) used a modified version of this equation to compare swale characteristics. Dividing by drainage area yields:

$$q_p / A = C\ I \qquad (5)$$

and integrating over the storm duration yields the equation:

$$R = C\ (P) + b \qquad (6)$$

where R represents the total runoff (cm), P is the total rainfall (cm), and b is the y intercept. By plotting rainfall data against runoff data, a linear regression allows the calculation of the fitting parameters. C is the Rational formula runoff coefficient and by setting R equal to zero, the amount of rainfall needed to satisfy initial abstraction and other losses prior to the occurrence of runoff can be estimated (Wu *et al.* 1998). These two parameters provide an understanding of the initial infiltration capability of the swale and the percentage of infiltration once runoff begins flowing out of the swale.

Storm characteristics appear to play an important role in swale hydraulics. Several studies found that during small storms, removal of total runoff volume was significant. However, as would be expected due to soil saturation, during large or intense storms, the total volume of runoff exiting the grass swales was equal to or larger than that entering the swale (Schueler 1994, Yu *et al.* 2001, Rushton 2001).

Pollutant removal efficiency appears to be independent of storm volume. A plot of TSS removal through grass swales as a function of total volume of storm runoff showed no relationship (Barrett 1998). Total runoff volume is not a good predictor variable for grass swale removal efficiency because the removal mechanism is based on both infiltration and increased particle settling due to decreased flow velocities. Long, large volume storms do not necessarily correspond to intense rainfall and therefore do not produce a greater water depth through the swale than do small, intense storm events. At high flow depths, water is not slowed by grass in the swale, allowing sedimentation, and also is too high to undergo filtration. Therefore, grass swales are most effective at removing highway pollutants during long, low intensity storms or very short storms that can be completely captured during the initial abstraction period (Yu *et al.* 2001).

Grass Swale Efficiency and Design Parameters As discussed above, grass swales function at their optimum efficiencies when the flow velocities are reduced through contact with the grass layer, allowing for increased sedimentation, filtration, infiltration, and other physical, biological, and chemical processes. It follows, therefore, that any design parameter for the construction of grass swales should focus on increasing these processes. There is a lack of research detailing the exact effects of certain design parameters on grass swale pollutant removal efficiency. However, current research supports the importance of parameters that increase hydraulic retention time and offers some efficiency trends when swales with a range of design parameters are compared.

The first, and possibly simplest, method to increase travel time within the swale is to extend the swale length. In research by Backstrom (2002), 7 field swales with a wide range of design conditions were compared during storm events artificially created with constant flows and constant TSS concentrations. Particle trapping efficiencies for three different particle settling velocities, corresponding to three different particle sizes indicate that increasing swale length greatly increases particle trapping efficiencies (Backstrom 2002). This difference is most notable for the smallest particles (0.1 m/h settling velocity, diameter < 25 μm). This large increase in sediment removal for small particles supports the conclusion that sedimentation is the controlling TSS removal mechanism in these swales. Other research agrees that increasing swale length greatly increases suspended solid removal (Yu *et al.* 2001).

Backstrom (2002) further examined the process of sedimentation in grass swales, with the intent to create design criteria for particle trapping with respect to particle size and settling velocity. For a given trapping efficiency, this research fit an exponential relationship between the mean swale residence time in seconds (T) and the particle settling velocity in m/h (Vs^*):

$$Vs^* = a\, e^{B\,T} \qquad (7)$$

where a and B are constants. Using this fit, it is possible to determine the swale residence time necessary to achieve a certain trapping efficiency, given a design particle. Swales in this study showed a good fit at the 50% and 90% trapping efficiencies, however, there were two distinct groups related to the soil infiltration rates. A more comprehensive study could produce a series of curves for differing soil infiltration rates, showing the design relationship between particle size, swale residence time, and particle trapping efficiency. This study corroborates findings by Yu *et al.* (2001), that swale pollutant removal reaches a plateau when swales are longer than approximately 75 m, regardless of shape. Beyond a certain residence time, sedimentation is no longer effective and processes like filtration and resuspension begin to control discharge concentrations.

The importance of infiltration rates in Backstrom's calculations highlights the importance of swale design parameters other than length. Many other factors, such as channel slope, soil type, vegetative cover, and age affect the residence time and removal efficiency of grass swales. In a study by Schueler (1994), 3 swales with similar lengths (60 m) and a wide range of conditions were analyzed. The first swale, with low slope, sandy soil and dense grass cover exhibited the best removal capability by total mass reductions: TSS (98%), nitrate (45%), TKN (48%), total phosphorus (18%), and metals (50-70%). By comparison, the worst pollutant removals occurred in a swale with moderate slope and poor grass cover. This poor grass cover caused severe erosion during large storms, resulting in an export of TSS (-85% by mass) and nitrate (-143% by mass). This swale also showed little capability to remove organic nitrogen, total phosphorus or metals. The last swale showed moderate removal efficiency due to its high slope, but good vegetative cover. The conclusions of this study agree with others that grass swales are most efficient when they have low slopes, soil with high infiltration capability, and dense grass cover (Yu *et al.* 2001).

Another possible grass swale design parameter is the inclusion of check dams along the length of the swale. Check dams are small weirs placed along the length of the swale to increase the retention time and to temporarily block the flow of runoff, increasing sedimentation and infiltration. By creating synthetic storm events and comparing removal efficiency of a swale with a check dam and without the dam during high and low intensity events, Yu *et al*. (2001) found that the inclusion of the check dam made a significant water quality improvement. The effect of the check dam is less pronounced during high intensity storms.

Current research does not show quantifiable, empirical relationships between grass swale design and removal efficiency. However it does show significant trends related to design criteria. Guidelines based on these trends were presented by Yu *et al.* (2001), who recommended a maximum 5% longitudinal slope, 30-60 m length, 0.6 m bottom width, soil with high infiltration rate, dense deep-rooted flood tolerant vegetation, and the inclusion of check dams. These recommendations are based on trends, however, and not on a unified physical model of grass swale processes.

Grass Swale Efficiency and Pretreatment Another important design parameter for grass swale construction is the location of the highway swale and any pretreatment that occurs prior to flow through the swale. Currently, little research is available regarding the effect of pretreatment in grass swales and that research which is available is contradictory.

In a study of two grass swales in Austin, Texas by Barrett (1998), grab samples were used to determine the distribution of TSS concentrations along the center of the swale. Analysis of these grab samples showed little change in TSS concentrations along the length of the median. It is assumed, therefore, that most suspended solid removal occurred in pretreatment or along the side slope of the swale, not along the length of the swale. This study also concluded that pretreatment areas function primarily through filtration and not sedimentation. Therefore, swale length is less important than the pretreatment area adjacent to the swale. This study added provisions for pretreatment areas to the above recommended grass swale design guidelines. Recommendations of the study state that pretreatment length should be at least 8 m (from pavement edge to center of swale) and that the ratio between swale area and contributing impervious area should be as close to 1 as practical (Barrett 1998).

While a similar study by Wu *et al.* (1998) agrees that including a pretreatment area can improve runoff quality, it concludes that the pretreatment area is not as important for improving water quality as Barrett (1998) had suggested. Wu *et al.* (1998) concludes that the roadside shoulder and pretreatment area is responsible for 10-20% hydrologic reduction of peak runoff discharge and a 30% reduction of TSS loadings when compared to a swale without a pretreatment area. However, these results are difficult to compare because the swales are not designed in a comparable manner. The swale without pretreatment area accepts flow from one direction at a constant slope, while the swale with pretreatment accepts flow two directions, with variable slopes and with 15% more pervious coverage (Wu *et al.* 1998).

Other studies, however, have disagreed with these conclusions. Instead, they conclude that sedimentation is the most important process in removing runoff pollutants and therefore swale length is the most important factor in swale removal efficiency (Backstrom 2003, Schueler 1994). These studies suggest that while a pretreatment area can provide pollutant removal, it is primarily due to extending the retention time for the runoff and does not supersede the importance of the grass swale in treatment.

Recent University of Maryland Study The performance of grass swales as a highway runoff treatment and the effect of including a grass filter strip pretreatment area adjacent to the swale were evaluated using a field-scale input/output study on a Maryland highway (Stagge 2006). Twenty-four rainfall events were monitored over 1.5 years, with rainfall depths ranging from 0.2 to 17.32 cm. The ranges of depths and durations included cover a reasonable distribution for that expected for Maryland. Half of the events were small enough that the entire flow was completely stored, infiltrated, and evapotranspired by the swales, resulting in no swale discharge. Swale discharge results show significant peak reduction (50-53% mean), delay of the peak flow (33-34 min) and reduction of total volume (46-54%). Mean values do not, however, convey the high variability in performance that was noted. The grass swales exhibited statistically significant removals by mean concentration of total suspended solids (41- 52%), nitrite (56-66%) and zinc (30-40%), lead (3-11%), copper (6-28%) and cadmium. Other monitored nutrients (nitrate, TKN, and total phosphorus) exhibited variable removal capabilities (-1-60%), while the swales exported chloride (216-499 mg/l) at a significant level. Results suggest the pretreatment grass filter strip imparts no significant water quantity or quality improvement and that the swale itself is the most important treatment mechanism.

Bioretention

Research studies have shown bioretention to have significant capacity to be effective in managing flows and pollutant loads from developed areas (Dietz and Clausen 2005, 2006, Heasom *et. al*. 2006, Hunt *et al.* 2006, Davis 2007, 2008).

Hydrocarbons are readily captured by organic matter and may be biodegraded over short times, thus propagating a sustainable process (Hong *et al.* 2006). More work continues in addressing nitrogen pollution and a sustainable nitrogen cycle may also be possible by carefully engineering the flow and facility media content to promote nitrification/denitrification processes. More problematic are compounds that do not have benign transformation states, such as phosphorus and heavy metals.

Recent University of Maryland Study Flows into and out of two bioretention facilities constructed on the University of Maryland campus were monitored for nearly two years, covering 49 runoff events (Davis 2008). The two parallel cells capture and treat stormwater runoff from a 0.24 ha section of an asphalt surface parking lot. The primary objective of this work was to quantify the reduction of hydrologic volume and flow peaks and delay in peak timing via bioretention. Overall, results indicate that bioretention can be effective for minimizing hydrologic impacts of development on surrounding water resources. Eighteen percent of the monitored events were small enough so that the bioretention media captured the entire inflow volume and no outflow was observed. Underdrain flow continued for many hours at very low flow rates. Mean peak reductions of 49 and 58% were noted for the two cells. Flow peaks were significantly delayed as well, usually by a factor of two or more. Using simple parameters to compare volume, peak flow, and peak delay to values expected for undeveloped lands, it was found that probabilities for bioretention Cell A to meet or exceed the LID hydrologic criterion were 55%, 30%, and 38%, respectively. The probabilities were 62%, 42%, and 31%, respectively, for Cell B.

These same two bioretention facilities were monitored from Summer 2003 through Fall 2004 to quantify water quality improvements to parking lot stormwater runoff (Davis 2007). One cell was a standard design and the other had an anoxic sump. Twelve inflow/outflow water quality data sets were successfully collected and analyzed for Total Suspended Solids (TSS), phosphorus, and zinc. Nine sets were collected for copper and lead, and three for nitrate. In 2 of the events, all of the runoff flow was attenuated by the bioretention media and no flow exited the cells, resulting in zero pollutant discharge. In all cases, the median pollutant output is lower than the input, indicating successful water quality improvement through the bioretention media. Statistically insignificant differences were noted between the two cells for all pollutants examined. Median values for effluent event mean concentrations and percent removals based on combined data sets (both cells) were TSS, 17 mg/L and 47% TP, 0.18 mg/L and 76%, copper, 0.004 mg/L and 57%, lead, 0.004 mg/L and 83%, zinc, 0.053 mg/L and 62%, and 0.02 mg-N/L and 83% removal of nitrate (based on limited data). Mass removals were higher than those based on concentrations due to flow attenuation. These values are in reasonable agreement with those previously published from bioretention field and laboratory studies.

Basins

Wet ponds have been shown to be more effective at removing pollutants than dry ponds as dry ponds typically hold water only during storms, and so there is only a short residence time for pollutant removal. In wet ponds, extended residence time provides a greater opportunity for solids to settle and dissolve and for components to be acted upon either biologically or chemically.

Studies by Comings *et al.* (2000) show highly variable removal efficiencies of phosphorus by ponds, but generally <50%. The removal of soluble reactive phosphorous is usually -12%; even -50% has been reported. Removal efficiencies for metals were good and similar in both the ponds studied (one was designed specifically for pollutant removal and the other for both detention and some water quality improvement). Nutrients showed high variability.

Pollutant settling rate plays a major role in the removal efficiency of BMPs such as wet ponds that rely on gravity as the primary removal mechanism. The presence of aquatic vegetation can improve a pond’s performance by the uptake of nutrients. The size of a pond is a major determinant of pond performance. The larger a pond is in relation to the area it drains, the better it performs at removing pollutants.

Stormwater quality improvements in SWM basins have been documented in a few cases. Several ponds have been studied in North Carolina (Wu *et al.*1996). Averaging removals over several events, good to excellent removals were found for several water quality parameters. However, in evaluating individual events, a wide range in water quality improvement is noted. In some cases, complete retention occurred for a small event, which accordingly provides 100% pollutant removal. Also, several instances of "negative removals," where output loadings were larger than input, were noted for large events. TSS removals of 41-93% were found. Other removals noted include 22-87% Fe, 22-80% Zn, 29-53% TP, and 21-37% TKN.

The ponds evaluated in Wu *et al.* had runoff surface-to-pond area ratios of 0.6 to 7.5. For TSS, Fe, and Zn, increased removals were found at higher ratios. A similar trend was apparent, but was less clear for TP and TKN. The presence of waterfowl in the ponds may have contributed to the discrepancies. Biological transformations could have also played a role.

A study of the removal of several pollutants from two wet detention ponds designed at 0.8 to 1% pond-to-runoff area demonstrated good removal for several pollutants (Borden *et al.* 1998). With these two ponds, biological reactions were found to be very important in controlling the effluent pollutant levels. Again, on an event basis, in the situation of small storms, detention ponds can provide 100% pollutant removal by storing all of the runoff from a particular event.

In a third study, the pollutant removal efficiencies of two neighboring detention ponds in New Jersey were investigated (Bartone and Uchrin 1999). The bottom of one of the basins was concrete and stone; the other was vegetated with various wetland plants. Sampling was completed over four storm events. Pollutants examined included TSS, various nitrogen and phosphorus species, petroleum hydrocarbons, and fecal coliform and fecal streptococcus. Because the land use in the watersheds was high density residential, the input pollutant levels were low and in several cases, below detection limits. In the concrete basin, some reduction in concentrations of the nitrogen and phosphorus species was noted. Slight removals of fecal coliforms were also found (fecal streptococcus were below detection limits). However, in three of the four cases, the output TSS exceeded the input mass.

The surprise was in the results from the basin with the vegetated bottom. For nearly every water quality measurement made, the effluent was worse than the influent. In some cases, the quality degradation was marked, as in the case of fecal coliforms, where levels in the effluent were ten to 100 times higher. Apparently, the quality of the water held in this basin between storm events became very poor. During the event, this poor quality water is washed from the basin.

Overall, these studies suggest complexity in the use of SWM basins for water quality improvement. In general, some removal of pollutants is expected, especially for small events when the majority of the flow is retained. Also, the data of Wu *et al.* (1996) suggest that larger basins provide better quality improvement (which agrees with conventional sedimentation theory). Chemical and physical processes that occur within the ponds, especially between events, are poorly understood and can have a major impact on water quality leaving these facilities.

Vegetative Buffer Strips

A few studies have evaluated water quality improvement for flow through vegetative buffer strips. Highway runoff quality data gathered by Wu *et al.* (1998) indicate that for small rain events, 50-84% of the TSS is removed by the adjacent grassy filter strip. At higher rainfall events, the runoff flow became deeper and the removal decreased from 20 to 35%. Similar results were obtained in another highway runoff treatment study (Yonge 2000). In this case, total suspended solids removal ranged from about 20 to 80%, with an average removal of 72% (average reduction of suspended solids from 41 to 6.7 mg/L). Total petroleum hydrocarbon removal was excellent, with most treated water having less than 1 mg/L TPH. With proper soil mixtures, infiltration of runoff can be an important water and pollutant attenuation pathway in vegetated buffer strips, reducing the volume of overland flow (Davis and McCuen 2005).

Sand Filters

Sand filters are specifically designed for the removal of particulate matter and are very efficient in this regard. Also, since many pollutants are affiliated with TSS, their removal is accomplished simultaneously. This is seen in the removal of Total Pb and Total Zn, and to a limited extent Total Cu and Total P. The removal of dissolved metals is somewhat perplexing and suggests that chemical mechanisms may be playing a role in the pollutant removal. Nitrate production was found, indicating nitrification of captured TN (Davis and McCuen 2005).

Clark *et al.* (1998) studied different types of media and media mixtures to evaluate the performance for enhanced pollutant removal through a runoff filter. Sand was mixed with activated carbon, peat, compost, zeolite, cotton textile waste, and agrofiber to examine both infiltration and pollutant removal characteristics. The best infiltration characteristics were provided by the sand-activated carbon. The other mixtures became clogged with suspended solids more easily; the worst were the peat and compost mixtures. The organic media, however, provided the best removal of metals.

Clogging by suspended solids remains the most important parameter in considering filter design. Studies by Barrett (2003) indicated that cumulative suspended solids loadings between 5 and 7.5 kg/m^2 (1.0 to 1.5 lb/ft^2) over several months will result in filter clogging and infiltration rates that are unacceptable

Wetlands

Fully functional wetlands have many provisions to improve the quality of incoming runoff. Sedimentation due to storage can play an important role in the removal of suspended particulates and the pollutants affiliated with them. Residence time in the wetland can also encourage several chemical processes. Most important, though, are the myriad of biological reactions that can be promoted in an active wetland ecosystem (Davis and McCuen 2005).

A large body of work has investigated wetlands as treatment zones for municipal wastewater, industrial wastewater, and agricultural runoff (e.g., Kadlec and Knight 1996). Information on urban runoff is much more scarce, but the same concepts that are important for these other applications can be applied here.

The presence of flora and fauna create a complex, but effective environment for pollutant management. Wetlands can be considered as complex ecosystems with interdependent communities. Microorganisms such as bacteria, fungi, and algae will thrive under appropriate environmental conditions. These organisms can metabolize carbon and nitrogen pollutants. Similarly, the vegetation can play a direct role in pollutant management by taking up and mineralizing various compounds, but also indirectly, by supporting pollutant degrading microbial populations. Both invertebrate and vertebrate animals will exist in the wetland, but their impact on water quality is expected to be minimal.

Some recent work has presented design information for water quality improvement for constructed wetlands for treating urban and highway runoff (Shutes *et al.* 1999). Foremost, as with many natural treatment systems, pretreatment is very important. A well-maintained sediment trap preceding the wetland is critical for the removal of many input suspended solids so as to prevent the accumulation of solids in the wetland itself. Optimum performance has been noted with a wetland design area that is 2-3% of the drainage area. A length-to-width ratio of 1:1 to 1:2 has been suggested. The wetland surface should include 0.44 m of pea gravel under 0.15 m of soil, for a total media depth of 0.6 m. The soil supports the wetland vegetation and associated microbiological communities. The pea gravel allows for subsurface flow of water. This subsurface area is an active biological zone and provides many important processes for pollutant removal. An impermeable clay layer below the gravel may be necessary to keep water in the wetland for supporting the various ecological processes under long periods of dry weather. The wetland should have a slope of about 1% to promote the water movement.

Ideally, the wetland should be sized to hold a 10-year storm event, although land area may not allow this. The hydraulic retention time should be at least 30 minutes for the maximum expected flow. Hydraulic retention times of 3-5 hours should be expected for annual storms and 10-15 hour retention times will provide optimum wetland performance. The maximum time should be limited to 24 hours to minimize stagnation and other problems associated with standing water. Hydraulic loadings less than 1 $m^3/day/m^2$ should be maintained, and flow velocities should be below 0.3 to 0.5 m/s. Velocities greater than 0.7 m/s can cause damage to wetland vegetation.

Suggested vegetation includes reedmace (*Typha latifolia*) and common reed (*Phragmites australis*) (Shutes *et al*. 1999). Regardless, it is important that the wetland vegetation blend in with the natural surroundings and diverse plant communities may provide more effective water treatment than wetlands containing only a few plant species (Karathanasis *et al.* 2003). The wetland planting designs should consider placements to minimize flow short-circuiting.

Because of the complex ecological communities established in working wetlands, a number of pollutant removal mechanisms are operational in a wetland. Physical processes dominate for the removal of suspended solids. Chemical processes such as adsorption and precipitation are important for the removal of inorganic compounds such as heavy metals and phosphorus, as well as hydrophobic organics, such as oils. Importantly, biological reactions can reduce BOD, nitrogen, and phosphorus levels in runoff waters. The variability of pollutant removal in wetlands is high and in some cases, negative removals (pollutant concentration increases) were found.

Percent pollutant removals in stormwater management wetlands were also regressed against the wetland:watershed area ratio. Although much scatter in the data was noted, these regressions provide a preliminary estimate for wetland performance for design or analysis. For example, for 31 measurements, TSS removal averaged 43%, but ranged from (–300) to 95% (Carlton *et al*. 2001).

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APPENDIX G:

Underground SWM Thermal Mitigation Studies – August 16, 2007 Progress Report

By University of Maryland

Progress Report: Underground Stormwater Management Thermal Mitigation Studies

Project Duration:	August 2006 – July 2007
Project Sponsor:	Karen Coffman Highway Hydraulics Division Maryland State Highway Administration 707 North Calvert Street C-201 Baltimore, MD 21202
Project Coordinators:	Allen P. Davis, PhD, P.E Professor Poornima Natarajan Graduate Research Assistant Department of Civil and Environmental Engineering University of Maryland College Park, MD 20742
REPORT DATE:	AUGUST 16, 2007

1.0 Introduction

Impervious surfaces like rooftops, parking lots and sidewalks have increased due to expanding urbanization. These impervious surfaces have high thermal capacity and absorb solar radiation. As stormwater runoff is conveyed over asphalt roadways and access areas, heat is transferred to the runoff via conduction, thereby raising its temperature. Summer is the period of concern when ground temperatures are highest and when intense direct sunlight will greatly increase the temperature of the black-colored asphalt (Figure 1). The discharge of this heated runoff into local streams increases the stream temperature causing adverse effects on its ecosystem.

Temperature increase is a serious and widespread problem in Maryland streams (Boward et al. 1999). The input of heated runoff can be lethal to temperature sensitive aquatic organisms such as trout (Galli 1990). Baldwin (1951) identified 14 ^{o}C as optimal water temperature for brook trout. The range for growth and survival is 11 to 16 ^{o}C (Baldwin 1951; Raleigh 1982; Drake and Taylor 1996). The upper lethal water temperature limit for hatchlings is 20 ^{o}C and approximately 25 ^{o}C for juveniles and adults, while the reported maximum temperature for growth of juvenile brook trout was 14.4 ^{0}C (MacCrimmon and Campbell 1969). Brown trout have an optimum temperature range of 7 to 17 ºC and become stressed at temperatures above 19 ºC (Roa-Espinosa et al. 2003). Cold-water streams are apparently the most ecologically sound at temperatures between 7 and 17 ºC (Lyons and Wang, 1996, Simonson, 1996).

The Maryland state water quality maximum temperature standard for wild reproducing trout stream designations (Maryland Department of the Environment, Use III, Natural Trout Water) has been established at 20 ºC (Butowski et al. 2006). At higher temperatures, the solubility of oxygen in water decreases, resulting in lower levels of dissolved oxygen. As temperature increases, the rise in metabolic rate of aquatic organisms causes an increase in the demand for dissolved oxygen. Also, photosynthesis and plant growth increase with higher water temperatures. The consumption of oxygen by bacteria for decomposing the dead plants further depletes the dissolved oxygen level in the stream (Paul and Meyer 2001).

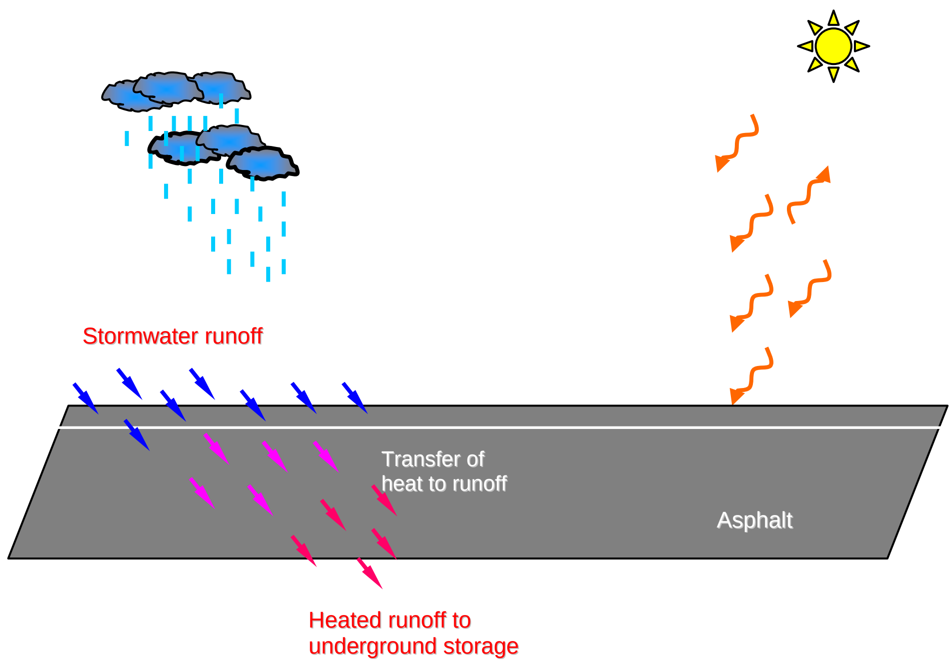


Figure 1. Transfer of heat to stormwater runoff from highway

The thermal impacts of urban runoff have become an issue of growing concern. Best management practices (BMPs) are widely used control measures for non point source of pollution. Studies on the thermal impacts associated with representative stormwater BMPs including an infiltration facility, artificial wetland, extended detention dry pond, and wet pond have been done (Galli 1990).

An underground storage and slow release facility is one of the most versatile stormwater best management practices. These detention facilities attenuate peak flows. Since the ambient temperature in the underground storage is cooler, reduction in the temperature of incoming stormwater runoff should occur. Thus, runoff discharged into the receiving waters or streams will be at relatively lower temperatures. However, the temperature reduction in underground storage BMPs has not been quantified.

The objectives of this study are to quantify the impact of underground storage on the temperature of runoff from highways and develop a simple heat transfer model. In order to achieve these objectives, the first task will be to setup and monitor stormwater runoff flows and temperatures into and out of three underground storage BMPs in Maryland. Automated flow and temperature monitoring equipment will be used. The data obtained will be used to quantify and develop the heat transfer model. The model, formulated as a differential equation, when solved numerically will predict the temperature of the runoff at the outlet of the facility. This will enable the determination of the efficacy of these BMPs in mitigating temperature of runoff. The impact of these BMPs in managing high temperature concerns in highway applications can hence be quantified for future design, analysis, and implementation.

2.0 Methodology

2.1 Field Measurements

2.1.1 Study sites

Several underground stormwater management facilities were investigated to determine their suitability for inclusion in the study. The sites were evaluated based on the size of drainage area, percentage imperviousness, asphalt vis-à-vis concrete pavement, number of inflow points, accessibility of inlet and outlet points, and safety. Three BMPs, BMP 03007 and BMP 03008 located along I-83 northbound, north of Seminary Avenue in Baltimore County (Figures 2, 3 and 4) and BMP 16133 located along MD 202 northbound, south of Black Swan Drive in Prince George's County (Figures 5, 6 and 7), were chosen for conducting the study. Each site has multiple inflow points and will be modified to have only two inflow points by blocking the additional inflow points and redirecting the runoff into a downstream inlet.

BMP 3007 has 3 inflow points and is drained by an area of 2.65 acres in which 66% area is impervious. After blocking one of the inflow points, the drainage area and percent impervious area become 2.64 acres and 66%, respectively. One of the three inflow points is to be blocked in BMP 3008 and this modifies the contributing drainage area from 3.12 acres to 3.04 acres and percent impervious area from 45% to 43%. BMP 16133 has a drainage area of 10.34 acres of which 2.31 acres is impervious area. The number of inflow points need to be modified from 4 to 2 in this BMP. All three BMPs are located within the State Highway Authority right of way. Also, pavement sensors are located within a reasonable distance from all the BMPs. The nearest sensor for the I-83 sites is in I-695 at I-83 N. The pavement sensor in I-95 at MD 4 is the nearest to BMP 16133.

Figure 2. BMP 16133

Figure 3. Inlet at centre of BMP16133

Figure 4. View of centre inlet and storage pipes from control structure of BMP16133

Figure 5. BMP 3007 seen behind the noisewall along I-83

Figure 6. Inlet along I-83 NB

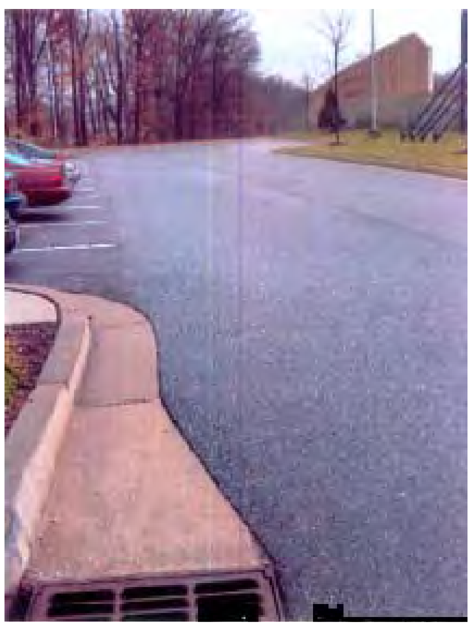


Figure 7. Access point from Timonium Business Park, Timonium two

2.1.2 Equipment Specifications

The equipment selected for this study are manufactured by Global Water Instrumentation Inc. (Gold River, CA). A Global Water FL16 flow logger will be used to record the stormwater runoff flow rate and temperature at the BMP inflow and outflow points. This instrument can record approximately 81,750 flow, temperature, depth and velocity readings. The operating temperature range is -40 to +85 °C. The sensor works in depths as low as 1.9 cm (3/4”) and can be programmed according to the pipe and flow conditions. The flow parameters can be calibrated for the flow conditions and the sampling rate can be set from 1 second to >1 year or 10 times/second mode. The conductivity measurements will be made using a conductivity sensor (WQ301) working over the range of 0-5000 micro siemens (micro mhos). A 15.2 cm (6”) tipping bucket rain gauge (RG 200) will be used to monitor the rainfall rate and total rainfall. A temperature sensor (WE700) capable of operating in the temperature range of -50 to +50 °C will be used to record air temperature. The sensor is provided with a ventilated solar shield having high reflectiveness, low heat retention and low thermal conductivity to protect it from direct sunlight effects.

The conductivity sensor, air temperature sensor and rain gauge will be connected to individual data loggers (GL500-2-1 USB model) capable of recording over 81,000 readings. The data logger can be programmed to sample at the desired interval from 1 second to multiple years or logarithmic or fast (10 samples per second). The instruments are battery powered and operate on a Windows-based software interface. The data stored in the logger’s memory can be downloaded and saved as a file. All the instruments will be placed in a weather-proof enclosure.

2.1.3 Sampling

The flow logger and conductivity probes will be placed at the inflow and outflow points in the underground storage facility (Figure 8). The probes will be programmed to sample data every two minutes. Runoff flow and temperature will be monitored year-round and data will be collected for as many storm events as possible, placing importance on data obtained during late spring, summer, and early fall, when high temperatures are most critical. The rain gauge and air temperature sensor connected to the data logger will also be set to log data every two minutes. The data loggers connected to the sensors will all be synchronized.

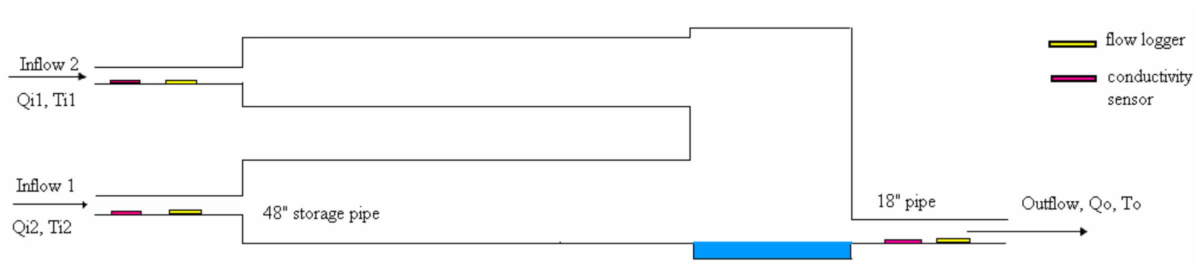


Figure 8. Schematic diagram showing the underground storage system

3.1.4 Data Analysis

The data collected will include stormwater runoff flow rate and temperature, and conductivity at the two inflow and the outflow points of the BMP. For each storm event, the total thermal energy (E) present is calculated as:

$$E = \int_0^{T_d} QT\rho C_p dt \qquad (1)$$

where Q is the measured stormwater flow rate, T is the water temperature, ρ is the density of water and C_p is the specific heat capacity of water. T_d is the duration of storm event.

In addition, the event mean temperature (EMT) is defined and calculated similarly as:

$$EMT = \frac{\int_0^{T_d} TQdt}{\int_0^{T_d} Qdt} \qquad (2)$$

The EMT represents the temperature that would result if the entire storm event discharge were collected in one container. EMT weights discrete temperature measurements with flow volumes and can be employed to compare temperatures among different events. Additionally, peak input and output temperatures will be evaluated, as will time exceeding target temperature thresholds.

3.2 Model

The impact of the underground storage BMP in mitigating stormwater runoff temperature can be estimated using a heat transfer model. The underground storage facility can be modeled as a set of completely mixed tank reactor (CSTR) in series. The runoff inflow to the underground facility is considered to be under non-steady and non-uniform flow conditions. The water stored in the pipes is the control volume for the model and the heat balance is evaluated over this volume of water.

The volume is computed by solving the differential equation involving θ, given by:

$$\frac{d\theta}{dt} = \frac{2}{(1-\cos\theta)R^2 L}\left(Q_i - Q_o\right) \qquad (3)$$

The volume of water in the storage pipe is hence calculated using:

$$V = \frac{R^2}{2}(\theta - \sin\theta)L \qquad (4)$$

where, V is the volume of water in the pipe in cm^3; R is the radius of the storage pipe (in cm), L is the length of one CSTR (in cm), Q_i is the inflow rate (in cm^3s^{-1}), Q_0 is the computed outflow rate (in cm^3s^{-1}), and θ is the angle subtended by the water surface at the centre of the pipe (in radians).

The outflow is calculated based on the flow volume in the storage pipe using:

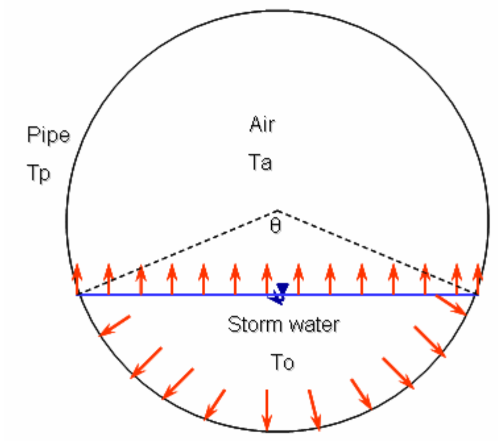
$$Q_o = C_d a\sqrt{2gh}^3 = \frac{C_d \Pi d^2}{4}\sqrt{2gR\left(1-\cos\frac{\theta}{2}\right)}^3 \qquad (5)$$

(or)

$$Q_o = \frac{2}{3}C_d\sqrt{2gR\left(1-\cos\frac{\theta}{2}\right)} \qquad (6)$$

where, C_d is the coefficient of discharge, a is the area of orifice (in cm^{-2}), d is the diameter of orifice (in cm), g is the acceleration due to gravity (in cm s^{-2}), and h is the head over the weir (or) upstream head above the center of the orifice (in cm).

Runoff coming into the system is at a higher temperature than the water already stored in the pipe during summer. Transfer of heat from the warm runoff to the stored water will occur due to convection. As water flows in the pipe, heat energy will be transferred to the pipe walls from the runoff by convection. The pipe material and air present in the partially flowing pipe might conduct some heat. The heat transfer in the pipe is shown by a simple diagram in Figure 9.



To = temperature of stormwater
Ta = temperature of air
Tp = temperature of pipe

Initial condition: To = Ta = Tp

Figure 9. Heat transfer in the storage pipe

Taking into consideration these heat transfer terms, the heat balance for the system is given as:

Heat energy stored = Heat in – Heat out – Heat loss (7)

The heat loss term includes the heat transfer to the pipe and the air.

The change in heat energy in the system per unit time can be written in the form of a differential equation as:

$$\frac{dE}{dt} = V_w \rho_w C_{pw} \frac{dT_o}{dt} = Q_i \rho_w C_{pw} T_i - Q_o \rho_w C_{pw} T_o - U_a A_a (T_o - T_a) - U_p A_p (T_o - T_p) \qquad (8)$$

where, T is the temperature (in °C), ρ_w is the density of water (in g cm^{-3}), C_p is the specific heat capacity of water (in J g^{-1}°C^{-1}), U is the overall heat transfer coefficient (in J s^{-1} cm^{-2} °C^{-1}), A is the surface area in contact (in cm^2), and M is the mass (in g). Subscripts ‘a’, ‘p’ and ‘w’ denote air, pipe and water, respectively.

Solving the differential equations by a numerical approach, the temperature of the outflow runoff can be obtained. The change in air and pipe temperature can be obtained by a heat balance on air and that on the pipe. Air has a poor thermal conductivity and hence is likely to conduct very little heat.

$$M_a C_{pa} \frac{dT_a}{dt} = U_a A_a \left(T_o - T_a\right) \tag{9}$$

$$M_p C_{pp} \frac{dT_a}{dt} = U_p A_p (T_o - T_p) \tag{10}$$

Where,

$$A_a = 2RL \sin\frac{\theta}{2} \tag{11}$$

$$A_p = R\theta L \tag{12}$$

$$M_a = \rho_a R^2 \left[\Pi - \frac{\theta - \sin\theta}{2}\right] L \tag{13}$$

$$M_p = \rho_a A_p k \tag{14}$$

Here, k is the thickness of the storage pipe in cm. The constants used in the above equations are listed in Table 1.

The model assumes that the stored runoff (if any), pipe and air have the same initial temperature. Runoff inflow and temperature data obtained from the instruments and constants (density and thermal constants) will be the model inputs. The model will perform the heat balance according to the inflow runoff rate and temperature and predict the temperature of outflow runoff as a function of time. The model results can hence be used to quantify the reduction in temperature of runoff.

Since the system is expected to deviate from an ideal behavior of a single CSTR, the degree of mixing of water is to be determined. The conductivity measurements will be used for the residence time distribution analysis. This process is similar to a tracer study to find the dispersion coefficient for a non-ideal reactor. Using this information, the system will be modeled as a CSTR-in-series system to incorporate the non-ideal flow behavior.

3.0 Research Progress

3.1 Instrumentation

The order for the instruments to be installed in the I-83 sites is complete. The instruments are to be installed in the appropriate locations in the study site. The instruments will be housed in a weather-proof enclosure. A 66 cm x 35 cm x 45 cm box will be used to place the instruments, the details of which are shown in Figure 10.

3.2 Model

The thermal constants and other parameters have been determined (Table 1) and the heat transfer model has been formulated based on the derived heat balance equations.

A preliminary simulation of a short-duration storm has been done in Microsoft Excel to observe the model behavior. An underground storage system with a single inflow and single outflow point was considered. The initial temperature of the water, pipe and air was assumed to be 10 $^{\circ}$C. An average rainfall intensity of 3.3 cm/hr (1.3 inch/hr) on a drainage area of 2.65 acres (1.07 ha) and inflow temperature range of 27 - 38 $^{\circ}$C was used. The model output is shown in Figure 11.

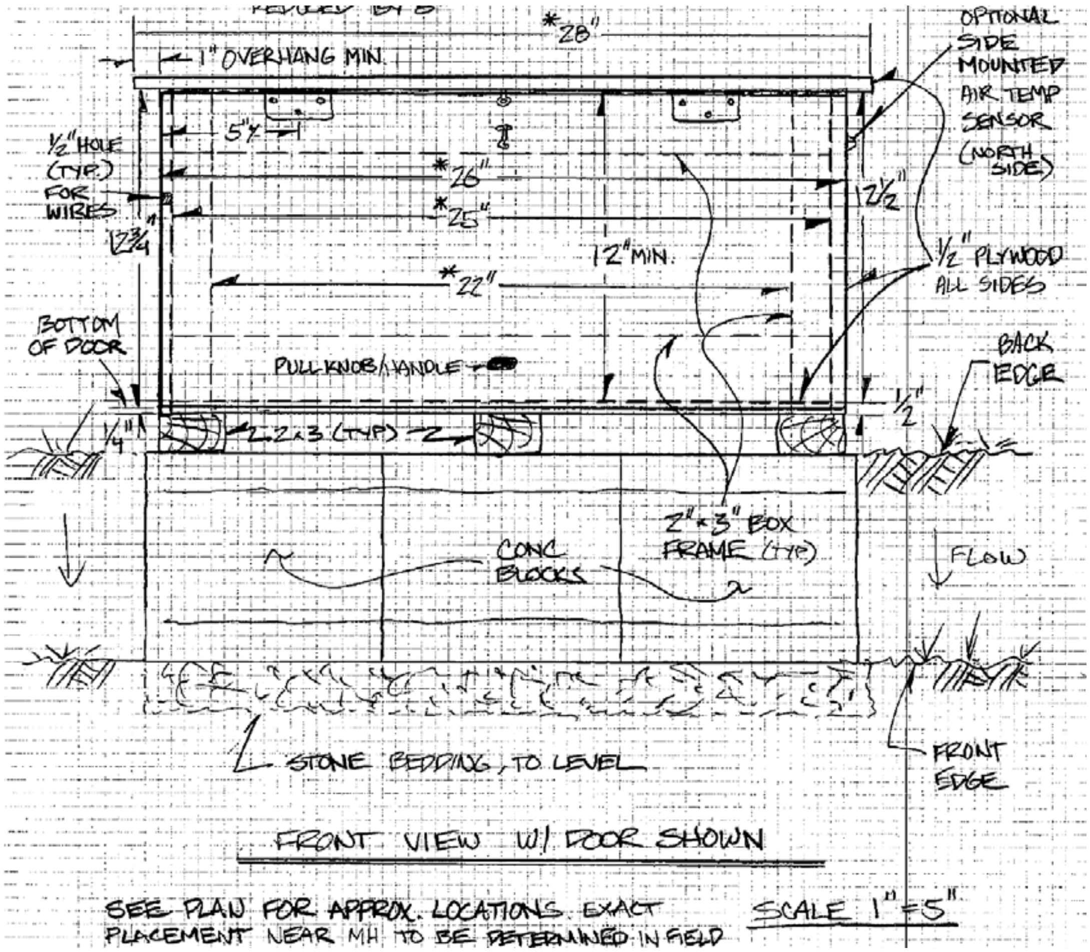


Figure 10. Front view of weather-proof box

As expected, the outflow temperature gradually approaches the inflow temperature. The total input thermal energy was found to be approximately 58 GJ and the total output thermal energy as 42 GJ using absolute temperature. The input event mean temperature (EMT) was computed as 34 °C (307 K) and the output EMT was calculated as 27 °C (300 K). The peak temperature input and output were 38 °C and 36 °C, respectively. The EMT gives an idea of temperature for one storm event and also compares the temperatures of different storm events. The peak temperature values provide a measure of the performance of the BMP.

Table 1. Constants and parameters used in the model

Parameter/Constant		Value	Units	Reference
Data from instruments	Q_i		cm^3s^{-1}	
	T_i		°C	
Constants	g	980	cms^{-2}	Gibson (1952)
	C_d	0.6	-	Gibson (1952)
	ρ_w	1.000	g cm^{-3}	Incorpera and DeWitt (1990)
	ρ_p	0.950	g cm^{-3}	Matweb*
	ρ_a	1.247	g cm^{-3}	Incorpera and DeWitt (1990)
	C_{pw}	4.184	J g^{-1}°C^{-1}	Incorpera and DeWitt (1990)
	C_{pp}	2.197	J g^{-1}°C^{-1}	Matweb*
	C_{pa}	0.715	J g^{-1}°C^{-1}	Incorpera and DeWitt (1990)
	U_p	4.997×10^{-3}	J s^{-1} cm^{-2} °C^{-1}	Matweb*
	U_a	9.993×10^{-5}	J s^{-1} cm^{-2} °C^{-1}	Incorpera and DeWitt (1990)

*http://www.matweb.com/search/SpecificMaterial.asp?bassnum=O4000

Matlab R2006b will be used to solve the modeling system employing a numerical approach. Simulation of a 9-hour storm data set consisting of runoff inflow and temperature has been done. An underground storage system having two inflow and one outflow points has been modeled as 1-CSTR (Figure 8).

The Matlab coding for the hydrology part of the model has been done. Given the inputs of runoff inflow and other parameters, the model will compute the outflow. A Runge Kutta numerical method was used for solving for the theta (θ) differential equation, (Eqn. 3). From the values of θ, the volume of water in the storage pipe was calculated for each time step. The Matlab output of volume of runoff in the underground storage pipe for the 9-hour storm is shown in Figure 12. The first sub plot shows the runoff inflows at the two inlets of the BMP.

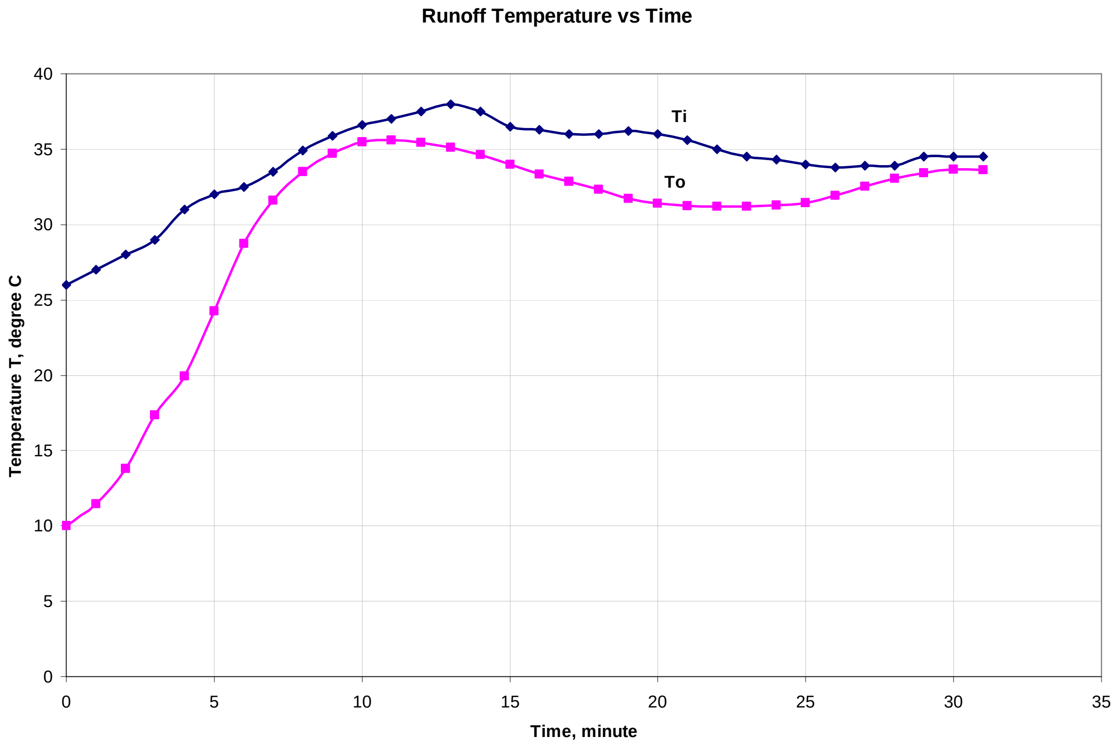


Figure 11. Inflow and outflow runoff temperature with respect to time

For the system considered (Figure 8), the outflow is through a 46 cm (18") pipe. The discharge through the outflow pipe is controlled by the volume of water in the 122 cm (48") storage pipe. The model computes the outflow using a weir equation, orifice equation or no outflow according to the upstream head in the pipe. The theta (θ) differential equation is solved numerically and hence the volume is calculated. The plot of θ and volume (V) with respect to time is shown in Figure 12.

The Matlab coding for the heat transfer module is in progress. The temperature differential equation will also be solved using a Runge-Kutta method.

4.0 Some Implications

The data set obtained and the model results will enable the evaluation of efficiency of the underground storage systems in reducing the temperature of the stormwater runoff. The reduction in temperature of runoff from highways for varying storm intensities and duration occurring in different seasons will provide useful information regarding the impact of these underground storage BMPs in temperature mitigation.

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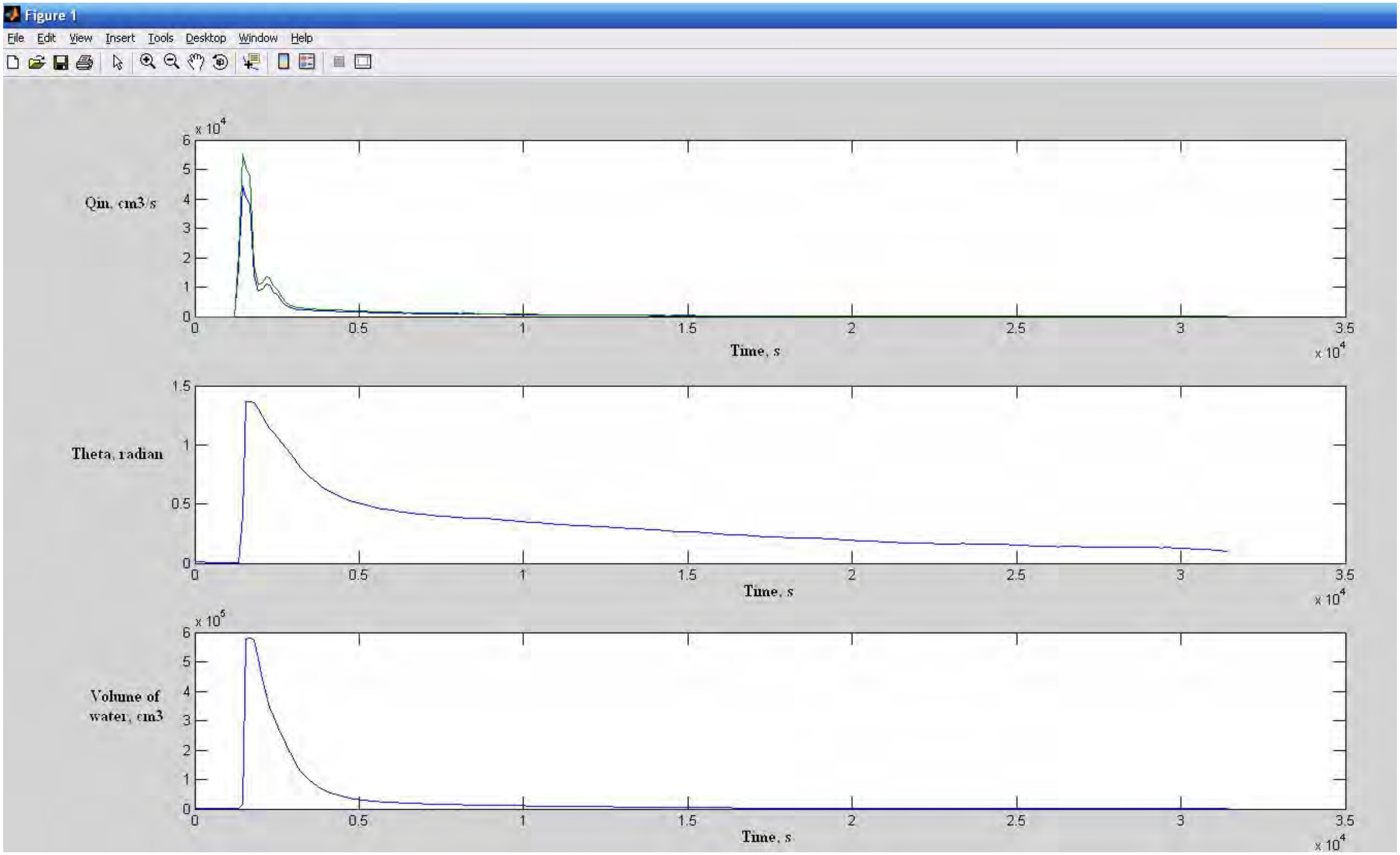

Figure 12. Matlab output of volume of water in the storage pipe for a storm event

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APPENDIX H:

Prediction of Temperature at the Outlet of Stormwater Sand Filters – August 26, 2007 Progress Report

By University of Maryland

Summary Progress Report (September 26, 2007)

Time Period: 1 July 2006 – 1 September 2007

Project Title: Prediction of Temperature at the Outlet of Stormwater Management Structures

Submitted by: K. E. Herold, University of Maryland

Project Objectives

The primary objective is to create a computer model of the current BMP stormwater management structures that will allow prediction of outlet temperature as a function of time. The approach is physics based, depending on energy and mass balances, and heat and mass transfer predictions.

Overview of Activities

This effort has involved the following major tasks:

Task	**Time Frame**
I. Creation of initial computer models	November 2003 – August 2004
II. Bench scale testing of sand filter	March 2004 – August 2004
III. Data collection at UMUC sand filter	Initiated June 2004, 2005, 2006
IV. Data analysis	2005 -->
V. Ad hoc analyses	Throughout, cooling report July 2005

Creation of initial computer models: At the start of the project we created a computer model to predict the temperature in a sand filter when water flows through. The model involved heat and mass balances and involved the assumption of uniform flow of the water through the sand. By numerically solving differential equations, it was possible to predict the outlet temperature of the water as the inlet temperature and flow rate changed with time. This model was designed to be able to handle storm water runoff situations and to predict the thermal mitigation that the sand filter would provide.

Bench scale testing of a sand filter: To evaluate the assumptions in the model, we set up a bench scale sand filter for testing. This was a relatively simple test where we filled a PVC pipe with sand and then allowed water to flow through by gravity. We were able to provide a step change in the inlet water temperature and see the effect on the outlet temperature.

The major result from the bench scale tests was that the system did not behave as expected. We found that the outlet temperature responded to inlet temperature more rapidly than was predicted by the model. We tried a number of things to better understand these results. We obtained a temperature profile at a cross-section in the sand. The profile was not symmetric. This led to the conclusion that the flow through the sand was not uniform. All of the bench scale results seemed to show that the flow through the sand was localized instead of flowing uniformly and wetting all sand particles. We tried various approaches to get it to be more uniform including careful packing of the sand and variations on the outlet particle filter but none of these attempts led to any significant improvement in the apparent non-uniform flow.

Data collection at the UMUC sand filter: Another opportunity to validate the model was to take thermal data from an existing sand filter. We chose to instrument the sand filter on the edge of the UMUC campus. An aerial photograph of the site is shown below as Figure 1. The facility is designed to treat runoff from the parking lots which are close by. We instrumented it with battery-powered data acquisition systems that can record temperatures and water level.

Two Hobo data loggers were used for temperature recording in the sand filter and at the outlet. These units are battery-powered and store data for a few weeks (depending on the rate of storage). The main purpose of the data collection was to correlate the temperatures at the inlet and outlet of the sand filter bed to better understand energy transfer between the water and the bed. For this purpose, the temperature of the water in the pond was characterized by a temperature sensor on the bottom of the pond (inlet to the sand filter) and a sensor in the flow at the outlet. In addition, an air temperature sensor was positioned in a spot near the outlet which was shaded from sun exposure. This arrangement was chosen assuming that the pond temperature sensor is representative of the water inlet temperature to the sand filter. On hindsight, we should have installed multiple sensors to better characterize the pond bottom temperature. The temperature sensors were checked against an independent portable thermocouple temperature sensor and always read within 0.5°C.

An ultrasonic level sensor was used to record pond water level. The sensor was installed in a PVC pipe that was fixed to a concrete entrance pipe housing. After installation, the level sensor calibration was checked against a measuring stick and found to be accurate to +/- 1 cm. The purpose of the water level measurements was to determine the flow rate through the sand filter. The water height is the largest driver of the flow through the sand bed. To obtain the relationship, we measured the outlet flow rate from the sand filter using a bucket and stopwatch method. The flow rate was found to be a simple function of water height as indicated in Figure 2. Flow rates at high water levels were difficult to measure because the bucket filled up rapidly. The outlier point was the first one attempted at the high flow rates and was known to be erroneous but is included here for historical documentation. That outlier point was ignored in generating the curve fit that is also shown in Figure 2. The curve fit was used in all subsequent data analysis of water level. It is important to note that the flow rate is non-zero even when the water level in the pond goes to zero. This is apparently to due some underground bypass flow that follows a short-circuit through the system. Under dry conditions when the pond was empty by visual observation there was often still a small trickle flow rate into the pond system and a corresponding outflow.

The testing timeline is shown on Figure 3. Although there is a small number of sensors, numerous things went wrong during the testing. These included flooded data loggers, construction activity at the site, battery problems, and others. The end result is that the data is not continuous over the entire season. However, we were able to get stretches of continuous data that tell an important story. The complete data is too extensive to include in this summary report. As a representative set, the data from October 2005 is included here.

Figure 1. Aerial view of UMUC sand filter site

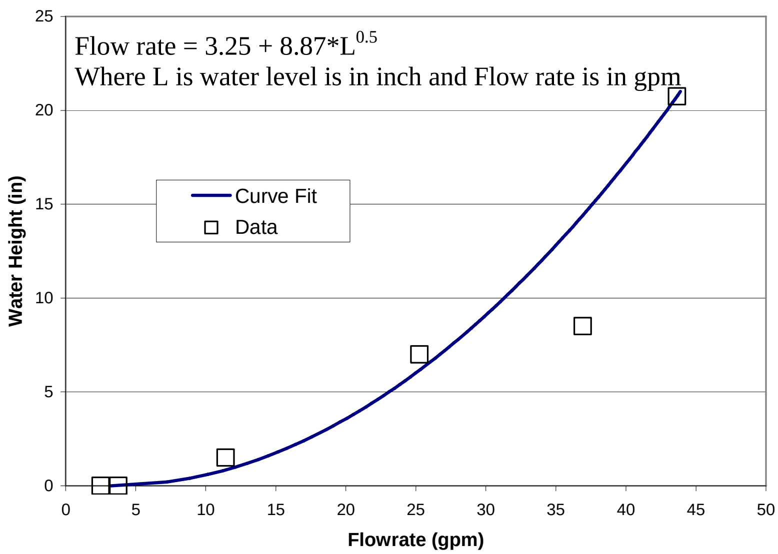

Figure 2. Flow rate to water level correlation for UMUC sand filter

Figure 4 shows the data for most of October 2005. The vertical grid lines are at intervals of one week. The plot includes the three temperature sensors and the flow rate deduced from the water level. This data set is interesting because it includes three major storms which show up as large outflow rates. For situations where the level sensor reported negative levels, a zero flow rate was plotted. Flow rates below 10 gpm are not considered very significant. During dry spells between storms, the pond dries out and the pond temperature tends to follow the air temperature closely except that the air temperature peaks are higher. This is thought to be due to the thermal capacitance of the ground on which the sensor is laying. In some cases, the outlet water temperature also follows the air temperature closely – these are times when the system dries out completely and there is no flow at the outlet. For the majority of the time, the outlet water temperature is significantly different from the air temperature, often exhibiting a value that is some kind of average between the high and low values of the air temperature for that day. The daily periodicity of the air temperature is evident for most days, with the exception of days where there was significant cloud cover.

An interesting observation is that the outlet water temperature seems to follow closely the pond temperature for periods where there is water in the pond. During the three storms, this correlation is evident. These periods are thought to represent the data that is most significant for answering the question about energy transfer between the water and the sand. If there is significant energy transfer, then we would expect a significant time lag between the two signals with the outlet temperature lagging the pond temperature. Calculations from our model assuming uniform flow through the sand, indicate a time constant on the order of 6 hours. This type of energy transfer would be of interest for stormwater thermal mitigation. However, the data does not seem to exhibit much time lag. The largest phase difference observed appears in the last week of October and it is in the wrong direction (that is, the data shows the outlet temperature leading the pond temperature).

We examined all of the data to evaluate this aspect and we concluded that the data does not indicate much energy storage in the sand.

Ad-hoc analyses: During the project, we have analyzed a number of ideas and design concepts for thermal mitigation. These have included passive schemes (heat transfer to the soil or air using a heat exchanger) and active systems using refrigeration (including ground coupled and air-cooled systems). Some of these analyses were more involved than others depending on SHA needs. The end result of these analyses is that we did not find any scheme that was as attractive as the sand filter. In particular, most of the schemes require some electric power input that would increase cost (both capital and operating). If we were willing to bear the cost, we could easily arrange cooling but the intermittent nature of the stormwater would require some sort of storage system and the cooling would have to be augmented by fans or active cooling. The only scheme considered that does not require an energy input is an underground reservoir. Unfortunately, the soil surrounding such a structure would act as a very effective thermal insulator so that it would take weeks or months to transfer a significant amount of the energy – this option was rapidly ruled out as ineffective from a thermal standpoint.

Discussion

Data from both our bench tests and the UMUC sand filter indicate that the flow through the sand is not uniform. A literature review was initiated to find other work on this subject. The

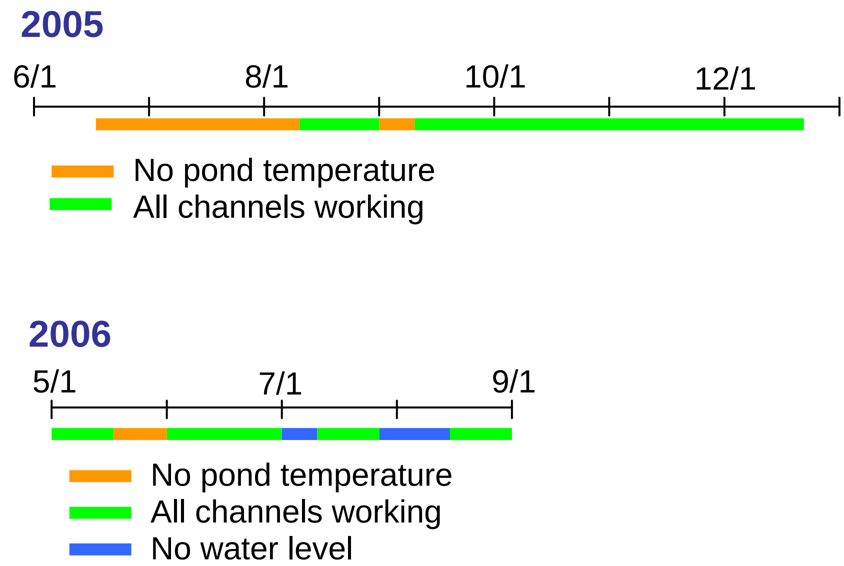

Figure 3. Timeline of main testing at UMUC sand filter

term used in the literature is “preferential flow”. It means non-uniform flow. Instead of flowing uniformly around each sand particle, water in sand (and other soils) tends to flow in channels (called fingers in the literature). These channels not fully understood but they are possibly caused by the wetting characteristics of the soil. Preferential fingered flow is found to be reproducible in the sense that the fingers in a given soil sample occur in the same location from one water flow event to another. This may be due to a complex set of physical and chemical phenomena that create preferentially wet-able channels. For our purposes, it means that the water does not come into energy-exchange contact with much of the sand in the system. The following literature review covers a small subset of the available literature on the subject.

Literature Review

The subject of preferential flow in porous media is a complex subject that manifests itself on several scales from geological flows through cracked rock to sand and soil permeation. A large body of literature exists on the subject. The present review is of a small subset of the literature selected from the most recent articles that appear relevant.

The scientific consensus seems to be that the problem of preferential flow through sand or soil is not completely understood. This is reflected in the large number of approaches used to study the problem and the jargon used to describe it. Preferential flow is used to describe any non-uniform flow through the sand matrix. The term fingering flow is also used (Dekker et al. 1994; Ritsema et al. 1997; de Rooij 2000; Sililo et al. 2000; Rezanezhad et al. 2006). Fingering flow has been traced to soil wetting characteristics (Ritsema et al. 1996; Ritsema et al. 1997; Dekker et al. 1998; Dekker et al. 1999; Dekker et al. 2000; Dekker et al. 2001; Dekker et al. 2005; Dekker et al. 2005; Garcia et al. 2005; Taumer et al. 2006), presence of air in the soil (Rezanezhad et al. 2006) and the presence of roots (Johnson et al.

2006). The preferential flow is found to recur in particular locations and this has been explained by wetting characteristics (Ritsema et al. 1997).

Many different experimental methods have been used to attack this problem but the basic difficulty is that there are too many variables that can influence the flow (Freeland et al. 2006; Kung et al. 2006). Various modeling attempts have been made (Gardenas et al. 2006) but they have generally been of limited use because of the same issues.

When sand it used as a filter with a permeable reactive barrier, the barrier tends to experience bio-clogging (Seki et al. 2006) that further encourages preferential flow by funneling the entry flow.

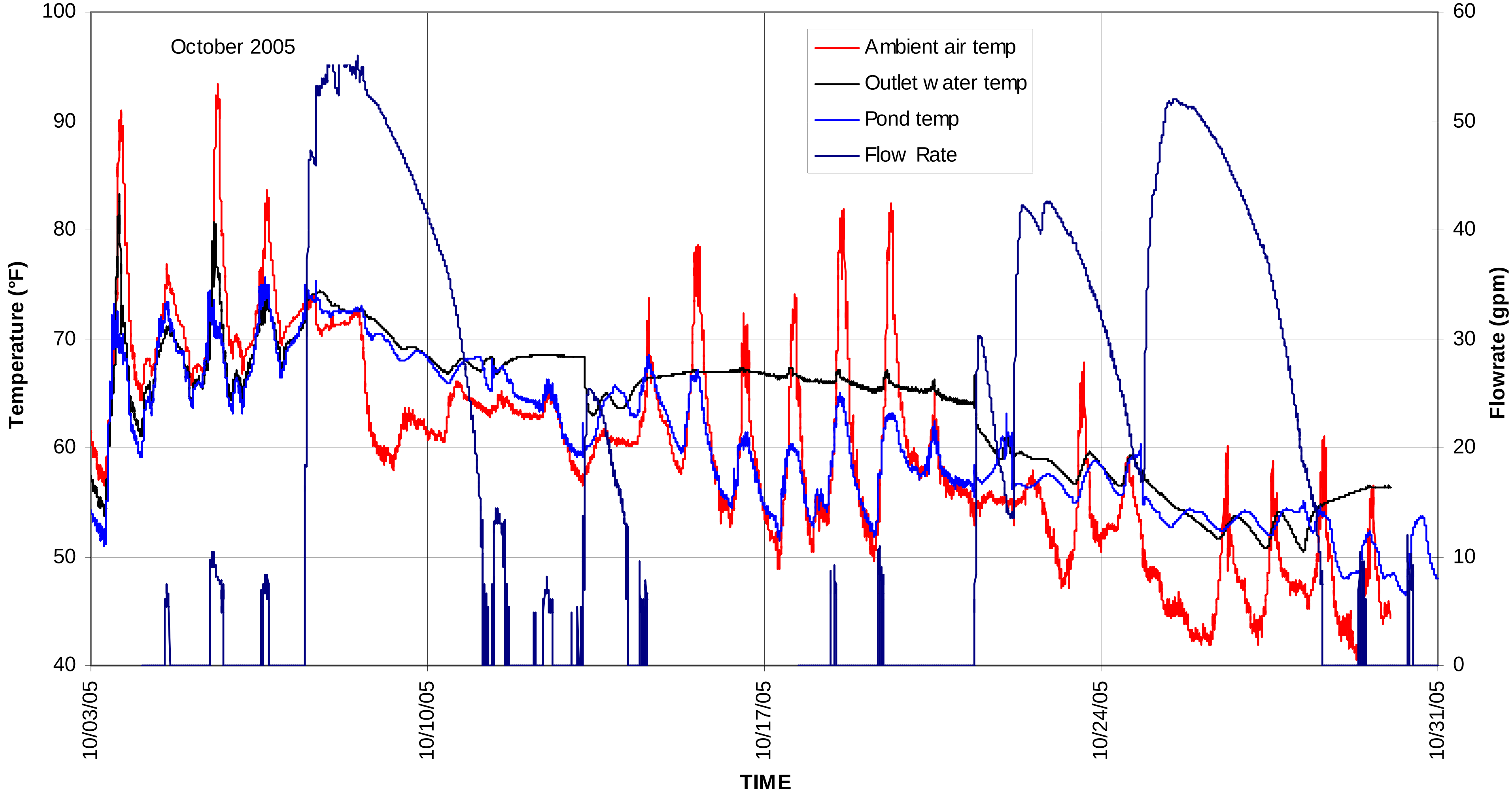

Figure 4. UMUC sand filter data from October 2005

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APPENDIX I:

Industrial NPDES Capital Improvement Summary

Industrial NPDES Capital Improvement Summary

DISTRICT	FACILITY	ITEM	FY04	FY05	FY06	FY07	FY08	FY09	FY10
1	**Berlin**	Fuel Canopy & Drainage - New		X					
		Material Storage Bin Structure - New					O		
		Berm/Swale to Divert Site Runoff						O	
	Cambridge	AST - Removal and Remediation			X				
		Oil Water Separator Upgrade					O		
		Material Storage Bin Structure - New					O		
		Berm/Swale to Divert Site Runoff						O	
	Princess Anne	Oil Water Separator Upgrade					N		
		AST - Removal and Remediation					O		
		Berm/Swale to Divert Site Runoff						O	
	Salisbury	Washbay - Retrofit				U	U		
	Snow Hill	Oil Water Separator - Connection to Public Sewer System			X				
2	**Centreville**	Oil Water Separator Upgrade			X				
	Chestertown	Washbay - Retrofit				U	U		
		Oil Water Separator Upgrade					O		
	Denton	Oil Water Separator Upgrade			X				
		Material Storage Bin Structure - New					O		
		Fuel Canopy Downspout/Oufall - Retrofit						O	
		Brine Operations - Retrofit/Repair							O
		Water Quality BMP							O
	Easton	Material Storage Bin Structure - New					O		
		Berm/Swale to Divert Site Runoff						O	
	Elkton	Material Storage Bin Structure - New	X						
		Riprap Channel Construction for Erosion Control						O	
	Millington	Fuel Canopy & Drainage - New						O	
	Stevensville	Salt Contamination Remediation/ Site Redevelopment				U	U		

Note: X = Completed N = No Longer Necessary
U = Underway O = Pending

Industrial NPDES Capital Improvement Summary

DISTRICT	FACILITY	ITEM	FY04	FY05	FY06	FY07	FY08	FY09	FY10
3	**Fairland**	Drainage Coverage						O	
		SWM Infiltration Trench Retrofit							O
	Gaithersburg	Oil Water Separator Repair		X					
		Material Storage Bin Structure - New					O		
		Fuel Canopy Downspout/Oufall - Retrofit						O	
		Berm/Swale to Divert Site Runoff						O	
		Brine Operations - Retrofit/Repair							O
	Kensington	Material Storage Bin Structure - New					O		
		Berm/Swale to Divert Site Runoff						O	
	Laurel	N/A							
	Marlboro	AST - Removal & Remediation					O		
		Inlet Grit Chamber - New					O		
		SWM Infiltration Basian Retrofit							O
	Metro/Landover	Material Storage Bin Structure - New					O		
		Fuel Canopy & Drainage - New						O	
		Berm/Swale to Divert Site Runoff						O	
4	**Churchville**	Oil Water Separator Upgrade			X				
		Plumbing - Connect to Oil Water Separator			X				
		Fuel Canopy Downspout/Oufall - Retrofit						O	
	Golden Ring	Control						O	
	Hereford	Oil Water Separator Upgrade	X						
		Washbay Treatment System Upgrade					U		
		Material Storage Bin Structure - New					O		
		Berm/Swale to Divert Site Runoff						O	
	Owings Mills	Sewer System			X				
		Material Storage Bin Structure - New					O		

Note: X = Completed N = No Longer Necessary
U = Underway O = Pending

Industrial NPDES Capital Improvement Summary

DISTRICT	FACILITY	ITEM	FY04	FY05	FY06	FY07	FY08	FY09	FY10
5	**Annapolis**	Erosion Stabalization				U	U		
		Material Storage Bin Structure - New					O		
		Berm/Swale to Divert Site Runoff						O	
		Water Quality BMP							O
	Glen Burnie	Dewatering Structure - New		X					
		Fuel Canopy Downspout/Oufall - Retrofit		X					
		Bioretention Retrofit			U	U	U		
		Material Storage Bin Structure - New					O		
	Hanover Complex	Oil Water Separator Upgrade			X				
	LaPlata	Oil Water Separator - Connection to Public Sewer System			X				
		Material Storage Bin Structure - New					O		
	Leonardtown	Oil Water Separator Upgrade	X						
		Washbay Treatment System Upgrade				U	X		
		Material Storage Bin Structure - New					O		
		Berm/Swale to Divert Site Runoff						O	
	Prince Frederick	Oil Water Separator - Connection to Public Sewer System		X					
		Fuel Canopy Downspout/Oufall - Retrofit		X					
		Washbay - Retrofit				U	X		
		Inlet Sediment Trap						O	
		Riprap Channel for Erosion and Sediment Control						O	
		Water Quality BMP							O

Note: X = Completed N = No Longer Necessary
U = Underway O = Pending

Industrial NPDES Capital Improvement Summary

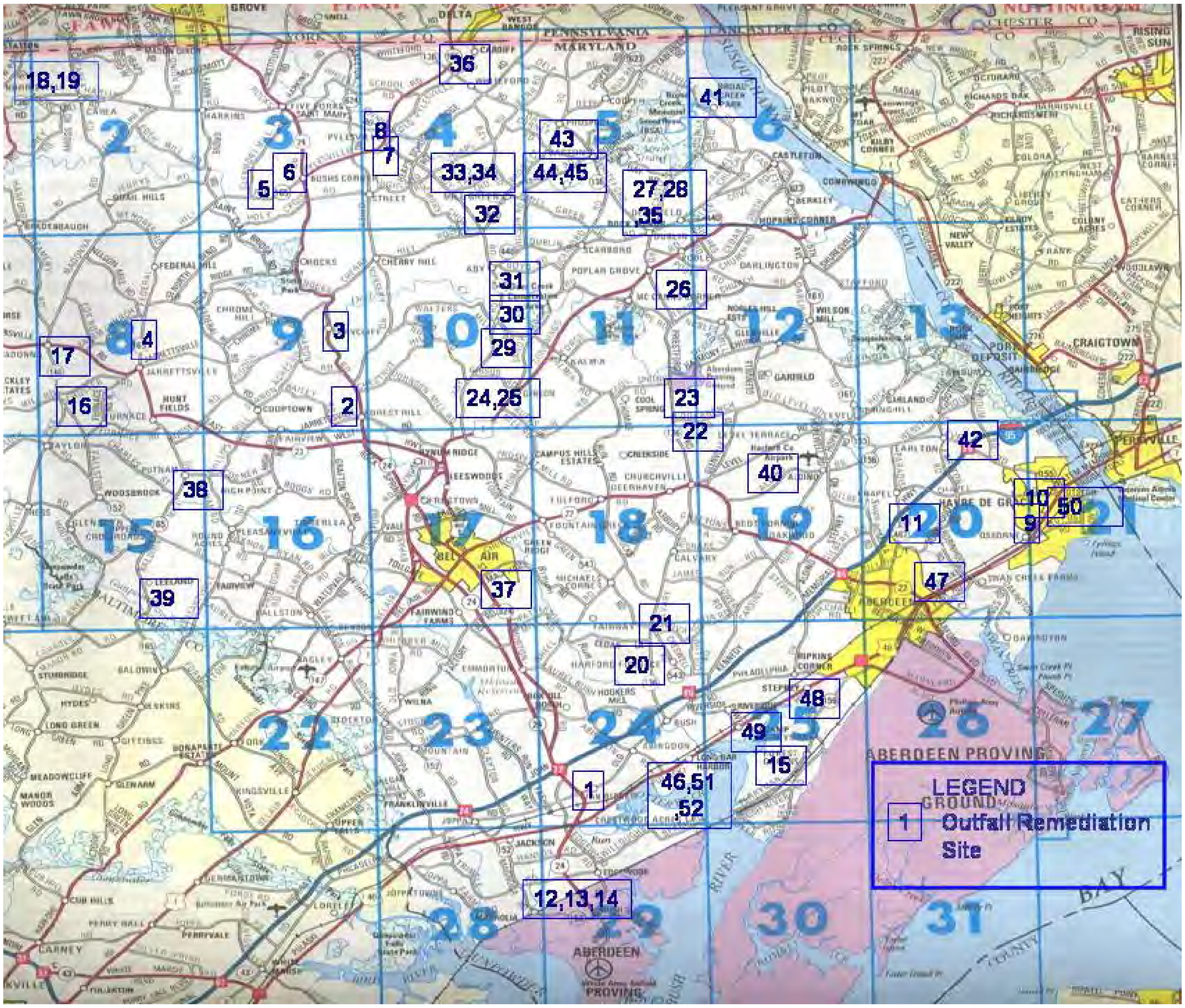
DISTRICT	FACILITY	ITEM	FY04	FY05	FY06	FY07	FY08	FY09	FY10
6	**Frostburg**	Material Storage Bin Structure - New					O		
		Water Quality BMP							O
	Hagerstown	Washbay - Retrofit				U	U		
		Fuel Canopy Downspout/Oufall - Retrofit						O	
	Hancock	Fuel Canopy & Drainage - New						O	
		Storm Drain System - New Construction						O	
		Water Quality BMP							O
	Keysers Ridge	Oil Water Separator Upgrade			X				
		Washbay - Retrofit				U	U		
		Oil Water Separator - Connection to Public Sewer System						O	
		Fuel Canopy Downspout/Oufall - Retrofit						O	
		Water Quality BMP					O		
	LaVale	Washbay - Retrofit				U	U		
		Fuel Canopy Downspout/Oufall - Retrofit						O	
	Oakland	Fuel Canopy Downspout/Oufall - Retrofit		X				O	
		Material Storage Bin Structure - New					O		
		Inlet Sediment Trap					O		
		Water Quality BMP							O
7	**Dayton**	N/A							
	Frederick	Material Storage Bin Structure - New					O		
	Thurmont	Oil Water Separator Upgrade					N		
		Water Quality BMP							O
	Westminster	N/A							

Note: X = Completed N = No Longer Necessary
U = Underway O = Pending

APPENDIX J:

Storm Drain Outfall Inspection & Remediation Program – Remediation Sites

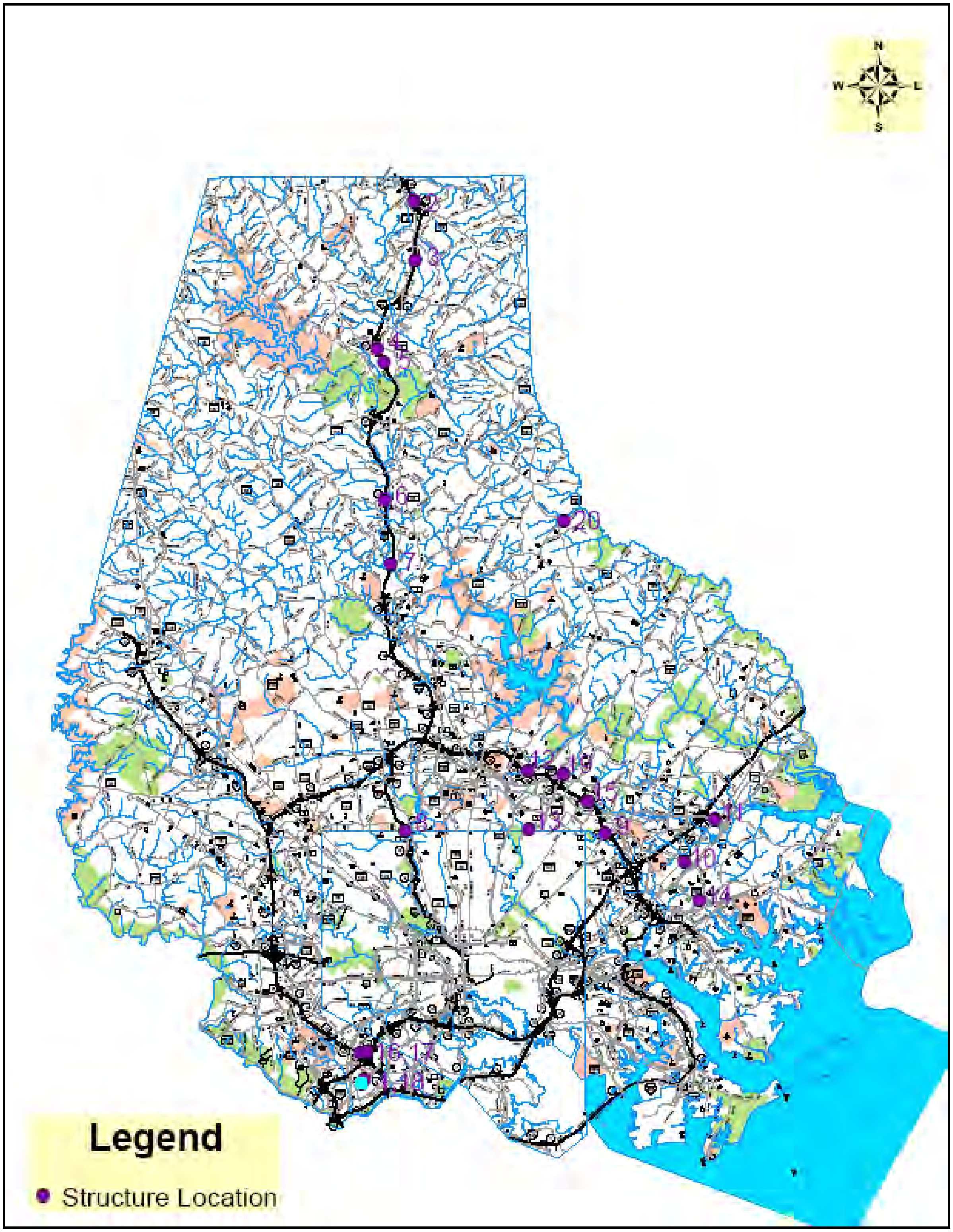
Harford County
Baltimore County



HARFORD COUNTY OUTFALL REMEDIATION SITES

Map Location No.	Pipe number	Rating	Location	Pipe type	upstrm_str
1	1200054	4	MD 24 APPROX 500' NORTH OF PULASKI/EMMORTON CONNECT	24" HDPE	1200027.002
2	1200158	4	MD 24 NW OF INTERSECTION W/ JARRETTSVLLE RD	18" RCP	1200121.002
3	1200188	4	MD 24 - 3222 ROCKS ROAD	54" x 36" CMP	1200161.002
4	1201449	4	MD 165 APPROX 7500' NORTHEAST OF NORRISVILLE ROAD	18" CMP	1200305.002
5	1201636	4	MD 165 APPROX 4000' WEST OF ROCKS ROAD	24" CMP	1200327.002
6	1201639	4	MD 165 300' NORTHWEST OF OLD PYLESVILLE ROAD	30" RCP	1200331.002
7	1200617	4	MD 543 APPROX. 45' NORTH OF OLD PYLESVILLE ROAD	18" CMP	1200346.002
8	1201649	4	MD 165 APPROX 1200' NORTH OF ADY ROAD	30" RCP	1200348.002
9	1202535	4	US 40 APPROX 1200' NORTHEAST OF OLD POST SPLIT	15" CMP	1200554.002
10	1201580	4	US 40 APPROX 570' SOUTHWEST OF LEWIS LANE	15" CMP	1200561.002
11	1201794	4	MD 462 @ I-95 SOUTH OF BRIDGE	24" CMP	1200656.002
12	1200543	4	MD 152 APPROX 55' SOUTHEST OF FORT HOYLE ROAD	15" CMP	1201000.002
13	1200545	4	MD 152 APPROX 430' SOUTHWEST OF FORT HOYLE ROAD	15" CMP	1201001.002
14	1200547	4	MD 152 APPROX 700' SOUTHWEST OF FORT HOYLE	18" CMP	1201002.002
15	1200030	4	MD 159 APPROX 570' SOUTHWEST OF CANNING HOUSE ROAD	12" CMP	1201105.002
16	1201032	4	MD 146 @ MD 152	30" RCP	1201177.002
17	1021040	4	MD 146 - 500' SOUTH OF MD23	24" CMP	1201182.002
18	1021075	5	MD 136 APPROX 40' EAST OF ISLAND BRANCH ROAD	21" CMP	1201204.002
19	1201080	5	MD 136 APPROX 100' WEST OF CAREA RD	12" RCP	1201209.002
20	1201084	4	MD 136 1/4 MILE NORTH OF GOAT HILL ROAD	18" CMP	1201241.002
21	1201088	4	MD 136 - 500' NORTH OF MD 543	12" PVC	1201245.002
22	1200999	4	MD 136 150' NORTH OF E MEDICAL HALL ROAD	18" CMP	1201268.002
23	1201009	4	MD 136 APPROX 3000' SOUTHEAST OF PALMER VIEW DRIVE	36" CMP	1201274.002
24	1200671	4	MD 543 APPROX. 3030' NORTH OF SLADE LANE	15" CMP	1201303.002
25	1200866	4	MD 543 APPROX. 820' SOUTHWEST OF CHESTNUT HILL ROAD	15" CMP	1201305.002
26	1200958	4	MD 136 350' SOUTHEAST OF POPLAR GROVE ROAD	18" CMP	1201320.002
27	1201106	4	MD 136 APPROX. 1190' SOUTHEAST OF DEERFIELD ROAD	36" CMP	1201326.002
28	1201107	4	MD 136 APPROX. 400' NORTHWEST OF DEERFIELD ROAD	15" CMP	1201327.002
29	1200681	4	MD 543 APPROX. 1490' NORTH OF SMITHSON DRIVE	42" CMP	1201344.002
30	1200687	4	MD 543 APPROX. 1600' NORTH OF EAST WALTERS MILL ROAD	24" CMP	1201350.002
31	1200699	4	MD 543 APPROX 360' NORTHWEST OF BRINEGAR ROAD	18" CMP	1201357.002
32	1200710	4	MD 543 APPROX. 420' SOUTHEAST OF DOYLE ROAD	18" CMP	1201368.002
33	1200719	4	MD 543 APPROX. 560' SOUTHEAST OF HEAPS ROAD	48" RCP	1201377.002
34	1200720	5	MD 543 APPROX 40' SOUTHEAST OF HEAPS ROAD	18" RCP	1201378.002
35	1201109	4	MD 136 APPROX 2100' NORTHWEST OF DEERFIELD ROAD	24" CMP	1201385.002
36	1201121	4	MD 136 1000' SOUTH OF MD165 INTERSECTION	24" RCP	1201408.002
37	1201266	4	MD 924 100' SOUTH OF VICTORY LANE	30" CMP	1201431.002
38	1201669	4	MD 165 APPROX 7800' SOUTHWEST OF EAST-WEST HIGHWAY	49"x33" CMP	1201473.002
39	1201678	4	MD 165 APPROX 8000' SOUTH OF FALLSTON ROAD	18" CMP	1201493.002
40	1201763	4	MD 156 APPROX. 2165' SOUTHWEST OF TIMOTHY ROAD	12" CMP	1201523.002
41	1201710	4	MD 623 APPROX 200' NORTHEAST OF PADDRICK ROAD	24" RCP	1201538.002
42	1201630	4	MD 155 APPROX. 980' NORTHWEST OF I-95	36" RCP	1201570.002
43	1201911	4	MD 646 APPROX 730' SOUTH OF WHITEFORD ROAD	36" RCP	1201627.002
44	1201919	4	MD 646 APPROX 1300' NORHTEAST OF BAY DRIVE	18" RCP	1201635.002
45	1201833	4	MD 646 APPROX 1100' SOUTHWEST OF BAY DRIVE	36" RCP	1201638.002
46	1202563	4	US 40 APPROX 1160' SOUTHWEST OF OTTER POINT ROAD	24" RCP	1201661.002
47	1202793	4	US 40 WEST OF BEARDS HILL ROAD	15" CMP	1201696.002
48	1202783	4	US 40 APPROX 1000' SOUTHWEST OF SPESUTIA ROAD	15" RCP	1201673.002
49	1202648	5	US 40 APPROX 640' NORTHEAST OF LONG BAR HARBOR ROAD	18" RCP	1201683.002
50	1203106	4	US 40 SOUTHWEST OF OTSEGO STREET	18" RCP	1201706.002
51	1202640	5	US 40 APPROX 4000' SOUTHWEST OF OTTER POINT ROAD	24" CMP	1201724.002
52	1202566	4	US 40 APPROX 470' SOUTHWEST OF OTTER POINT ROAD	30" RCP	1201727.002

TABLE OF HARFORD COUNTY SITES



BALTIMORE COUNTY OUTFALL REMEDIATION SITES

Map Location No.	Pipe Number	Rating	Location	Pipe Type	upstrm_str
1	303971	4	US ALT 1- Across From CNR Lighting	36" RCP	301136.005
2	310715	4	I-83 NBL at MD439	24" CMP	301242.004
3	310766	4	I-83 SBL Before Exit 33	30" CMP	301259.002
4	310614	4	I-83 SBL- SW Ramp Exit 31	30" RCP	301300.002
5	310609	4	I-83 NBL at Mile 30	36" RCP	301304.002
6	310818	4	I-83 at Belfast Road NW Quad	18" RCP	301343.010
7	310879	4	I-83 NBL- One Mile Past Shawan Road Exit	36" RCP	301373.002
8	311241	4	I-83 SBL at Baltimore City/County line	24" RCP	301868.002
9	309265	3	US 1 at 695 Ramp	24" RCP	302056.002
10	309475	4	MD 7 EBL Past King Avenue	24" CMP	302151.003
11	309448	4	MD 43 EBL at MD 7	24" RCP	302161.002
12	304505	4	I-695 West Ramp	24" CMP	302274.002
13	304352	4	MD41	18" RCP	302346.002
14	304015	4	MD 700 North Bound Lane, by Windsor House Apts.	15" CMP	302407.004
15	307505	4	MD147/ I-695- NE Quad.	24" RCP	302632.002
16	313630	5	I-695/ I-95 Interchange	36" RCP	302984.002
17	313633	4	I-695/ I-95 Interchange	18" CMP	302993.004
18	303973	4	US-1 ALT- Across From Kangaroo Coach	28" CMP	320719.002
19	304390	3	MD41 north of Satyr Hill Rd.	30" CMP	321018.002
20	304988	4	MD 146 at 15041	18" CMP	321308.002

TABLE OF BALTIMORE COUNTY SITES

APPENDIX K:

Illicit Discharge Screening Reports

Frederick County
Howard County
Montgomery County

FREDERICK COUNTY
ILLICIT DISCHARGE INSPECTION

Submitted June 11, 2007

Submitted to:
Karen Coffman
Highway Hydraulics Division
Maryland State Highway Administration
707 N. Calvert St.
Baltimore, Maryland 21202

Prepared by:

GREENMAN-PEDERSEN, INC.

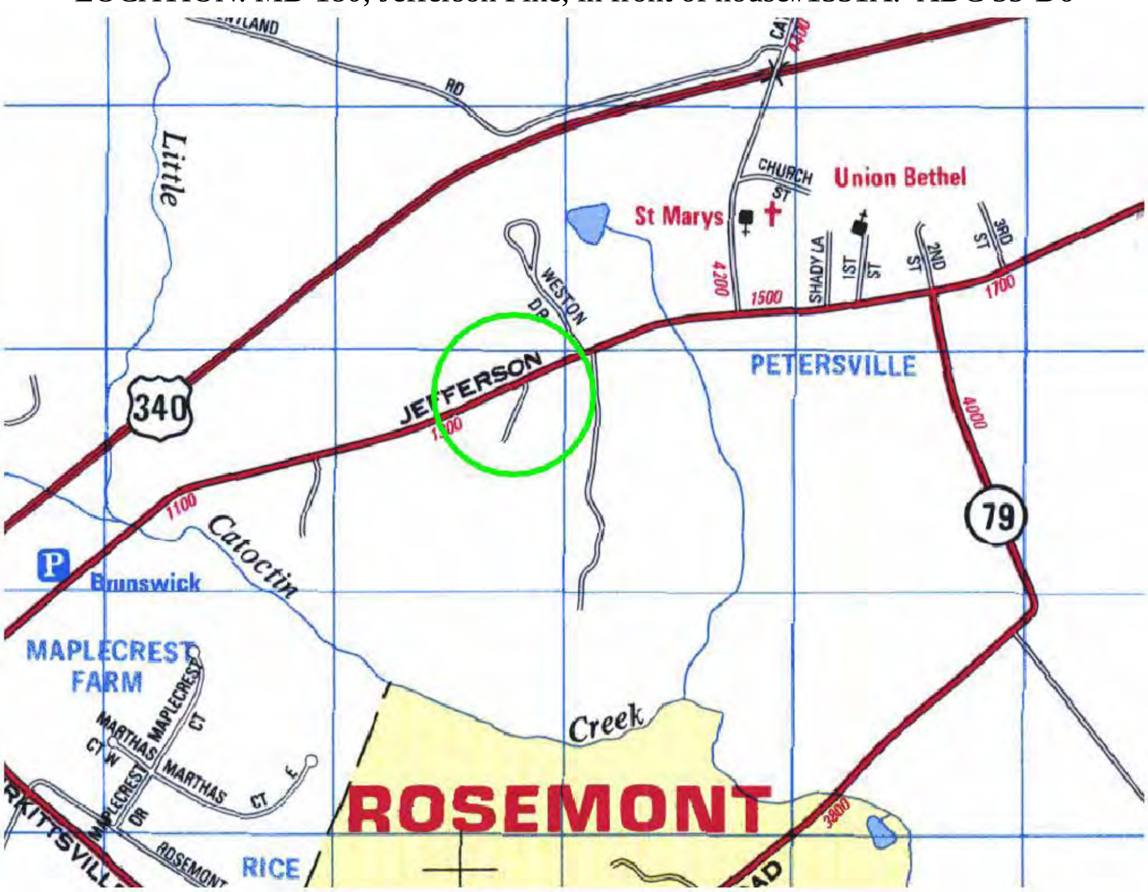
CHESAPEAKE ENVIRONMENTAL MANAGEMENT, INC.

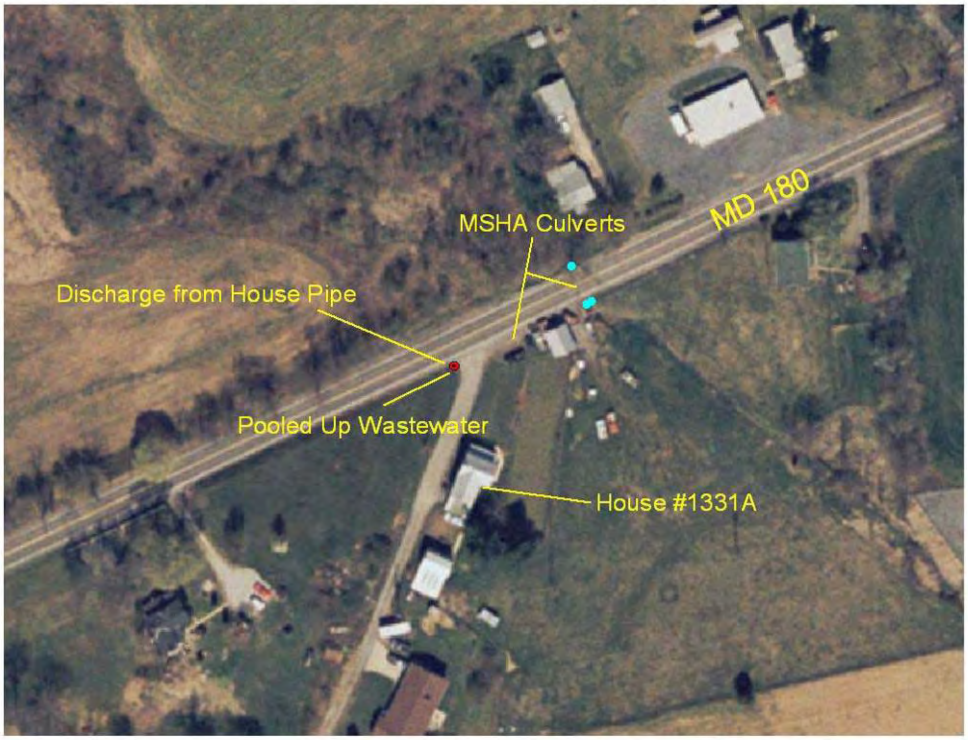
Illicit Connection 1

On May 18, 2005 while verifying Maryland State Highway Administration (MSHA) owned stormwater structures in Frederick County, a PVC pipe connected to house #1331A along MD 180 was found to be discharging laundry and other wastewater into a MSHA culvert. The PVC pipe conveying the wastewater is visible next to a headwall, in which the owner of the property admitted to connecting his house to the culvert. The wastewater discharge flows through a MSHA culvert before it outfalls into a natural stream.

On March 14, 2007 illicit discharge inspectors revisited the site to verify the illicit connection. The PVC pipe was uncovered by inspectors, beneath a layer of soil and leaves. Once the end of the pipe was dug out, effluent that was backed up within the pipe was released. The effluent smelled like sewage and was too thick to sample using the field test kit. The downstream SHA outfall is buried beneath riprap at the stream and could not be inspected (12" CMP pipe was in adequate condition at upstream headwall).

LOCATION: MD 180; Jefferson Pike, in front of house#1331A. ADC 35-D6






Wastewater discharge at SHA culvert inflow point.

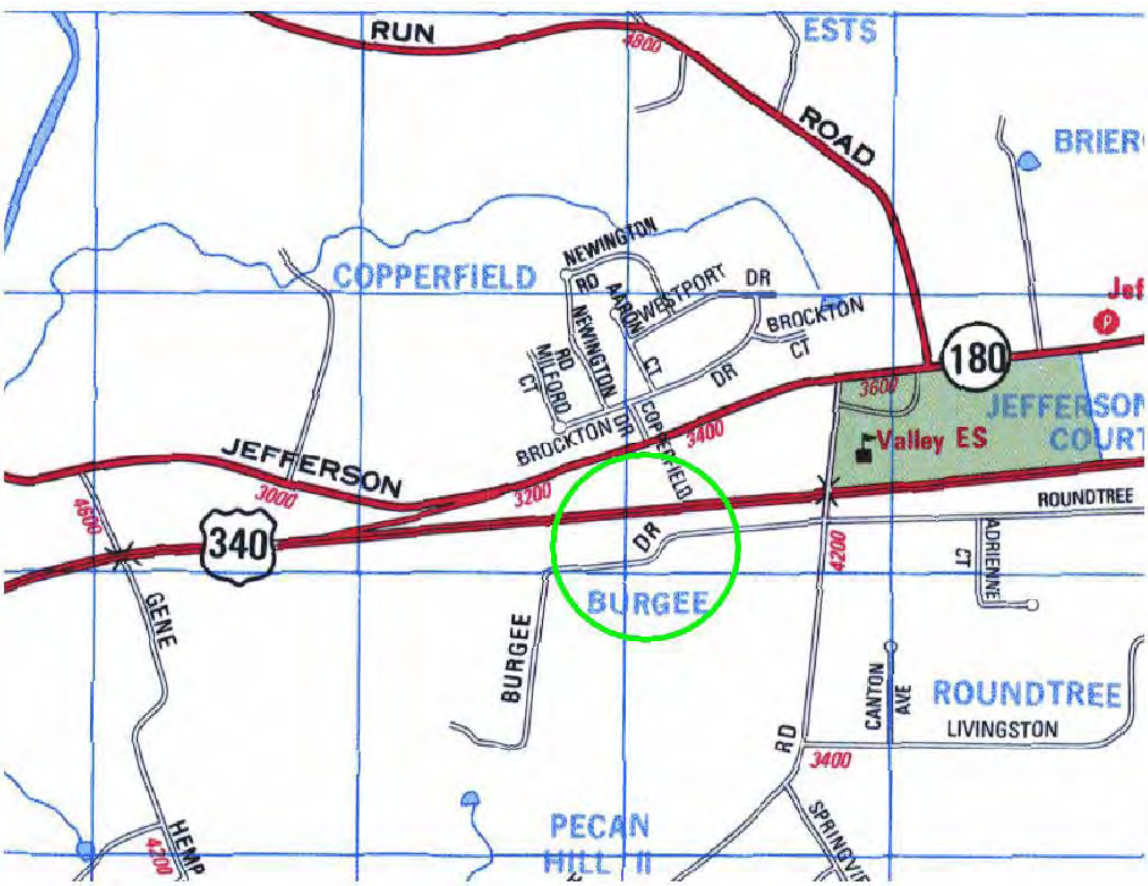
1331A Jefferson Pike.

Illicit Connection 2

On June 15, 2005 while verifying Maryland State Highway Administration (MSHA) owned stormwater structures in Frederick County, a pipe connected to house #3302 along Burgee Drive (next to US 340) was found to be discharging raw sewage into a MSHA culvert. The pipe conveying the raw sewage was not visible from the house, but there were signs of discharge in the grass ditch leading to the MSHA culvert and inside the culvert. After the raw sewage flows through a MSHA culvert under Burgee Drive, it is then discharged into a farm field.

On March 14, 2007 illicit discharge inspectors revisited the site to verify the illicit connection. Although the downstream SHA outfall #1001748.001 was dry, a trickle of water from the pipe connected to house #3302 on Burgee Drive was flowing. Between the pipe and the SHA culvert, signs of heavier recent flow were observed. The sample taken from the trickling pipe had a sewage smell. When field tested, the sample exceeded allowable limits for detergents (.5 mg/L).

LOCATION: Directly in front of house #3302 on Burgee Drive. ADC 36-E3



Wastewater discharge at 3302 Burgee Drive.

3302 Burgee Drive.

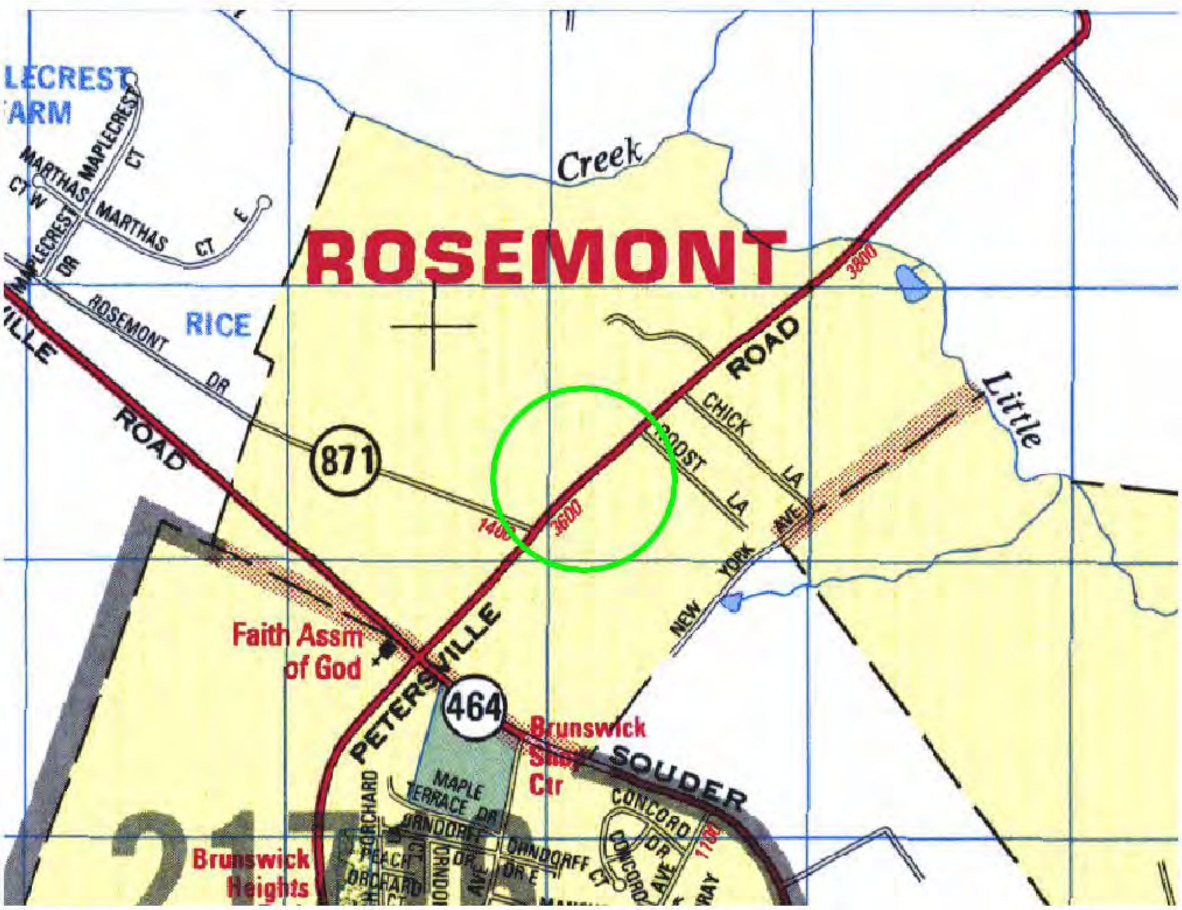
Downstream SHA outfall structure #1001748.001.

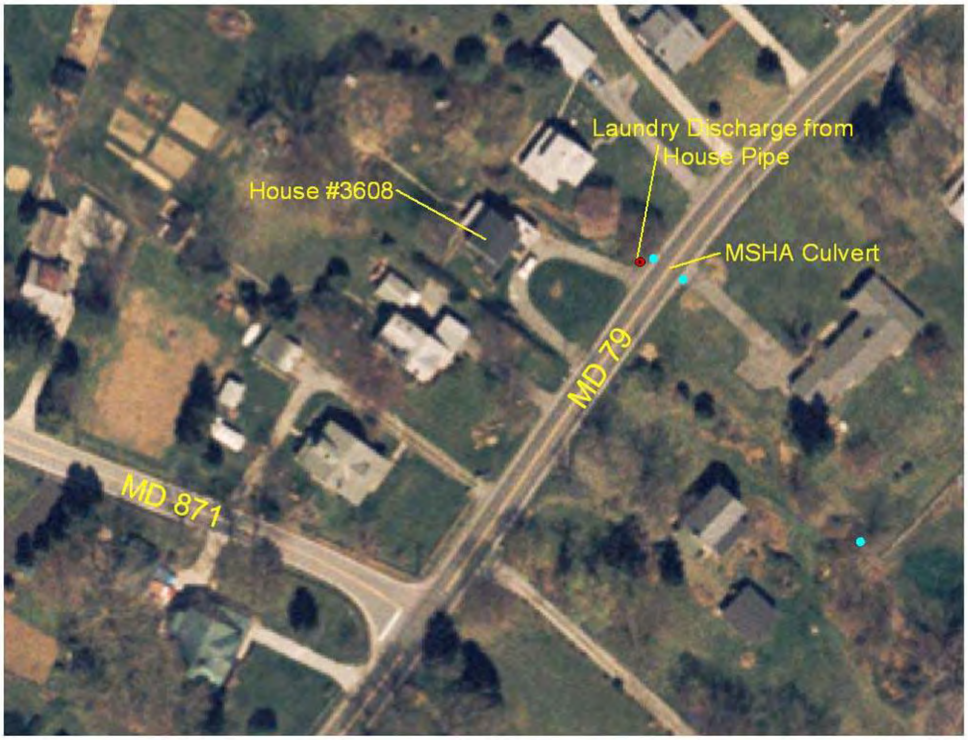
Illicit Connection 3

On May 4, 2005 while verifying Maryland State Highway Administration (MSHA) owned stormwater structures in Frederick County, a PVC pipe connected to house #3608 along MD 79 was found to be discharging laundry wastewater into a MSHA "S" inlet. The PVC pipe conveying the laundry wastewater is visibly connected to the house. The laundry discharge flows through a MSHA culvert and then outfalls into a farm field.

On March 14, 2007 illicit discharge inspectors revisited the site to verify the illicit connection. Two PVC pipes connected to house #3608 were observed, one near the house garage and one closer to the inlet on Petersville Road. The pipe nearest the road was active at the time of visit, and the other was not. The active flow was sampled and field tested, and none of the test parameters were exceeded. The discharge from this pipe could be untreated groundwater (sump pumped), and investigation of the other connected pipe may be necessary. In addition, the downstream SHA outfall, a 12" reinforced concrete projecting pipe, was in adequate condition.

LOCATION: MD 79; Petersville Road, in front of house #3608. ADC 35-E8






Indication of illicit flow at 3608 Petersville Road.

Pipes connected to house # 3608 (note discharge additional discharge in front of garage)

Downstream SHA outfall structure.

Illicit Connection 4

On May 4, 2005 while verifying Maryland State Highway Administration (MSHA) owned stormwater structures in Frederick County, a PVC pipe connected to house #3874 along MD 464 was found to be discharging laundry wastewater into a MSHA inlet. The PVC pipe conveying the laundry wastewater discharge is visibly connected to the house. The laundry wastewater discharge flows through a MSHA culvert before it outfalls into an ephemeral stream channel in a farm field.

On May 5, 2007 illicit discharge inspectors revisited the site to verify the illicit connection. The PVC pipe within the inlet as mentioned above was dry. Downstream at the outfall point, the pipe is nearly submerged in sediment. There was an odor of laundry wastewater and signs of recent flow were seen downstream.

LOCATION: MD 464; Point of Rocks Road, in front of house #3874. ADC 43-G2

Illicit connections within SHA inlet.

3874 Point of Rocks Road.

Downstream SHA outfall structure nearly submerged.

Illicit Connection 5

On May 4, 2005 while verifying Maryland State Highway Administration (MSHA) owned stormwater structures in Frederick County, a PVC pipe connected to house #3884 along MD 464 was found to be discharging a liquid that smelled liked raw sewage into a MSHA inlet. The PVC pipe conveying the foul smelling discharge is visibly connected to the house. The foul smelling discharge flows through a MSHA culvert before it outfalls into an ephemeral stream channel in a farm field.

On May 4, 2007 illicit discharge inspectors revisited the site to verify the illicit connection. The PVC pipe coming from house #3884 was dry at the time of visit. There was no noticeable odor as previously reported. Also, there were no indications of an illicit discharge at the downstream outfall. A 24" CMP pipe at the downstream outfall location was in adequate condition. Following the PVC pipe uphill to house #3884, inspectors were unable to locate where the pipe connects to the house. The pipe seems to encircle the house, lying at the toe of a slope in the homeowner's backyard. These observations support the idea that the pipe is meant to carry sheet flow away from the home.

LOCATION: MD 464; Point of Rocks Road, in front of house #3884. ADC 43-G2

Connection from 3884 Point of Rocks Road.

3884 Point of Rocks Road. PVC continues encircling house in backyard.

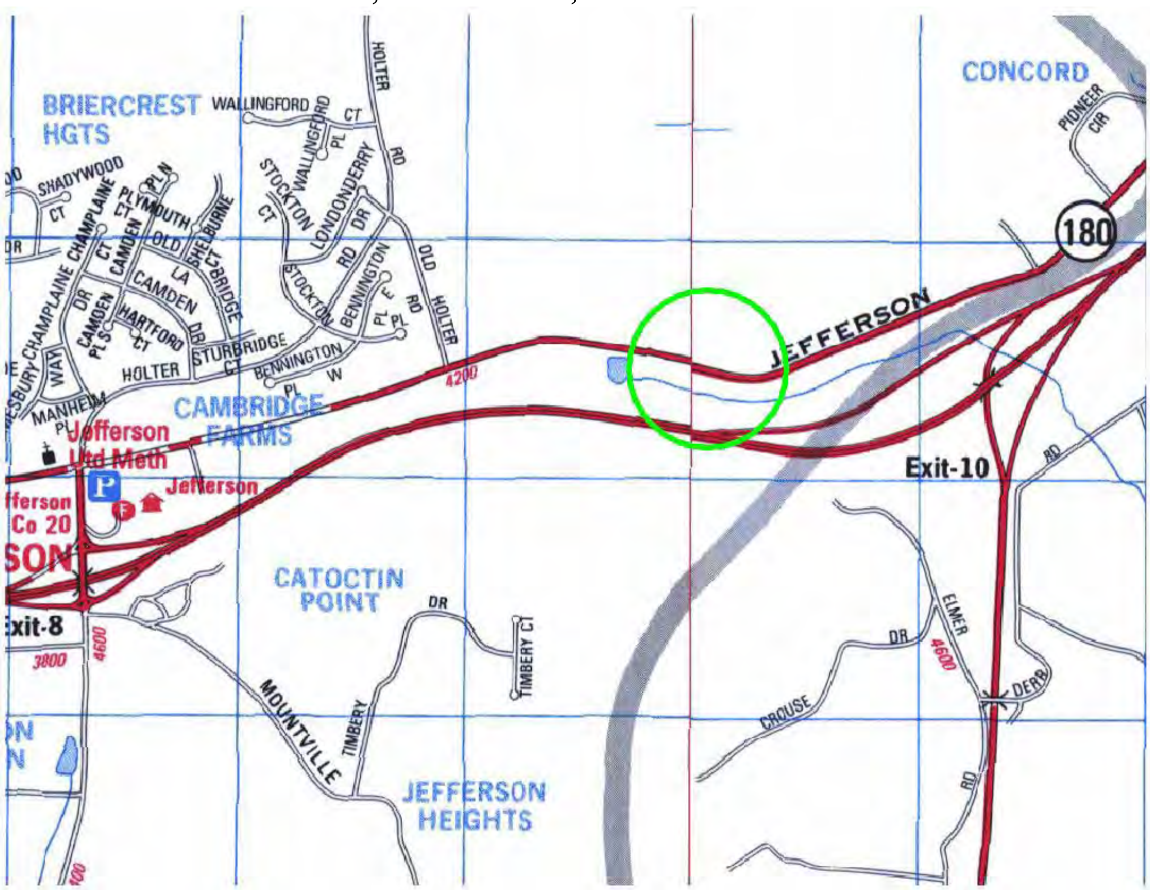
Downstream SHA outfall structure.

Illicit Connection 6

On May 31, 2005 while verifying Maryland State Highway Administration (MSHA) owned stormwater structures in Frederick County, a 4" flexible plastic pipe connected to house #4416 along MD 180 was found to be discharging raw sewage into a MSHA culvert. The raw sewage discharge flows through a MSHA culvert and outfalls onto a hillside that drains to a perennial stream.

On March 14, 2007 illicit discharge inspectors revisited the site to verify the illicit connection. During the site visit, inspectors observed a discharge of approximately 2 gallons of effluent over a 30 second period. A sample gathered from the discharge exceeded allowable limits for detergents (>1.4) and phenols (2.0). The sample was foamy, had a sewage odor, and had a yellow/brown color. At the downstream end of the SHA culvert, a 24" corrugated metal pipe, there was undermining of the end structure and erosion of the downstream channel taking place.

LOCATION: MD 180; Jefferson Pike, in front of house #4416. ADC 37-A2



Sewage discharge at SHA inflow point.

4416 Jefferson Pike.

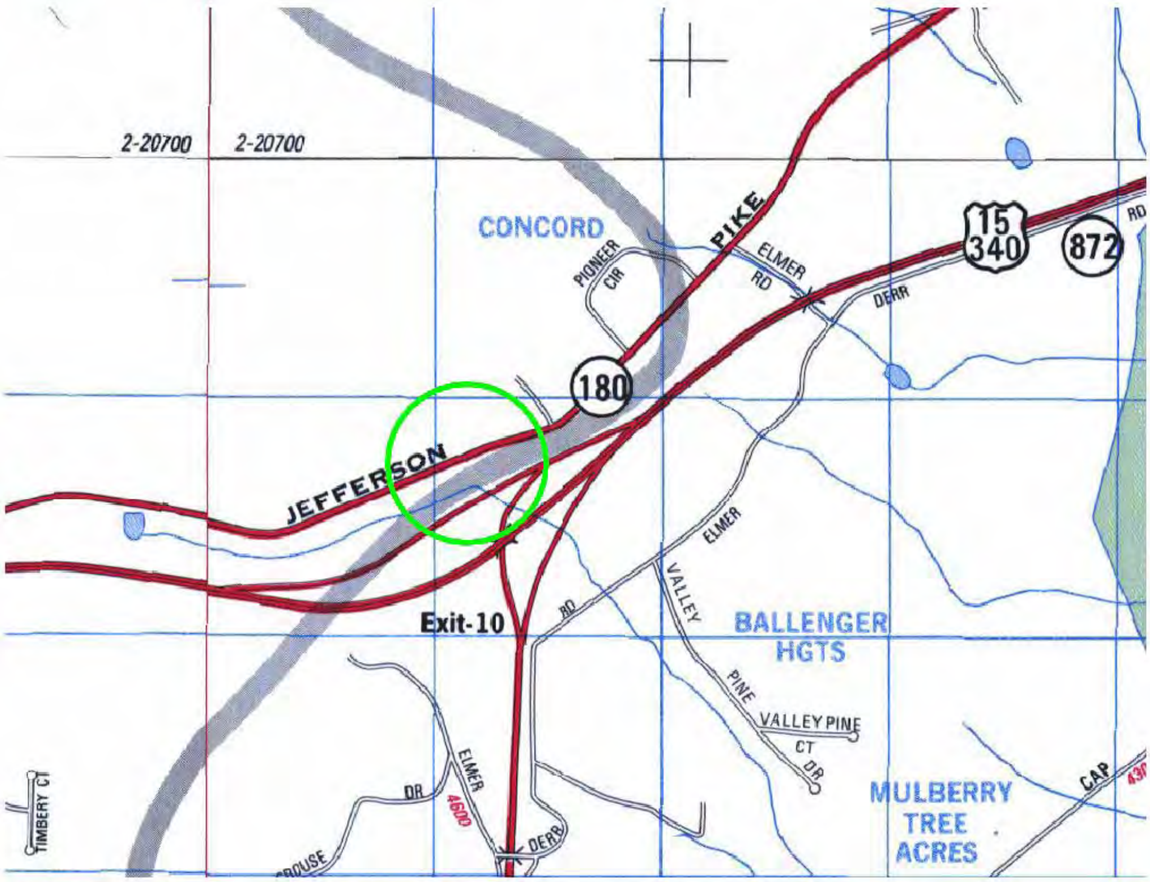
Downstream SHA outfall structure.

Illicit Connection 7

On June 16, 2005 while verifying Maryland State Highway Administration (MSHA) owned stormwater structures in Frederick County, a plastic pipe connected to house #4617 along MD 180 was found to be discharging laundry wastewater into a perennial stream that flows to a MSHA culvert under US 340. The plastic pipe conveying the wastewater ends at the stream's top of bank and then flows directly into the stream over placed rocks.

On March 14 and May 5, 2007 illicit discharge inspectors revisited the site to verify the illicit connection. On both occasions the HDPE pipe was dry. But, on both visits there was a laundry odor coming from the pipe and clumps of lint, observable at the illicit connection.

LOCATION: Jefferson National Pike (MD 180) next to house #4617. ADC 14-B1



Laundry wastewater connection to natural stream channel.

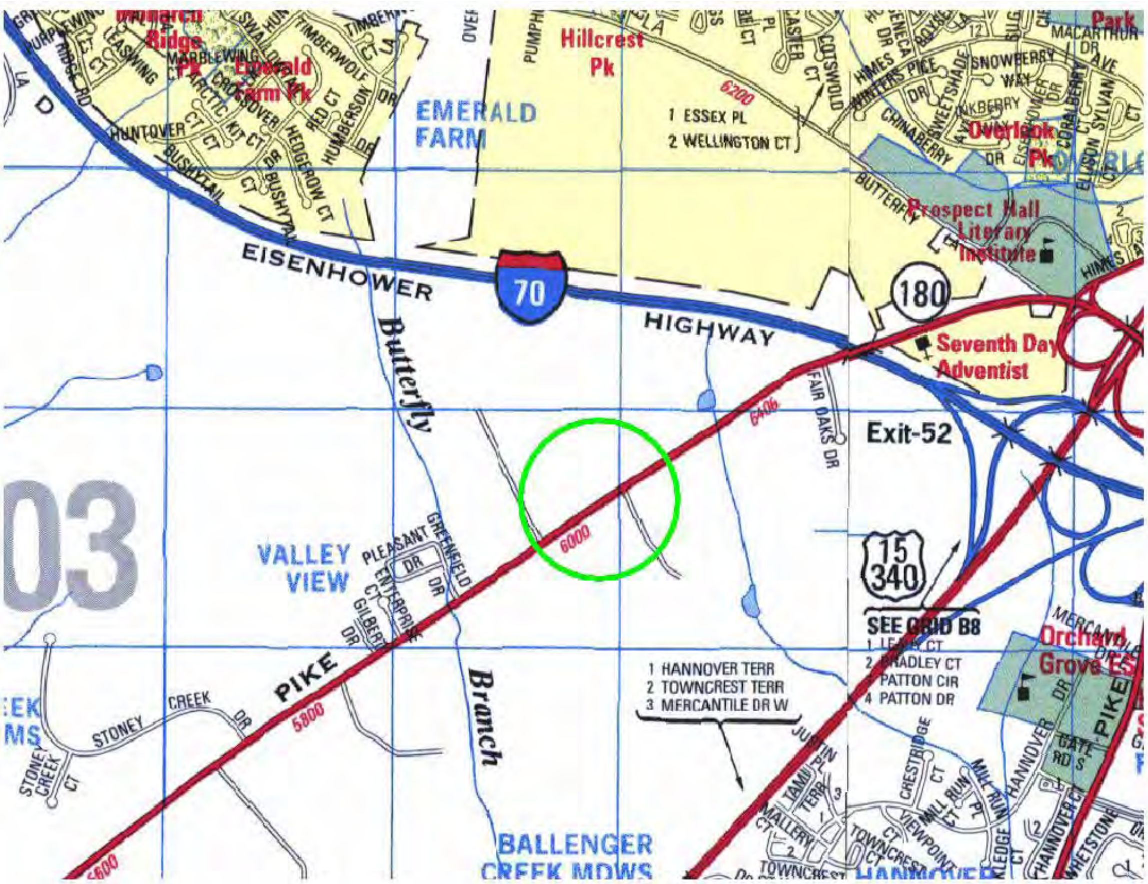
Property at 4617 Jefferson Pike.

Illicit Connection 8

On June 2, 2005 while verifying Maryland State Highway Administration (MSHA) owned stormwater structures in Frederick County, a 4" Terra Cotta (TC) pipe connected to house #6101 along MD 180 was found to be discharging raw sewage into a MSHA rip rap ditch. The TC pipe discharge travels along MD 180 in a rip rap ditch until it reaches a perennial stream approximately 1000' southwest of the pipe.

On March 14, 2007 illicit discharge inspectors revisited the site to verify the illicit connection. The 4" TC pipe connected to house #6101 was found beneath a layer of soil likely deposited by erosion or snow plowing. Once the end of the pipe was dug out, effluent that was backed up within the pipe was released. The effluent smelled like sewage and was too thick to sample using the field test kit. Inspectors revisited the site on May 5, 2007 and observed that the homeowner at house #6101 had made some changes. The terra cotta pipe had been replaced with a plastic, perforated pipe, which was dry at the time of visit. Still, directly downstream from this pipe there was a sewage odor and wet soil indicating recent flow. There are still indications of raw sewage discharge.

LOCATION: MD 180; Jefferson Pike, in front of house #6101. ADC 28-J9



Sewage discharge at 6101 Jefferson Pike. Terra cotta pipe has been replaced with perforated PVC by the homeowner.

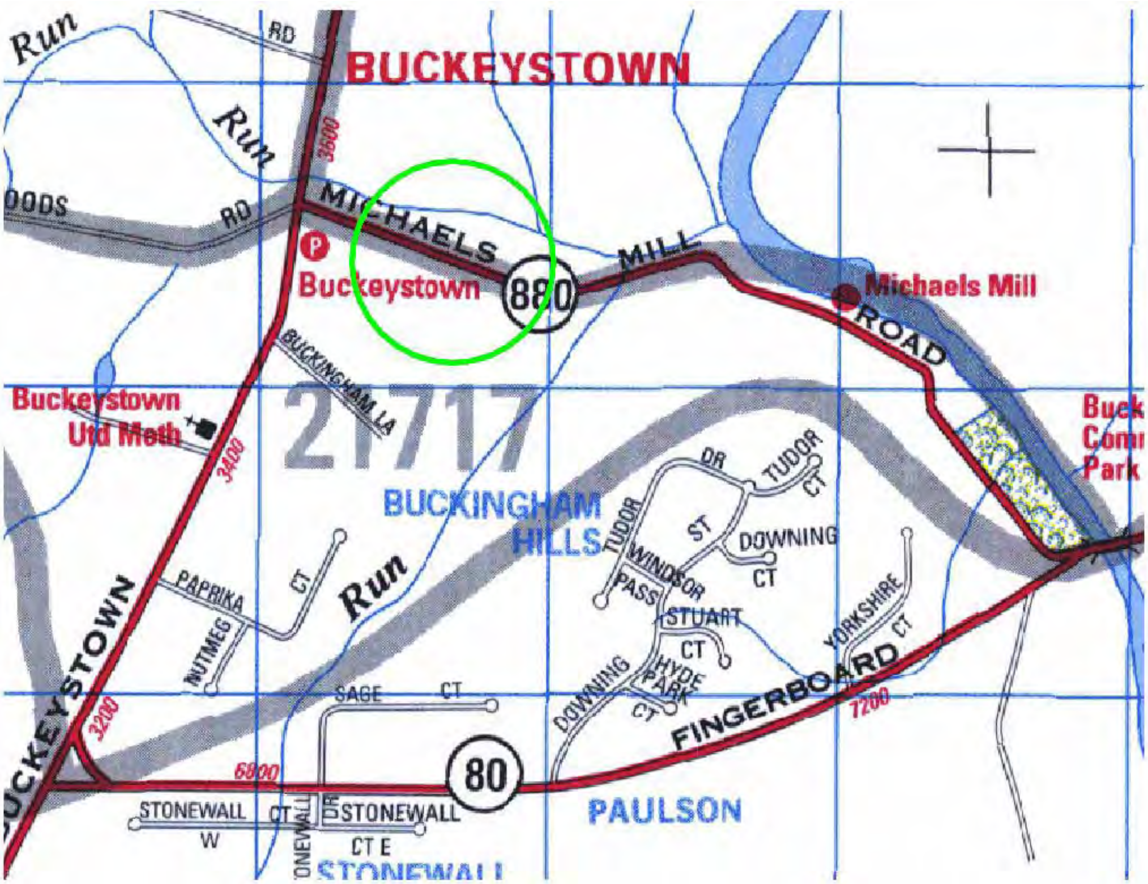
6101 Jefferson Pike.

Illicit Connection 9

On April 1, 2005 while verifying Maryland State Highway Administration (MSHA) owned stormwater structures in Frederick County, a flexible plastic pipe connected to house #6821 along MD 880 was found to be discharging a large amount of clear water into a MSHA trench drain. The plastic pipe conveying the clear water is visibly connected to the house. The clear water discharge flows through a MSHA culvert before it disappears into an inlet off of MSHA property.

On May 4, 2007 illicit discharge inspectors revisited the site to verify the illicit connection. A flashy flow of approximately three gallons per minute was observed at the time of visit. The flow was clear and odorless; a quick visual observation supported the idea that the discharge was untreated groundwater (sump pump flow). However, the sample gathered from the plastic pipe failed the test for detergents (.5 mg/L). No other parameters were exceeded in the sample. The trench drain carrying the illicit flow leads to SHA outfall #1020311.001 downstream.

LOCATION: MD 880; Michaels Mill Road, in front of house #6821 near the intersection of MD 85 and MD880. ADC 38-C8



Clear water discharge into SHA trench drain.

6821 Michaels Mill Road.

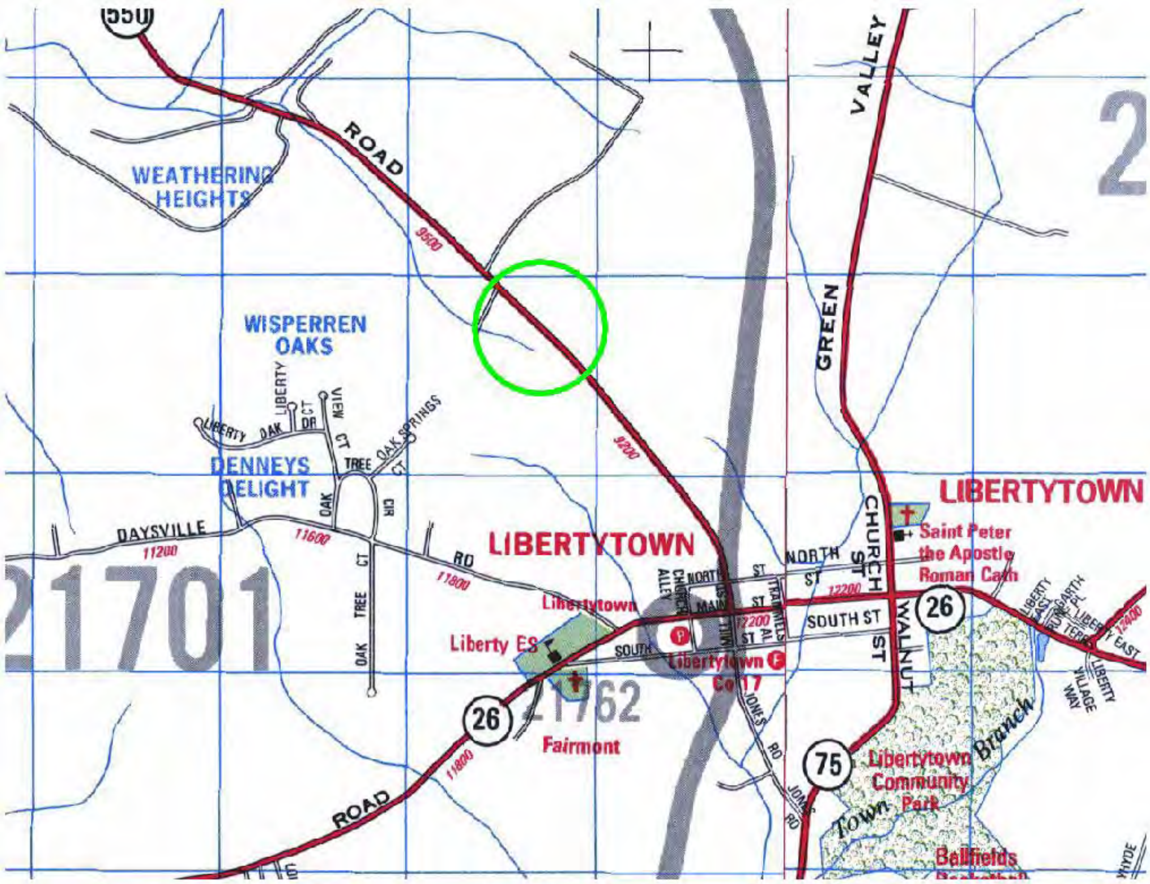
Downstream SHA outfall structure #1020311.001.

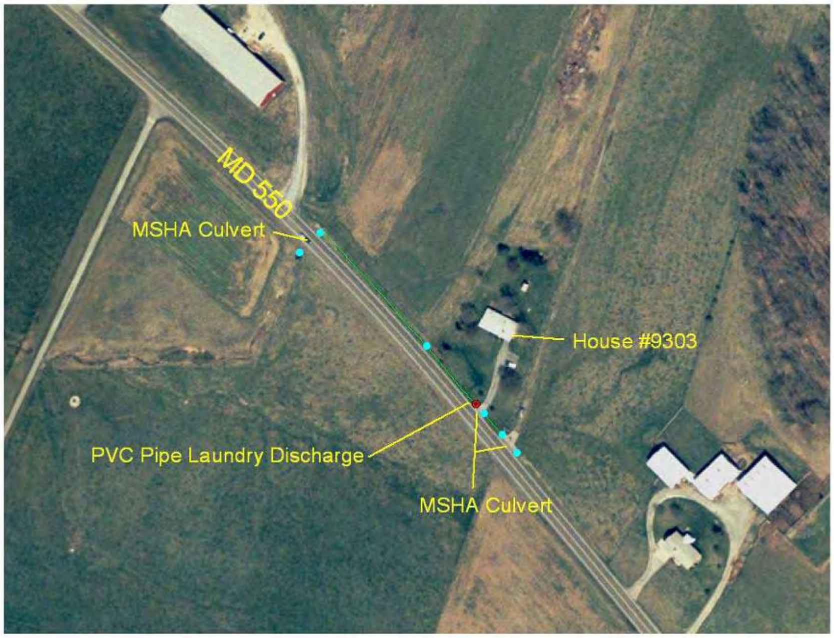
Illicit Connection 10

On March 30, 2005 while verifying Maryland State Highway Administration (MSHA) owned stormwater structures in Frederick County, a PVC pipe connected to house #9303 along MD 550 was found to be discharging laundry wastewater into a MSHA culvert. The PVC pipe conveying the wastewater is visibly connected to the house. The laundry discharge flows through one MSHA culvert before it outfalls into a ditch in a farm field.

On April 10, 2007 illicit discharge inspectors revisited the site to verify the illicit connection. There was no active flow from the PVC pipe at the time of visit, but water was sampled from a pool at the SHA outfall downstream. The sample had a faint sewage odor and failed the field test for pH (9.2). Field testing also indicated presence of chlorine (.1) and detergents (.35). Undermining is occurring at the SHA outfall which could eventually lead to separation of the end structure from the 24" reinforced concrete pipe.

LOCATION: MD 550; Woodsboro Road, north of Libertytown in front of house #9303. ADC 23-J5





Illicit connection at driveway culvert (outfall point shown). 9303 Woodsboro Road.

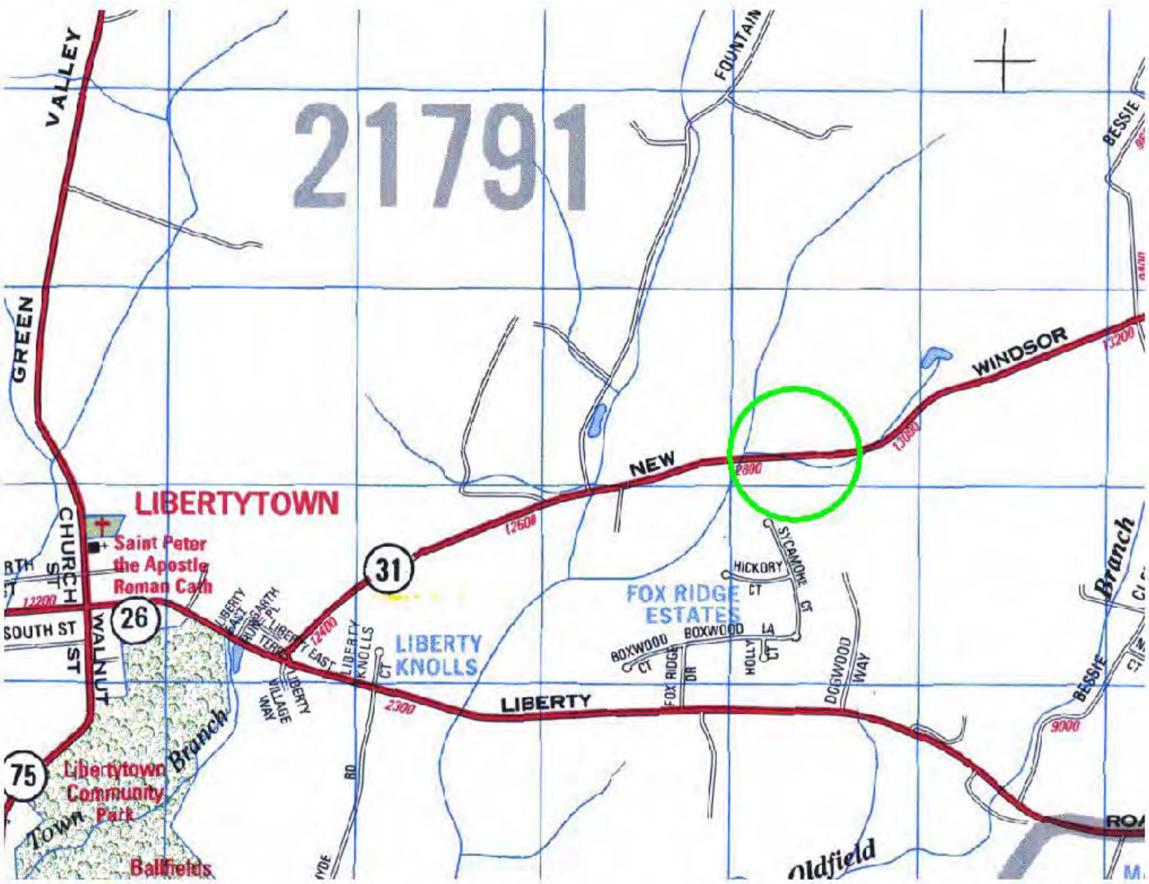
Downstream SHA outfall structure.

Illicit Connection 11

On March 30, 2005 while verifying Maryland State Highway Administration owned stormwater structures in Frederick County, a PVC pipe connected to house #12758 along MD 31 was found to be discharging untreated laundry water containing high amounts of detergents. The PVC pipe is visibly connected to the house and also discharges directly into a perennial stream in front of the house.

On April 10, 2007 illicit discharge inspectors revisited the site to verify the illicit connection. An intermittent flow was observed at the time of visit – approximately 5 gallons over a two minute period. The water was sudsy and it temperature was 105º. A sample of the water also failed the field test for chlorine (.6) and detergents (1.3). SHA structure number 1000109.001 is directly downstream from the illicit connection.

LOCATION: MD 31; New Windsor Road, in front of house #12758. ADC 24-E5



Illicit connection at 12758 New Windsor Road.

12758 New Windsor Road. PVC pipe connects directly to natural stream channel.

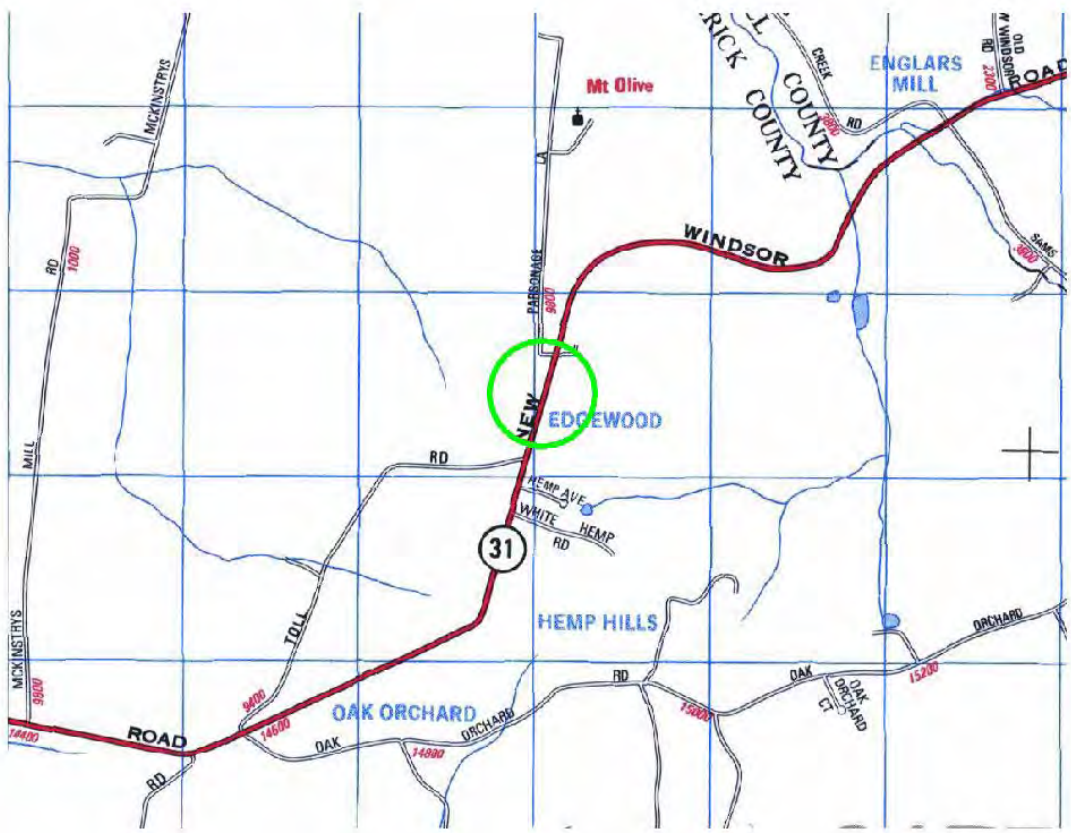
Downstream SHA outfall structure.

Illicit Connection 12

On March 30, 2005 while verifying Maryland State Highway Administration (MSHA) owned stormwater structures in Frederick County, a PVC pipe connected to house #15005A along MD 31 was found to be discharging untreated laundry water into a MSHA culvert. In the backyard of house #150005A, raw sewage was found to be seeping out of the ground and being conveyed through a MSHA culvert. The PVC pipe and sewage seep areas are visibly connected to the house. Both of these untreated discharges flow through a MSHA culvert, and then are discharged into a natural channel below the culvert.

On April 10, 2007 illicit discharge inspectors revisited the site to verify the illicit connection. Although there was no active flow at the time of visit, the SHA outfall structure was completely submerged in wastewater that was cloudy. A sample of the water failed the field test for detergents (.8). The illicit connection ties into SHA structure number 1000146.001.

LOCATION: MD 31; New Windsor Road, behind house #15005A. ADC 25-F3



Illicit discharge at 15005A New Windsor Road.

15005A New Windsor Road.

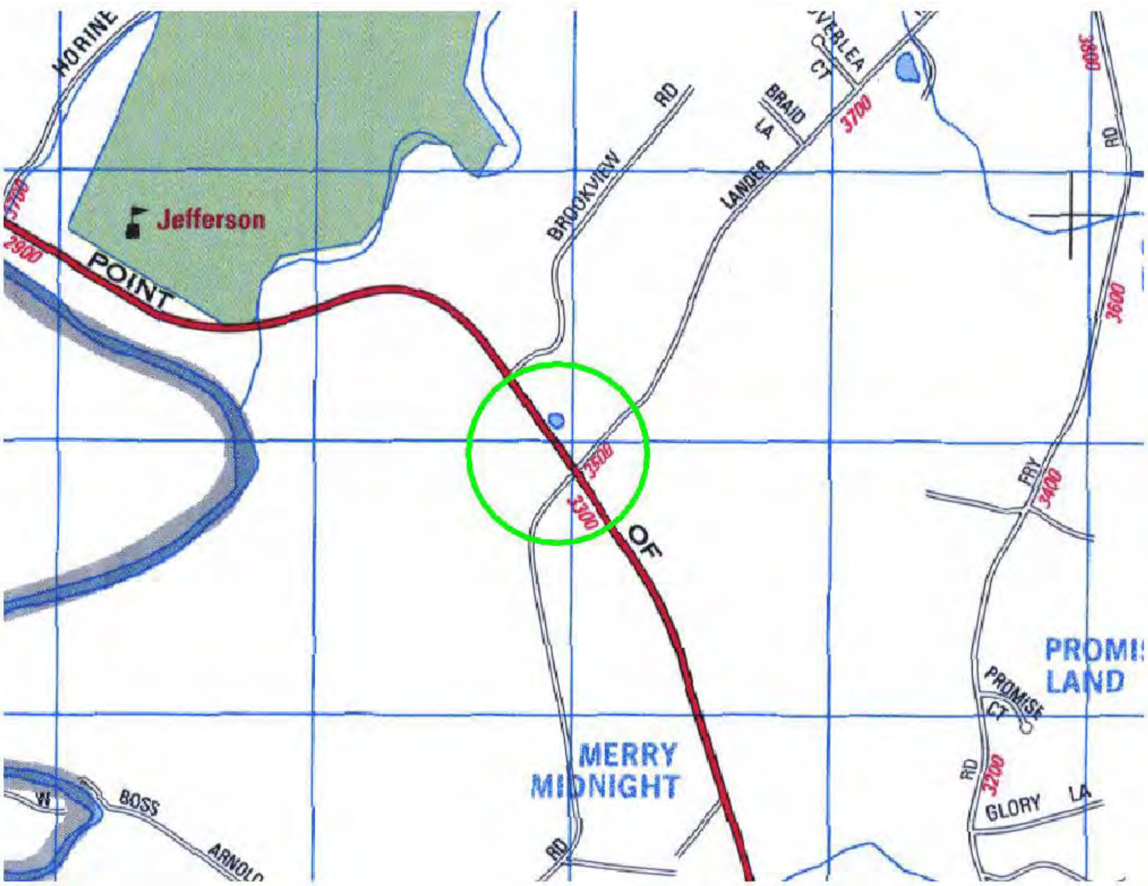
Downstream SHA outfall structure, submerged.

Illicit Connection 13

On May 3, 2005 while verifying Maryland State Highway Administration (MSHA) owned stormwater structures in Frederick County, a flexible plastic pipe connected to farm/house#3253 along MD 464 was found to be discharging animal wastewater and barn runoff into a MSHA "K" inlet. After the farm wastewater discharge flows into an inlet, it then flows under the road and outfalls into an ephemeral stream channel.

On March 14, 2007 illicit discharge inspectors revisited the site to verify the illicit connection. The HDPE pipe coming from the farm property was dry at the time, but standing water between the pipe and the SHA inlet indicated recent activity. A sample was gathered ten feet from the illicit connection where water could be drawn. The sample indicated the presence of chlorine (.02), and failed the field tests for detergents (>1.4) and phenols (4.5). The concrete end structure, directly downstream from the "K" inlet was found completely separated from a 24" reinforced concrete pipe.

LOCATION: MD 464; Point of Rocks Road, at the intersection of MD 464 and Lander Road in front of farm/house #3253. ADC 36-D9



Illicit connection in front of farm property at 3253 Point of Rocks Road.

Indications of recent flow at 3253 Point of Rocks Road.

Downstream SHA end section is separated from 24" pipe.

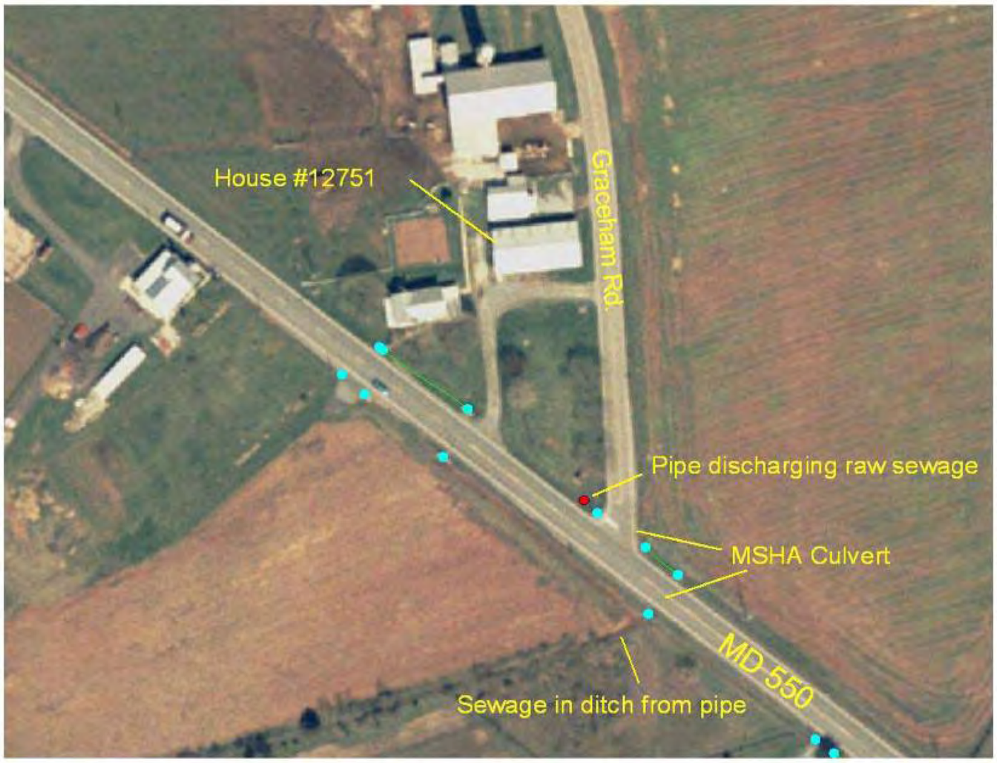
Additional view of end separation from pipe.

Illicit Connection 14

On March 22, 2005 while verifying Maryland State Highway Administration (MSHA) owned stormwater structures in Frederick County, a PVC pipe connected to house #12751 along MD 550 was found to be discharging raw sewage into a MSHA culvert. The PVC pipe conveying the raw sewage is visibly connected to the house. The raw sewage discharge flows through two MSHA culverts before it outfalls into a ditch between farm fields.

On April 10, 2007 illicit discharge inspectors revisited the site to verify the illicit connection. There was no active flow from the PVC pipe at the time of visit, but water was sampled from a small pool at the outflow point. The sample had a sewage odor and failed the field test for detergents (.65). Surrounding vegetation had white stains from the effluent. SHA outfall structure number 1000677.003 is directly downstream from the illicit connection.

LOCATION: MD 550; Creagerstown Road, at the intersection of Graceham Rd, in front of house #12751. ADC 14-B1



Wastewater discharge in front of 12751 Creagerstown Road.

12751 Creagerstown Road.

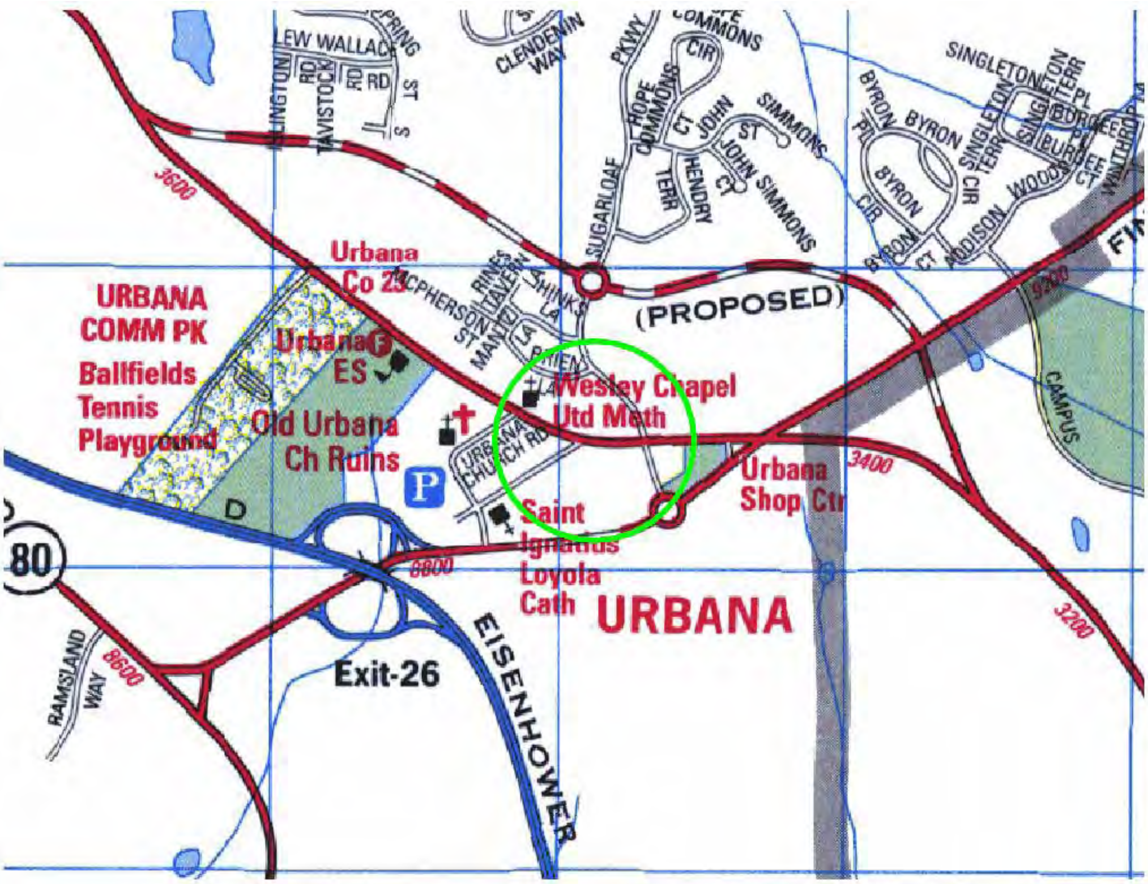
SHA outfall structure downstream of illicit connection.

Illicit Connection 15

On April 20, 2005 while verifying Maryland State Highway Administration (MSHA) owned stormwater structures in Frederick County, a pipe connected to house/business #3432 along MD 355 was found to be discharging raw sewage into a MSHA "S" inlet. The pipe conveying the raw sewage enters the inlet through a hole cut into the concrete wall. The raw sewage discharge flows through a large MSHA stormdrain network before it outfalls into a retention pond off of MSHA ROW.

On May 5, 2007 illicit discharge inspectors revisited the site to verify the illicit connection. Inspectors noticed strong sewage odor and a trickle from the pipe discharging within the "S" inlet as described above. The outfall point of the illicit flow (36" RCP endwall) was found in the southwest corner of the SWM pond nearby. Inspectors sampled from water ponding at this outfall and detected the presence of chlorine (.2) and detergents (.2). At the time, the illicit flow could actually only be seen from inside the pipe (see photo), as it fell between a pipe joint before reaching the SWM pond. The joint separation was not severe and otherwise the outfall structure was in adequate condition.

LOCATION: MD 355; Urbana Pike, at the intersection of Urbana Pike and Sugarloaf Pkwy., in front of house/business #3432. ADC 39-E9



Illicit connection within SHA inlet.

Business at 3432 Urbana Pike.

Downstream outfall structure #1020340.035 at SWM pond.

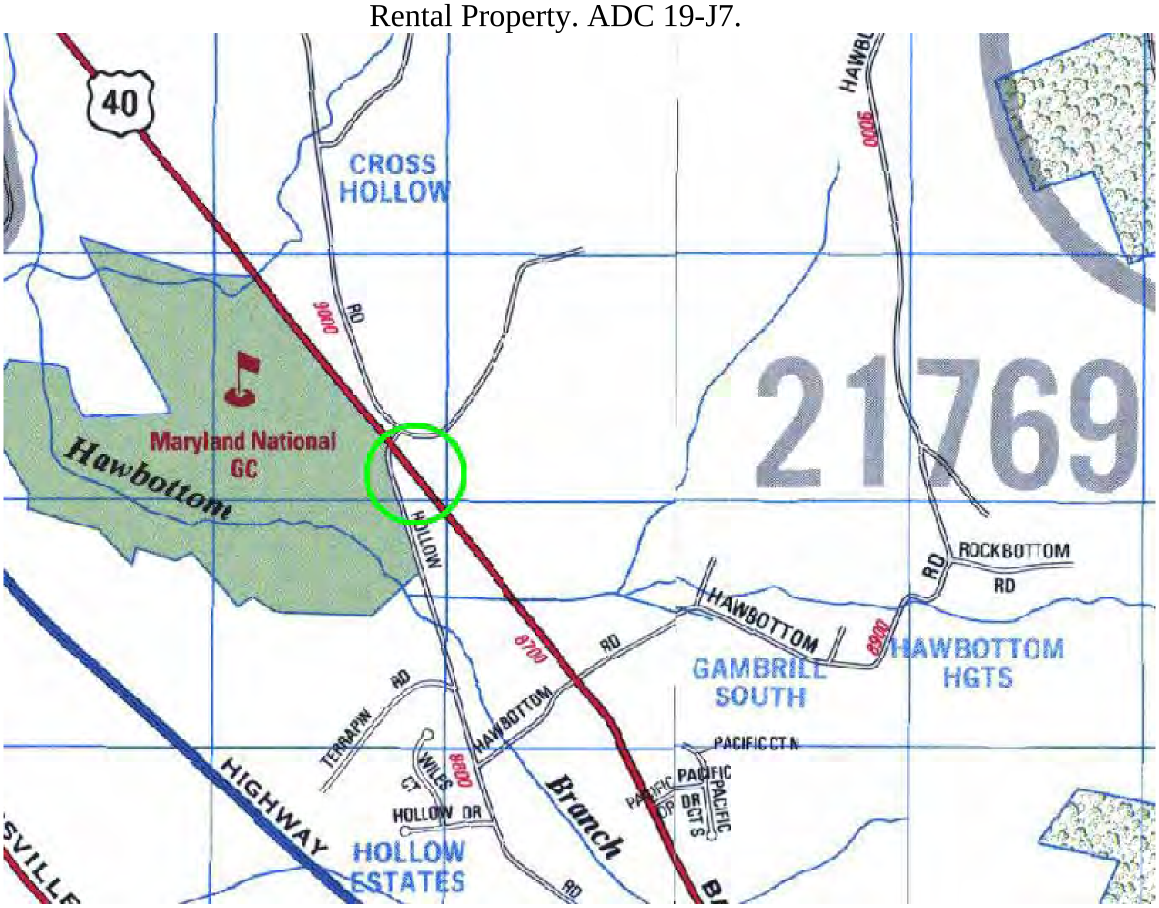
Illicit flow falls through pipe joints before discharging into SWM pond.

Illicit Connection 16

On May 4, 2005 while verifying Maryland State Highway Administration (MSHA) owned stormwater structures in Frederick County, evidence of raw sewage was discovered at an outfall point along US 40 EBL (south of Hollow Road across from the Mid Maryland Truck Rental property). Accumulation of sewage from an unknown source upstream has submerged the existing outflow structure and appears to be seeping down a natural stream channel leading into Hawbottom Branch. A manhole with a nonstandard inlet grate was found on the upstream side of the roadway culvert (off of the US 40 WBL) and may be an uncovered sanitary line connection.

On April 10, 2007 illicit discharge inspectors revisited the site to verify the illicit connection. The SHA outfall structure (#1001460.001) was completely submerged in wastewater that was cloudy and had a sewage smell. A sample of the water failed the field test for detergents (1.0). Upstream of the outfall, the nonstandard-type manhole was located. The inlet grate on the manhole was bolted down, but a photo taken from inside the grate showed piping coming from the direction of a septic field at property #9001 on Hollow Road. No one was home at the time of visit.

LOCATION: US 40 EBL; south of Hollow Road; across from the Mid Maryland Truck Rental Property. ADC 19-J7.



Illicit flow ponding at downstream SHA outfall. Nonstandard inlet grate near 9001 Hollow Road.

View inside inlet leads to 9001 Hollow Road.

Septic field area and residence at 9001 Hollow Road.

HOWARD COUNTY
ILLICIT DISCHARGE INSPECTION

Submitted September 18, 2007

Submitted to:
Karen Coffman
Highway Hydraulics Division
Maryland State Highway Administration
707 N. Calvert St.
Baltimore, Maryland 21202

Prepared by:

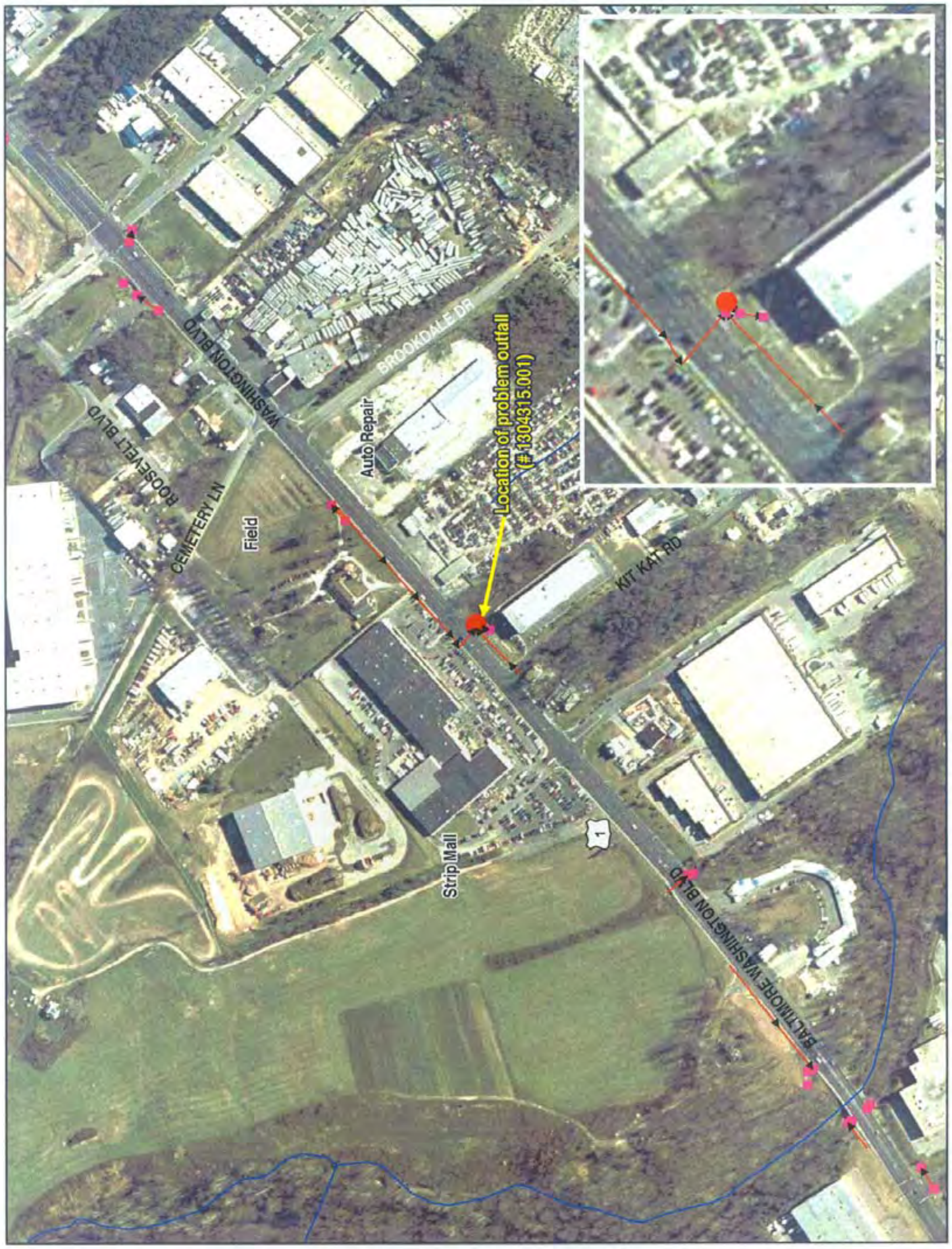
GREENMAN-PEDERSEN, INC.

CHESAPEAKE ENVIRONMENTAL MANAGEMENT, INC.

Illicit Connection 1

LOCATION: U.S. Route 1, in front of 7025 Kit Kat Road. ADC17-A13

On April 18th, 2005, while conducting outfall screenings of storm drain systems that discharge into waters of the U.S, McCormick Taylor, Inc. discovered an outfall with the smell of sewage in Howard County Maryland. The outfall (#1304315.001) is located on U.S. 1, north of Kit Kat Road alongside a Self Storage business. Upon chemical testing of the water at the outfall the detergent concentration in the water was found to be 0.6-0.7 mg/L, exceeding the allowed limit of .50 mg/L. There was a large amount of trash scattered at or around the outfall and the water was cloudy. No obvious illicit discharge source was found to be discharging detergents in this area. Maryland State Highway Administration was immediately notified by phone. Illicit discharge inspectors revisited the outfall to verify the illicit connection on July 27, 2007. At the time of visit, the outfall was partially submerged and with significant amounts of trash in the area. Waste disposal trucks routinely enter and exit Kit Kat Road and litter from the trucks appear to be the primary source of the accumulating trash.. The outfall failed the tests for detergents again (.5 mg/L). Tracking a low flow upstream, through a storm water management facility, did not lead to any visible illicit connection. However, seepage from the ground and standing water along Kit Kat Road were indications of a broken sewer line underground. The broken line could have been caused by the heavy dump truck traffic on Kit Kat Road.


Location of problem outfall
(#1304315.001)
WASHINGTON BLVD
BROOKDALE DR
Auto Repair
ROOSEVELT BLVD
CEMETERY LN
Field
KIT KAT RD
Strip Mall
BALTIMORE WASHINGTON BLVD

View of seepage

Seepage flows into inlet along Kit Kat Road..

SWM facility in front of Self Storage facility on Kit Kat Road.
showing seepage

View of outfall #1304315.001.

Illicit Connection 2

LOCATION: U.S. Route 1, in front of 7275 Waterloo Road. ADC20-H1

While conducting outfall screenings in Howard County Maryland on April 18th, 2005, McCormick Taylor, Inc. discovered an outfall that had a sewage smell. The outfall (#1300102.001) is located at the intersection of U.S. 1 and MD 175 on the northbound side of U.S. 1. After the inspectors tested the outfall, the chlorine concentration read 1.0 mg/L. The following day the level was 0.4 mg/L. It is possible that the source of the chlorine is coming from either the Holiday Inn or the Comfort Suites Hotel across the intersection from the outfall, and is related to pool maintenance activity. Maryland State Highway Administration was immediately notified by phone.

The illicit discharge inspectors revisited the site to verify the illicit connection on July 7, 2007. The outfall was partially submerged at the time of visit, but a small volume of flow was observed downstream. Detergents level of .35 mg/L and chlorine levels of .1 mg/L were found in the test sample. The illicit connection was identified in the rear of the Holiday Inn where a pipe was discharging into an inlet. Discolored and foamy discharge from the pipe within the inlet carried the same odor to the one at the outfall. The location of the illicit connection and the characteristics of the discharge suggest that dishwashing waste from the Holiday Inn ties into the storm water system.


Location of problem outfall
(# 1300102.001)
BALTIMORE WASHINGTON BLVD
WATERLOO RD
OLD WATERLOO RD
PARKSIDE RD
MANOR RD
AMITY RD
PIPER RD
CRESTMOUNT AVE
ASSATEAGUE DR
Comfort Suites
Holiday Inn
175
1

View of foamy discharge inside inlet in rear of Holiday Inn.

View of inlet where illicit flow was found.

Downstream inlet showing path of illicit flow towards a SHA outfall.

View of outfall #1300102.001.

MONTGOMERY COUNTY ILLICIT DISCHARGE INSPECTION

Submitted September 18, 2007

Submitted to:
Karen Coffman
Highway Hydraulics Division
Maryland State Highway Administration
707 N. Calvert St.
Baltimore, Maryland 21202

Prepared by:

GREENMAN-PEDERSEN, INC.

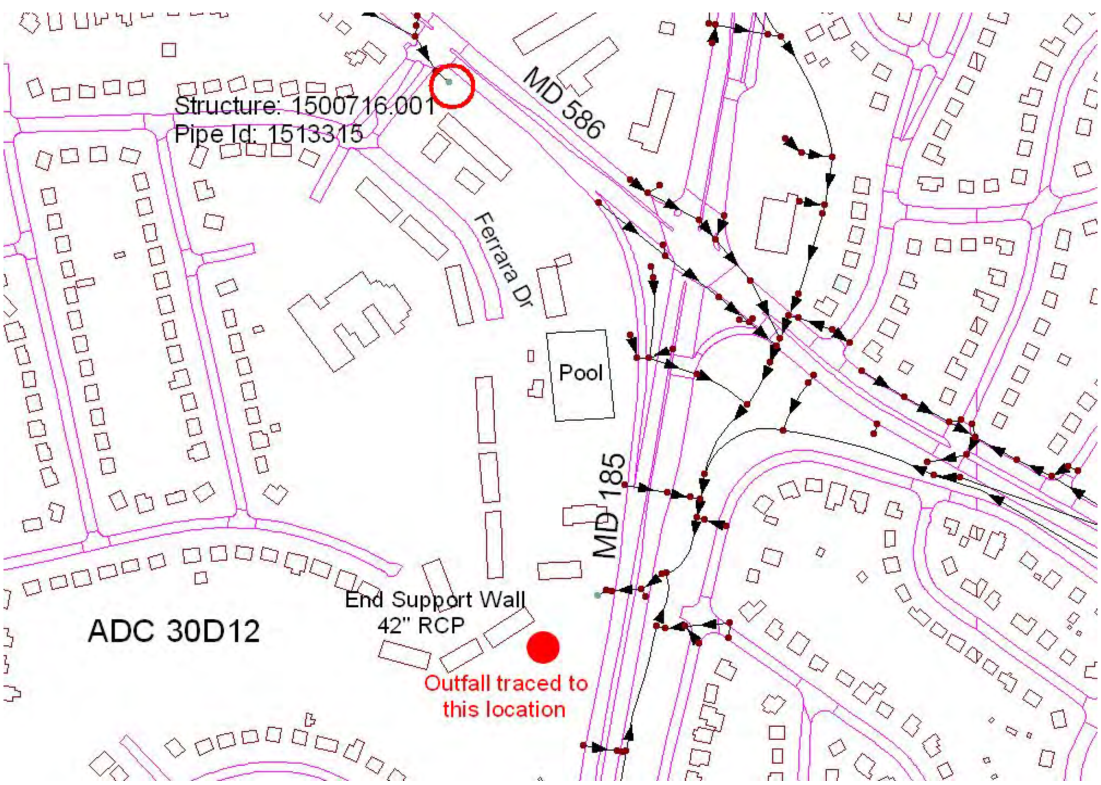
CHESAPEAKE ENVIRONMENTAL MANAGEMENT, INC.

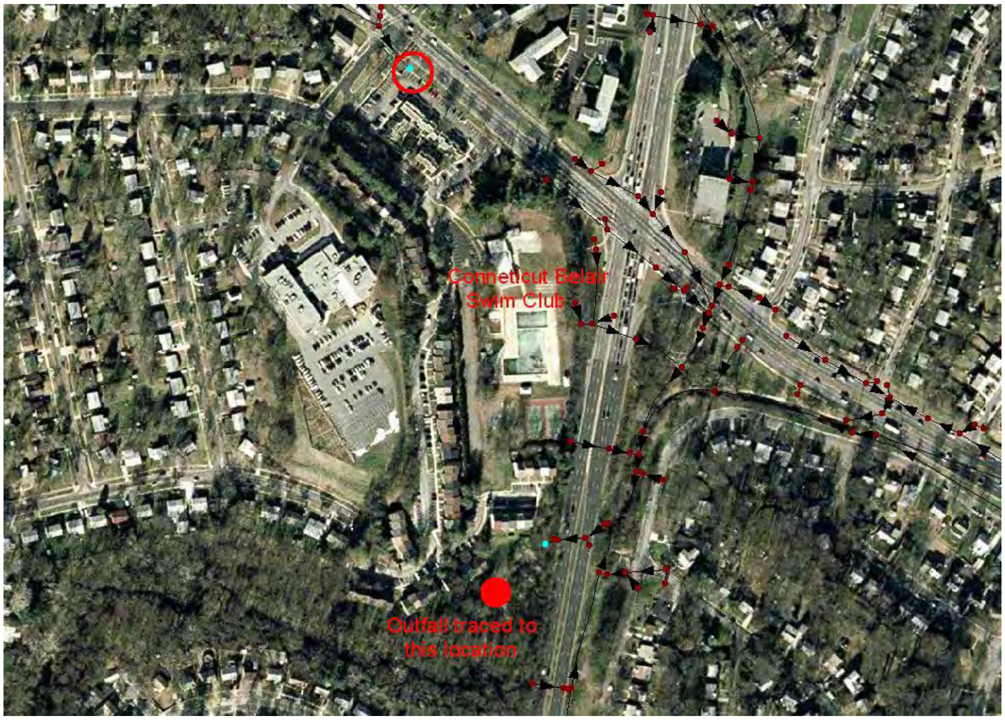
Illicit Connection 1

LOCATION: MD 586 at Ferrara Drive behind 3711 High View Drive by Connecticut Belair Swim Club. ADC30-D12

Inspectors found elevated chlorine levels of 0.5 mg/L while testing flow from a 42" RCP when performing outfall screening on May 7, 2004. The chlorine levels increased to 2.0 mg/L during a secondary test 4.5 hours later; well above the contamination limit of 0.4 mg/L. Inspectors noticed the Connecticut BelAir Swim Club swimming pool drainage overflow may tie into the system. While revisiting the site on June 20, 2004 the chlorine levels were again elevated to 1.8 mg/L. Although the pool was not being drained, water flowing over the concrete surface was reaching a drain connected to the storm drain system. It is unclear if this is the source of the elevated chlorine levels at the outfall.

CEM inspectors revisited the site to verify the illicit connection on July 3, 2007. Outfall #1500716.001 again exhibited steady flows and elevated chlorine levels of 0.5 mg/L. The source of the contamination was not found, but the elevated chlorine levels may originate from water leaking through cracks in the Connecticut Belair swim club's pool. The pool manager explained the facility was constructed in 1958 and admitted many leaks in the pool liner. She also told inspectors that many repairs have been made in recent years explaining why testing from 2004 showed higher levels of chlorine. Despite pool improvement, the chlorine concentration still exceeds the allowable limit.





Entrance at Swim Club.

View of outfall #1500716.001

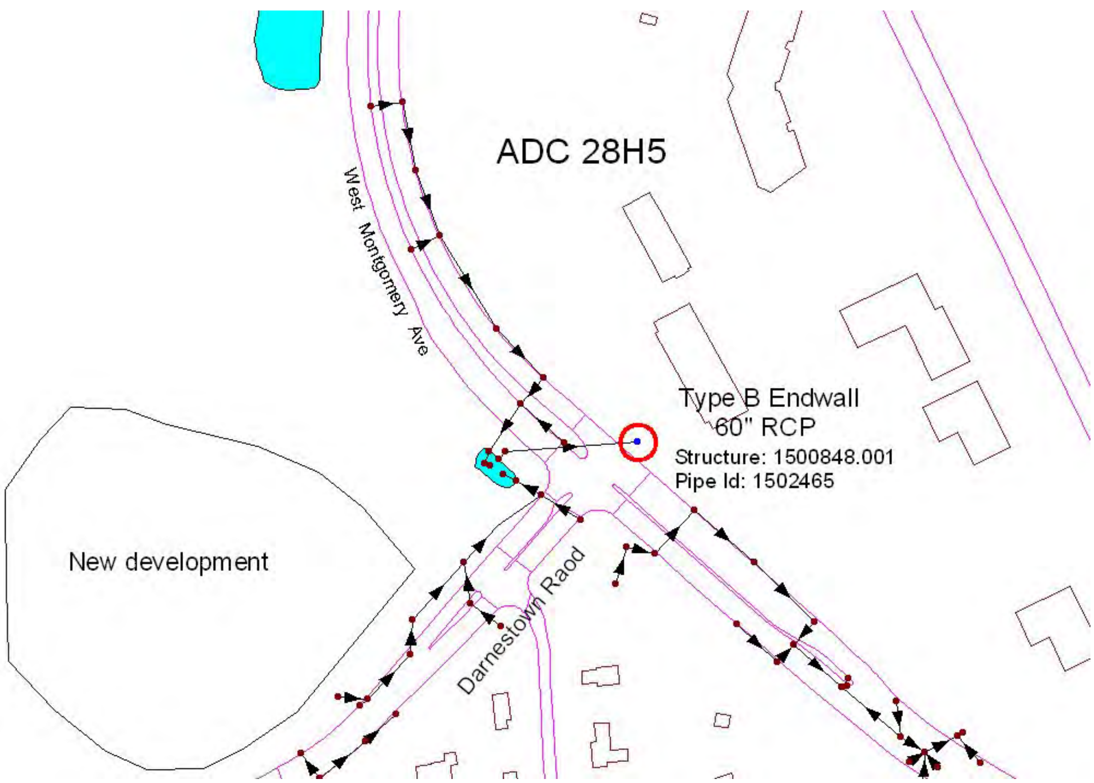
View of pipe

Illicit Connection 2

LOCATION: MD 28; West Montgomery Ave. at Darnestown Road. ADC28-H5 View of outfall #1500848.001.

On June 29, 2004, inspectors tested flow from outfall #1500848.001 and found elevated levels of detergent (0.95 mg/L) The site was revisited on June 30, 2004 and detergents levels were 1.3 mg/L, well above the allowed .5 mg/L. Inspectors tested the BMP upstream of the outfall and detergent levels matched those at the outfall (1.3 mg/L). The source was assumed to be a contractor power washing new homes in a housing development upstream.

On July 25, 2007 illicit discharge inspectors revisited the site to verify the illicit connection. There was flow at the 60" RCP Type B endwall from the storm water management facility upstream. There was nothing unusual about the flow or the outfall, and the test sample showed no concentrations of any of the field indicators. It is likely that the excessive detergent concentration from 2004 was caused by the power washing, and that this is no longer a problem outfall.



View inside pipe.

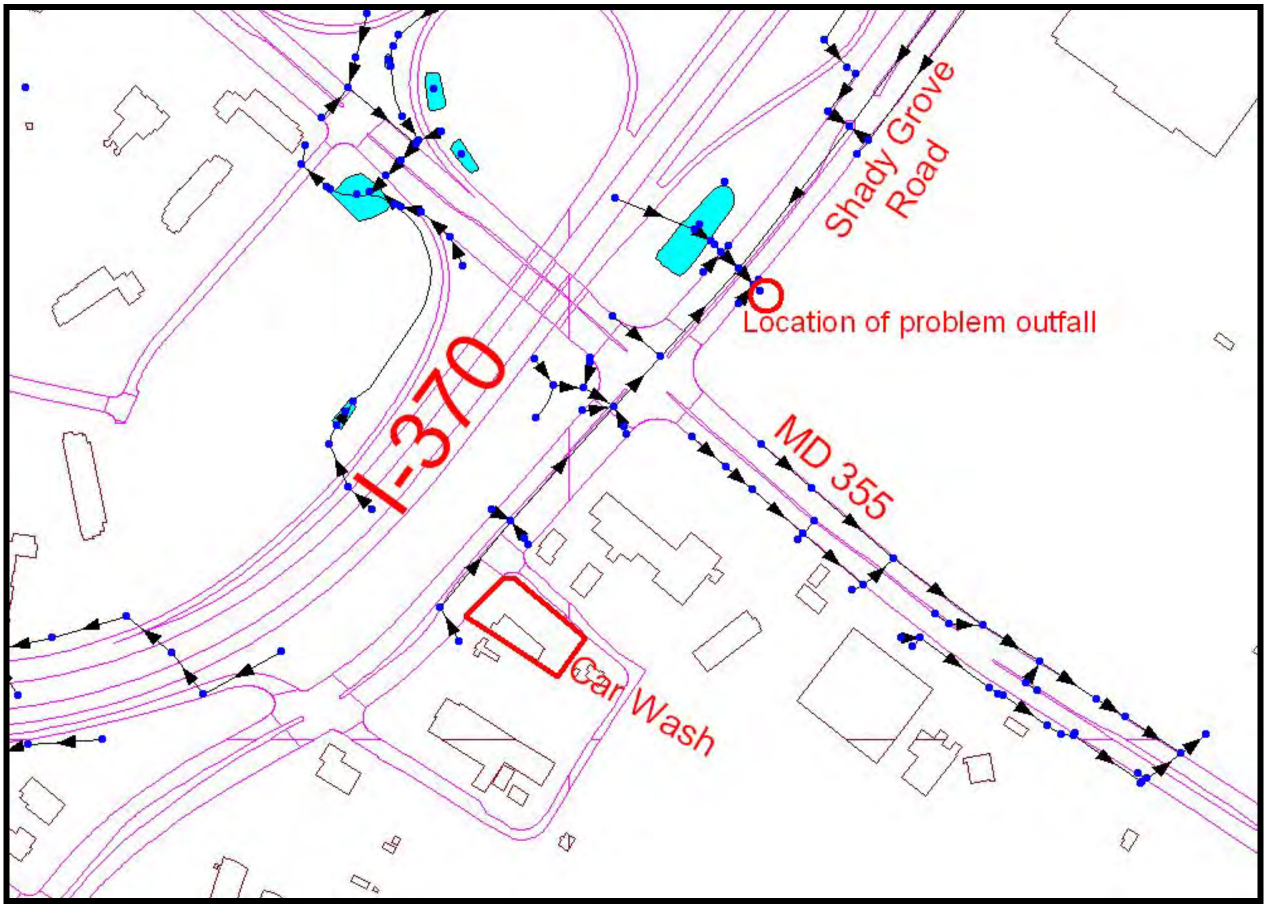
Illicit Connection 3

LOCATION: NE of intersection at MD 355 and Shady Grove Road. ADC19-J12

On February 28, 2001 while conducting outfall screenings of storm drain systems that discharge into waters of the US, KCI Technologies discovered an outfall in Montgomery County, Maryland that had a rancid, sour smell. Outfall #1501376.001 is located on Shady Grove Road, East of MD 355 across from BMP #15073 between Shady Grove Road and I-370 (ADC 19-J12). Upon chemical testing of the water at the outfall, it was found that the detergent concentration in the water was 1.3 mg/L, exceeding the allowed limit for detergents of 0.50 mg/L. The endwall was also submerged and the water was opaque with floating trash. Maryland State Highway Administration (MSHA) was immediately notified of the problem and conducted a site visit with KCI Technologies. It was determined by MSHA that the Touch Less II carwash on Shady Grove Road, West of MD 355 was illicitly discharging waste wash into the connecting stormdrain system (map attached).

KCI Technologies re-inspected this outfall and found detergent concentrations of 0.75 mg/L exceeding the allowed level of 0.50 mg/L on April 21, 2004. Five hours later, KCI returned to the site and sampled the outfall finding the detergent concentration dropped to 0.25mg/L. The field crew looked at the Touch Less II carwash parking area and found a small volume of water flowing into an inlet that connects to the SHA system which terminates at outfall#1501376.001. It appears that the carwash is still discharging waste wash directly into the stormdrain system, adversely effecting water quality. The source of the high detergent concentrations needs to be consistently controlled to assure effluent levels of detergent discharging into waters of the US remain below the allowable concentration of 0.50 mg/L.

Illicit discharge inspectors revisited the site to verify the illicit connection on August 3, 2007. Although no flow was observed, the plunge pool at the outfall was opaque and rancid smelling as described in previous visits. On this day, there was no observed connection between wash water from the car wash and the outfall; only a trickle from an irrigation system in front of the carwash that flowed to an SHA inlet along Shady Grove Road. Another illicit connection was found further upstream at the outdoor patio to a Checkers restaurant, where an inlet ties into the system. Sudsy wash water was found draining into the system where power washing had recently been performed. An employee at Checkers explained that she power washes the pavement daily.


Shady Grove Road
Location of problem outfall
I-370
MD 355
Car Wash

Irrigation from Touch Less II trickles into a SHA inlet - not washwater.


Washwater at Checkers walk up window from daily power washing.

Closer view where washwater enters stormdrain system.

Rancid smelling plunge pool at downstream outfall.

APPENDIX L:

Draft: Long Draught Branch Monitoring Report

September 24, 2007

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

The Long Draught Branch Restoration Project was initiated by the MDSHA to assess and restore/stabilize the degraded conditions of the stream channel from Clopper Road (MD 117) to the location of the Gaithersburg stormwater management facility. Long Draught Branch has deteriorated greatly due to channel straightening, piping, floodplain encroachments, damming, lining with stone, bark armoring, past poor land-use practices, and more recent urbanization. Chemical, physical and biological monitoring will be performed over a period of three years in order to determine the effectiveness of the restoration efforts of the Long Draught Branch Stream Restoration Project.

2.0 CHEMICAL MONITORING

2.1 Objectives

Monitoring the chemical water quality pre- and post-restoration is an important tool to (1) characterize baseline conditions prior to restoration and (2) gauge the success of restoration efforts in improving water quality.

Chemical water quality monitoring will occur in two phases:
Phase CHEM 1 (pre-restoration) was initiated November 2006. The goal of this effort is to conduct baseline characterization of the stream reach. While construction is underway, monitoring will stop and resume after the construction is completed. It is anticipated that construction will begin in February 2008 and end in September 2008.

Phase CHEM 2 will continue chemical monitoring post-stream bank restoration and stabilization. The goal of this effort is to provide data to help determine the effectiveness of the NPDES stormwater management program and progress toward improving water quality. Post restoration monitoring is anticipated to occur from October 2008 through October 2010.

Utilizing preliminary Phase CHEM 1 data collected from November 2006- July 2007 LimnoTech began characterization of water quality and evaluated the pre-restoration differences between pollutant concentrations in stormflow and baseflow. Additional analyses to be performed throughout the project duration are discussed in Section 3.3.

In association with the chemical water quality monitoring, LimnoTech is conducting continuous flow and rainfall monitoring in order to calculate pollutant loads and relationships to storm duration and intensity.

Site Locations

Water quality monitoring is being conducted at two sites within the stream reach: one above and one below the restoration site. The upstream site is located at the downstream end of the Clopper Road crossing of Long Draught Branch near Firstfield Road. The downstream site is located at the foot bridge crossing upstream of the City of Gaithersburg stormwater management facility (on Rabbitt Road west of Quince Orchard Road) (Figure 2.1). Continuous flow is being recorded at the upstream monitoring site. The flow meter is attached to the downstream side of the culvert at the Clopper Road crossing (MD 107 culvert).

Figure 2.1: Long Draught Branch Monitoring Locations

2.2 Sample Types and Sampling Frequency

Chemical water quality monitoring occurs monthly, with at least three sampling events occurring per quarter (based on calendar year), during storm events as well as selected dry weather periods. A qualifying storm event is defined as rainfall over 0.1 of an inch occurring after there has been no significant (> 0.1 inch) rainfall within 72 hours. To allow for the collection of sufficient data to characterize the impacts of stormwater discharges, baseflow samples are collected during dry weather approximately once per quarter in lieu of a wet weather event. Dry weather is defined as less than 0.1 inch having fallen within the previous 72-hour period.

2.3 Sample Collection Procedures

Samples are collected using manual grab methods following the protocols *EPA NPDES Stormwater Sampling Guidance* (1992). Samples are collected while facing upstream to minimize contamination from the sampler or field equipment and are transferred to lab provided sample containers (except Oil & Grease and E. coli which are sampled directly into the sample container per recommendations in EPA 1992). All samples are placed in coolers with ice and transported to the laboratory for analysis. In addition to water samples, field measurements of water temperature and pH are measured during the collection of samples using a hand held meter. Samples are analyzed according the methods approved in 40 CFR Part 146 by GPL Laboratories of Frederick, MD and Fredericktown Labs (E. coli) of Myersville, MD.

A meter (Teledyne Isco 4110 Ultrasonic Flow Logger), attached to the downstream side of the culvert at the Clopper Road crossing (MD 107 culvert) records water level continuously at 15 minute intervals (Figure 2.2). In conjunction with sampling events, the LimnoTech team also conducts flow measurements using a Marsh McBirney portable Flowmeter. Rainfall data is compiled from data collected by Montgomery County, MD at Dickerson, MD.

Figure 2.2: Continuous water level meter at upstream monitoring site

2.4 Sample Documentation

Sampling field sheets and sample labels are completed for each event. Information recorded on field forms includes the sampling field crew, sampling location, date and time of sample collection, number and volume of samples collected, sample identification numbers, preservatives used, as well as, weather and physical conditions.

Chain of custody forms are initiated by the sampling crew in the field and remain with the samples at all times. The chain of custody form includes the sample identification number, sample date and time, description, sample type, sample preservative, and analyses required.

2.5 Analytical Parameters

Targeted pollutants for monitoring include:

-Biochemical Oxygen Demand (BOD5)
-Total Lead
-Total Kjeldahl Nitrogen (TKN)
-Total Copper
-Nitrate plus Nitrite
-Total Zinc
-Total Suspended Solids
-Total Phosphorus
-Total Petroleum Hydrocarbons
-Oil and Grease
-Escherichia coli

Beginning in March 2007, orthophosphate and ammonia were added to the analyses.

2.6 Data Management Procedures

Water quality data are stored in a Microsoft Access database, designed by LimnoTech for this project. Water level data, rainfall data and flow measurements are tracked via Excel spreadsheets.

3.0 PRELIMINARY RESULTS

3.1 Comparison of Storm and Baseflow Pollutant Concentrations

Storm and baseflow concentrations of the targeted constituents were compared based on visual representation of the data and the use of Mann-Whitney U test, a nonparametric analogue of the two-sample t-test. Statistical significance was assessed based on an alpha level of 0.05. Summary data for all pollutants is located in Appendix A.

Between November 2006 and July 2007, LimnoTech sampled three storm events and six baseflow periods. Means of stormwater concentrations and baseflow concentrations based on this initial sampling period are presented in Table 3.1. BOD, TKN, total phosphorus and TSS had significantly higher concentrations (BQL, ND and J assessed as 0) in stormflow vs. baseflow, while nitrate/nitrite concentrations were significantly lower in stormflow.

Table 3.1: Mean pollutant concentrations. Parameters for which baseflow and stormflow differ significantly denoted in bold font. BQL, ND, and J calculated as 0; BQL, ND, and J calculated as detection limit given in parenthesis (Detection limits in Table 3.2)

Means:

		Baseflow	Stormflow
BOD (mg/L)	Upstream	**1.5 (2.5)**	**13.2**
	Downstream	**1.3 (2.7)**	**11.1**
Total Copper (ug/L)	Upstream	0 (10)	9.7 (16.4)
	Downstream	2.3 (10.7)	10.6 (17.3)
e.coli (col/100 mL)	Upstream	612.1	649.0*
	Downstream	227.2	1553.0*
Total Lead (ug/L)	Upstream	0.0 (10.0)	1.4 (10.2)
	Downstream	1.7 (10.0)	2.7 (11.6)
Nitrate/Nitrite (mg/L)	Upstream	**1.13**	**0.82**
	Downstream	**1.39**	**0.82**
Nitrogen, Total Kjeldahl (mg/L)	Upstream	**0.54**	**1.50**
	Downstream	**0.55**	**1.90**
Oil & Grease (mg/L)	Upstream	1.0 (5.2)	2.5 (6.4)
	Downstream	10.4 (12.9)	0.0 (5.0)
pH	Upstream	7.39	7.63
	Downstream	7.86	7.59
Total Phosphorus (mg/L)	Upstream	**0.060 (0.068)**	**0.148**
	Downstream	**0.103 (0.107)**	**0.185**
TSS (mg/L)	Upstream	**1.7 (5.8)**	**14.4 (16.1)**
	Downstream	**4.3 (7.7)**	**48.7 (49.8)**
TPH (mg/L)	Upstream	0.0 (5.0)	0.7 (5.1)
	Downstream	3.7 (4.8)	0.0 (5.0)
Zinc (ug/L)	Upstream	30.7 (37.3)	86.4
	Downstream	31.3 (38.0)	78.0
Ammonia (mg/L)	Upstream	0.277 (0.293)	0.129 (0.195)
	Downstream	0.577 (0.610)	0.400 (0.434)
Orthophosphate (mg/L)	Upstream	0.00 (0.02)	0.03 (0.04)
	Downstream	0.00 (0.02)	0.01 (0.03)

BQL: Below quantitaton limit
J: Value less than reporting limit but greater than the MDL/IDL
ND: Compound analyzed for but not detected
*concentration based on one storm event

Table 3.2: Detection Limits

Parameter	Detection Limit
BOD (mg/L)	2
Nitrogen, Total Kjeldahl (mg/L)	0.1
Nitrate/Nitrite (mg/L)	0.05
Total Phosphorus (mg/L)	0.02
TSS (mg/L)	5
Total Copper (ug/L)	10
Total Lead (ug/L)	10
Zinc (ug/L)	20
TPH (mg/L)	5
Oil & Grease (mg/L)	5
e.coli (col/100 mL)	1
Ammonia (mg/L)	0.1
Orthophosphate (mg/L)	0.02

3.2 Development of discharge rating curve

Water level/stage is continuously monitored via the meter located at the downstream end of the Clopper Road crossing. Water levels can be converted to flow rates (Figure 3.1) based on a preliminary rating curve developed for this site (Figure 3.2). The stage-discharge rating curve was developed using Manning's equations for water levels from 1.1 to 2.9 ft. With only six manual flow measurements available to validate the rating curve, and with only three storm events during the reporting period, the current rating curve does not extend past the maximum recorded water level of 2.9 ft. There is an assumption of no flow at < 1.1 ft. This is due to the presence of in-stream rocks near the meter location that effectively act as a weir, preventing measurable flow when the water level is below 1.1 ft. The Manning's equations used a culvert width of 8 ft. and assumed a 0.04 *n* value for the culvert bottom and a 0.01 *n* value for the culvert sides. The LimnoTech team is using flow measurements manually taken during each sampling event to refine and validate this rating curve (Table 3.3).

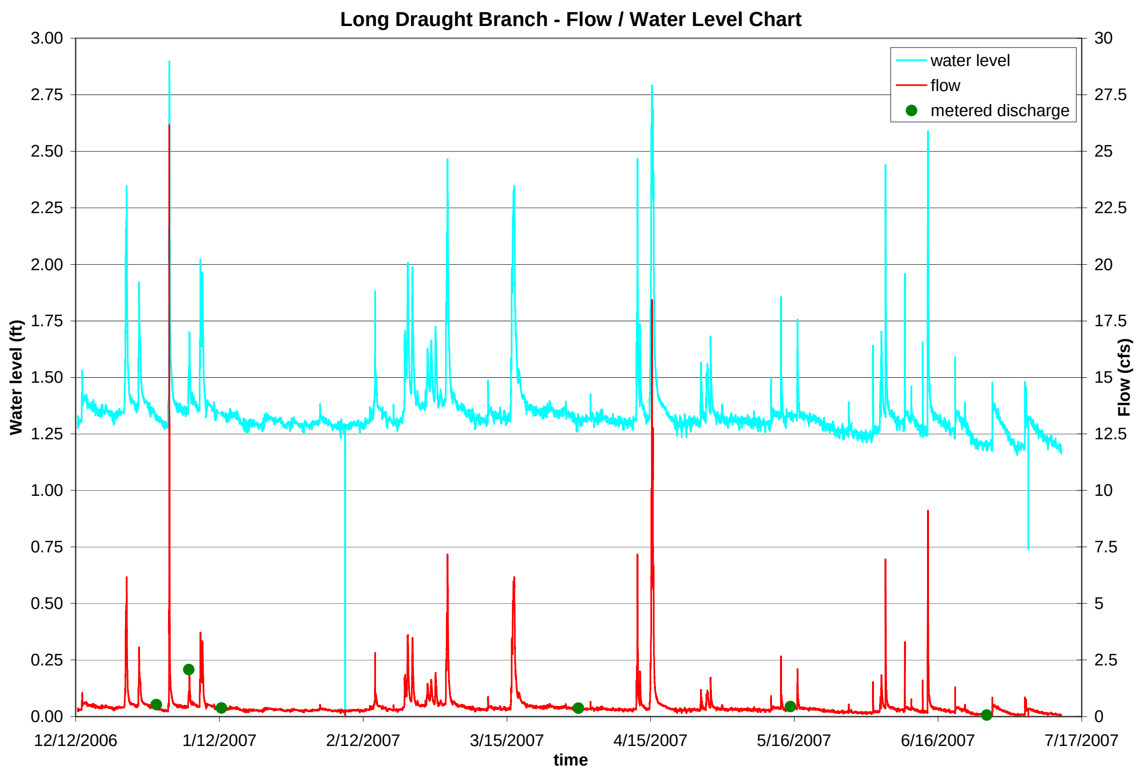


Figure 3.1: Long Draught Branch water level and discharge (cfs) at upstream monitoring site

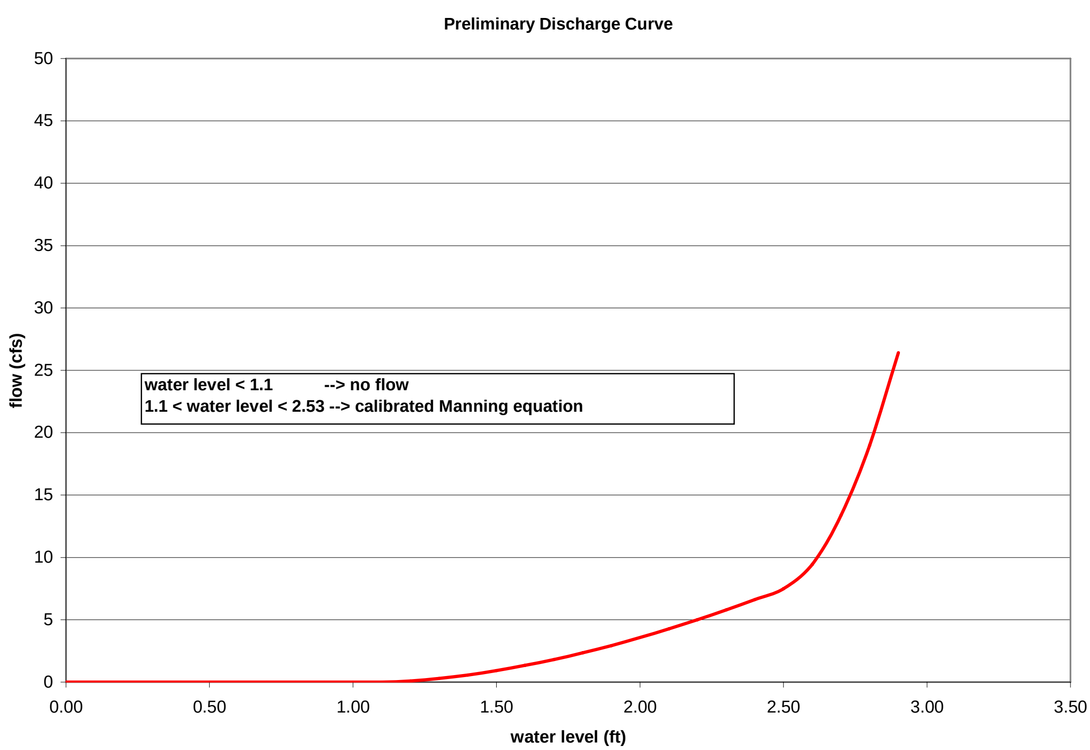


Figure 3.2: Preliminary Stage-Discharge rating curve for Long Draught Branch

Table 3.3: Discharge measurements taken during sampling events

Date	Discharge (cfs)	Water Level (ft)
11/27/2006	0.527	NM*
11/28/2006	0.570	NM*
12/29/2006	0.524	1.33
1/5/2007	2.072	1.53
1/12/2007	0.374	1.34
3/30/2007	0.369	1.31
5/15/2007	0.437	1.56
6/26/2007	0.067	1.20**
7/19/2007	-0.800	1.19**

*meter installed 12/12/2006
** at low water levels, backflow conditions may impact flow measurement

3.3 Future analyses

For the duration of the project, LimnoTech will continue to monitor chemical water quality to further refine our characterization of stormwater inputs. Post-restoration monitoring will also serve to quantify the impact of the restoration on water quality. LimnoTech will also continue to perform flow measurements during both storm and dry conditions over a wide range of stream stage levels to refine and validate our theoretical discharge rating curve.

LimnoTech will also estimate seasonal and annual pollutant loads and compile storm duration and intensity measures.

4.0 LITERATURE

EPA. 1992. NPDES Storm Water Sampling Guidance. United State Environmental Protection Agency, Office of Water. Report EPA 833-8-92-001, July 1992.

MSHA. 2005. Long Draught Branch Restoration/Stabilization Semi-Final Design Report, SHA Project No: MO357121. Maryland State Highway Administration, Highway Hydraulics Division. November 2005.

POLLUTANT SUMMARY INFORMATION

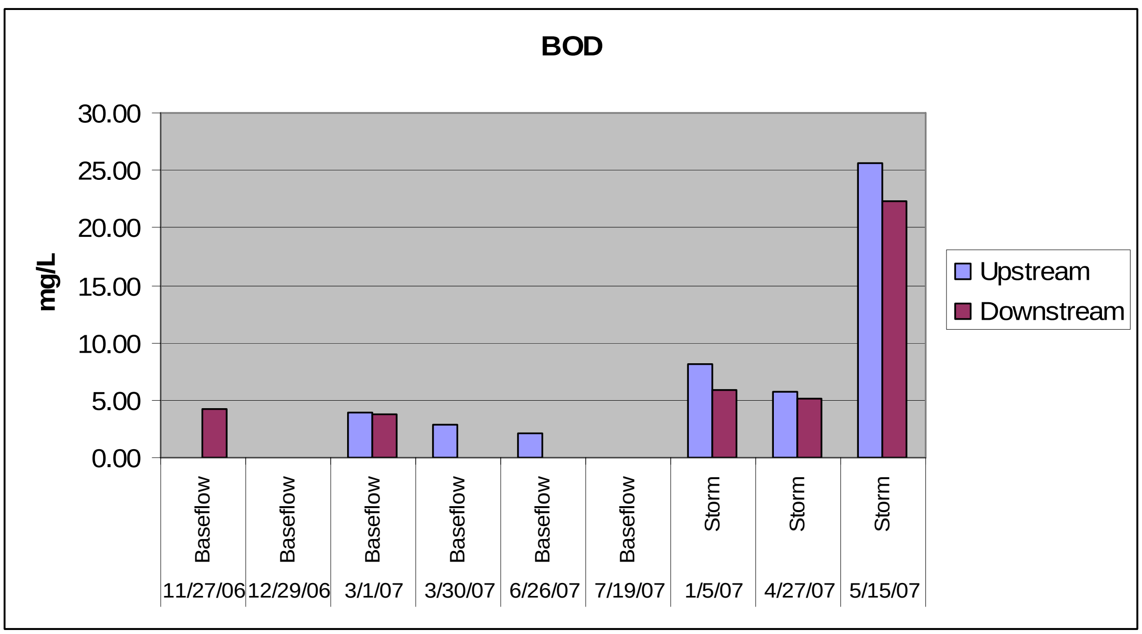
Biochemical Oxygen Demand

	Date		BOD (mg/L) Upstream	BOD (mg/L) Downstream
Baseflow	11/27/06		ND	4.2
	12/29/06		ND	ND
	3/1/07		3.9	3.8
	3/30/07		2.8	BQL
	6/26/07		2.1	ND
	7/19/07		ND	ND
		MEAN	**1.5**	**1.3**
		MEDIAN	**1.5**	**0.0**
		MIN	**0.0**	**0.0**
		MAX	**3.9**	**4.2**
Storm event	1/5/07		8.1	5.9
	4/27/07		5.7	5.2
	5/15/07		25.7	22.3
		MEAN	**13.2**	**11.2**
		MEDIAN	**8.1**	**5.9**
		MIN	**5.7**	**5.2**
		MAX	**25.7**	**22.3**

BQL: Below Quantitation Limit

ND: Indicates that the compound was analyzed for but not detected

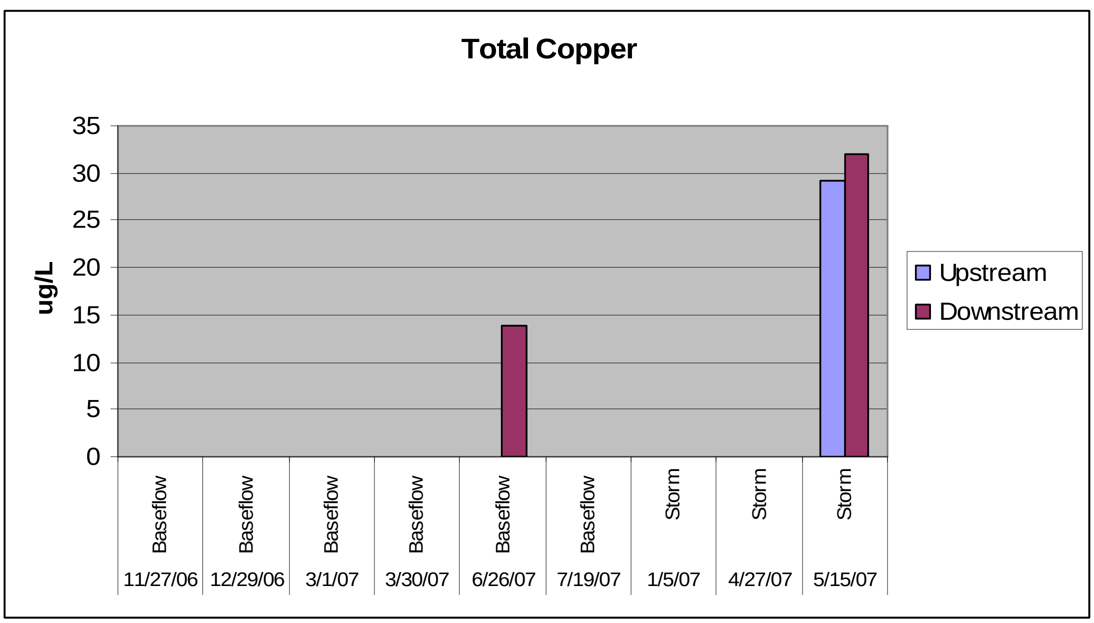
(BQL; ND assessed as 0)



Total Copper

	Date		Total Copper (ug/L)	
			Upstream	Downstream
Baseflow	11/27/06		J-metals	J-metals
	12/29/06		J-metals	J-metals
	3/1/07		J-metals	J-metals
	3/30/07		J-metals	J-metals
	6/26/07		J-metals	13.9
	7/19/07		J-metals	J-metals
		MEAN	**0.0**	2.3
		MEDIAN	**0.0**	0.0
		MIN	**0.0**	0.0
		MAX	**0.0**	13.9
Storm event	1/5/07		J-metals	J-metals
	4/27/07		J-metals	J-metals
	5/15/07		29.2	31.9
		MEAN	**9.7**	**10.6**
		MEDIAN	**0.0**	**0.0**
		MIN	**0.0**	**0.0**
		MAX	**29.2**	**31.9**

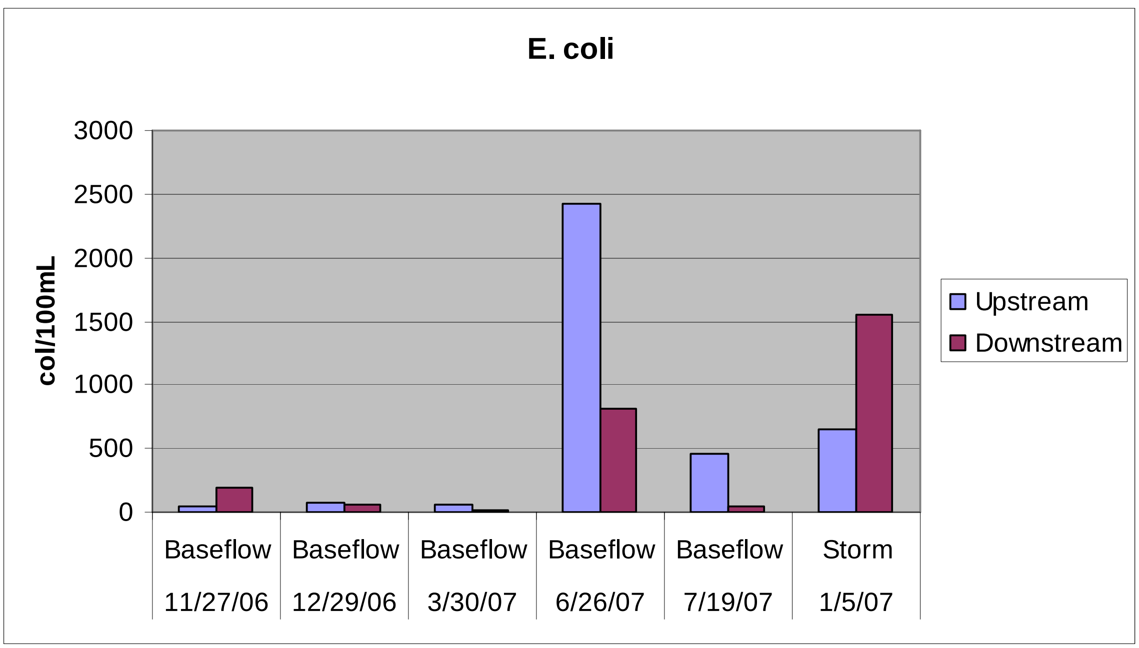
J-metals: Indicates that the reported value was less than the reporting limit but greater than or equal to the IDL/MDL
(J-metals assessed as 0)



Escherichia coli

	Date		e.coli (col/100 mL)	
			Upstream	Downstream
Baseflow	11/27/2006		51.2	198.9
	12/29/2006		78.2	56
	3/1/2007		NM	NM
	3/30/2007		52	21.8
	6/26/2007		2419.2	816.4
	7/19/2007		460	43
		MEAN	**612.1**	**227.2**
		MEDIAN	**269.1**	**127.5**
		MIN	**51.2**	**21.8**
		MAX	**2419.2**	**816.4**
Storm event	1/5/2007		649	1553
	4/27/2007		NM	NM
	5/15/2007		NM	NM

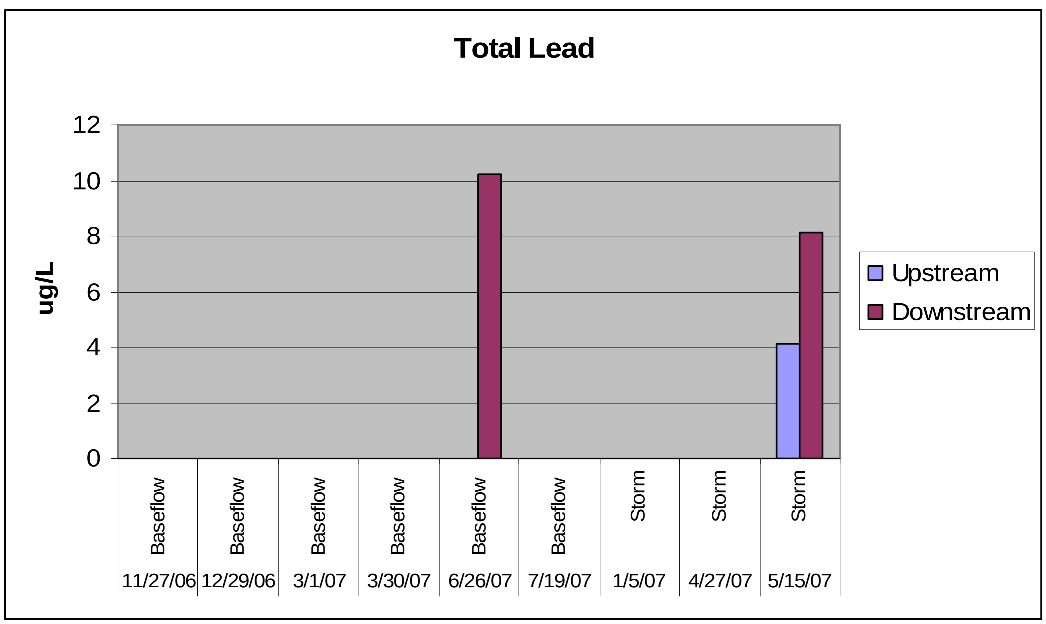
NM: Not measured



Total Lead

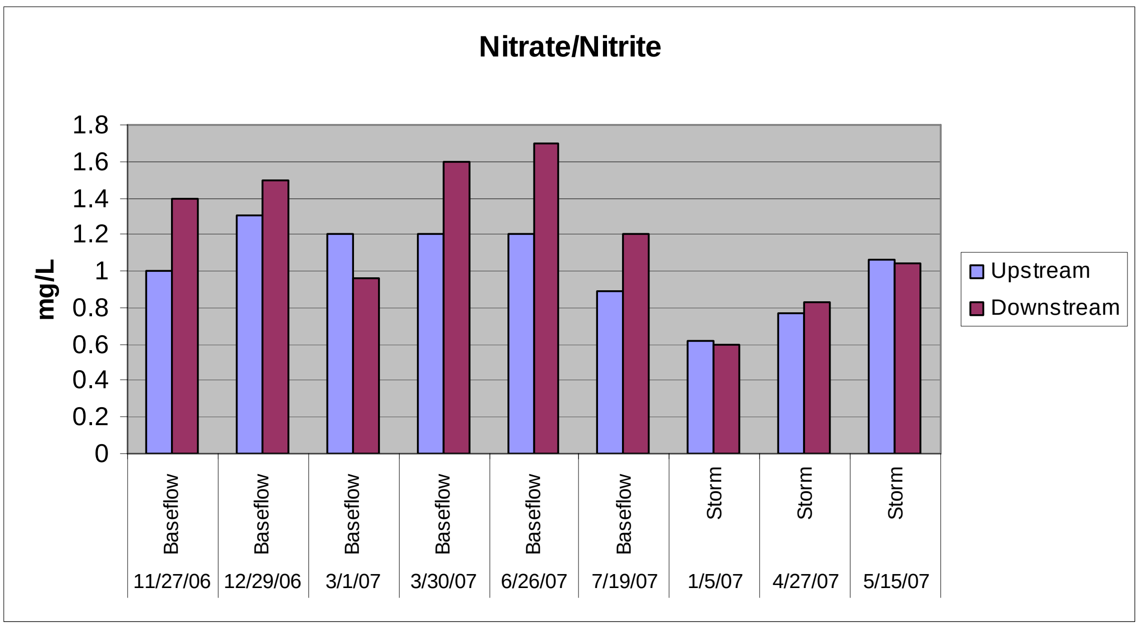
	Date		Total Lead (ug/L) Upstream	Downstream
Baseflow	11/27/06		J-metals	J-metals
	12/29/06		J-metals	J-metals
	3/1/07		ND	J-metals
	3/30/07		J-metals	J-metals
	6/26/07		J-metals	10.2
	7/19/07		J-metals	J-metals
		MEAN	**0.00**	**1.70**
		MEDIAN	**0.00**	**0.00**
		MIN	**0.00**	**0.00**
		MAX	**0.00**	**10.20**
Storm event	1/5/07		J-metals	J-metals
	4/27/07		ND	J-metals
	5/15/07		4.10	8.10
		MEAN	**1.37**	**2.70**
		MEDIAN	**0.00**	**0.00**
		MIN	**0.00**	**0.00**
		MAX	**4.10**	**8.10**

J-metals: indicates that the reported value was less than the reporting limit but greater than or equal to the IDL/MDL
ND: Indicates that the compound was analyzed for but not detected
(J-metals and ND assessed as 0)



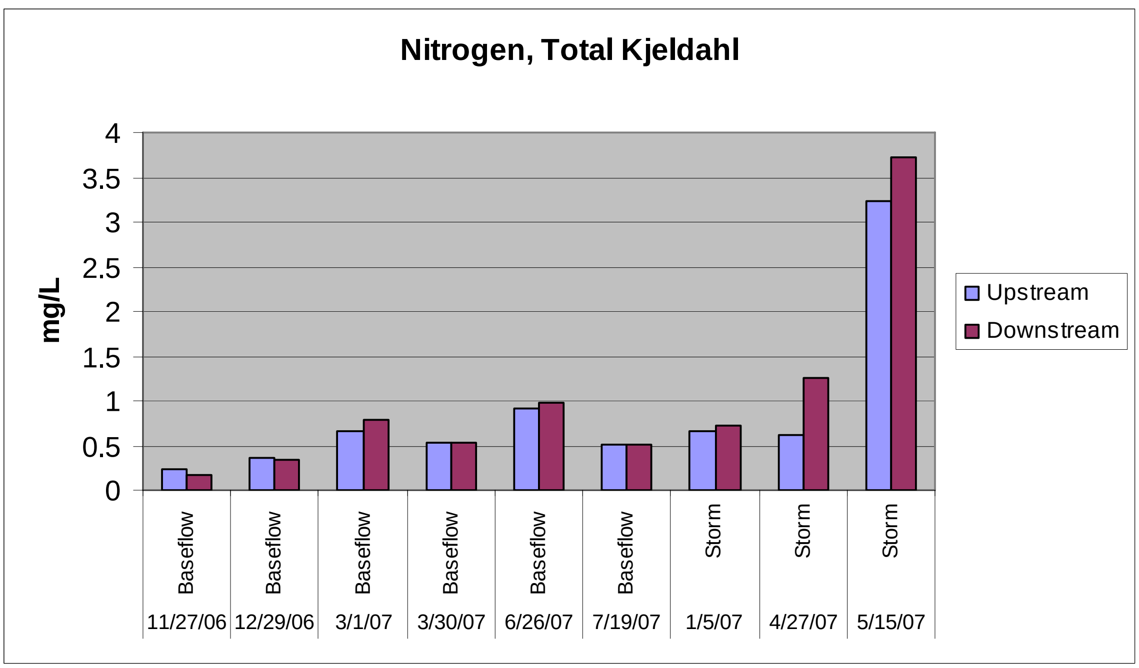
Nitrate/Nitrite

	Date		Nitrate/Nitrite (mg/L) Upstream	Downstream
Baseflow	11/27/06		1.00	1.40
	12/29/06		1.30	1.50
	3/1/07		1.20	0.96
	3/30/07		1.20	1.60
	6/26/07		1.20	1.70
	7/19/07		0.89	1.20
		MEAN	**1.13**	**1.39**
		MEDIAN	**1.20**	**1.40**
		MIN	**0.89**	**0.96**
		MAX	**1.30**	**1.70**
Storm event	1/5/07		0.62	0.60
	4/27/07		0.77	0.83
	5/15/07		1.06	1.04
		MEAN	**0.82**	**0.82**
		MEDIAN	**0.77**	**0.83**
		MIN	**0.62**	**0.60**
		MAX	**1.06**	**1.04**



Total Kjeldahl Nitrogen (TKN)

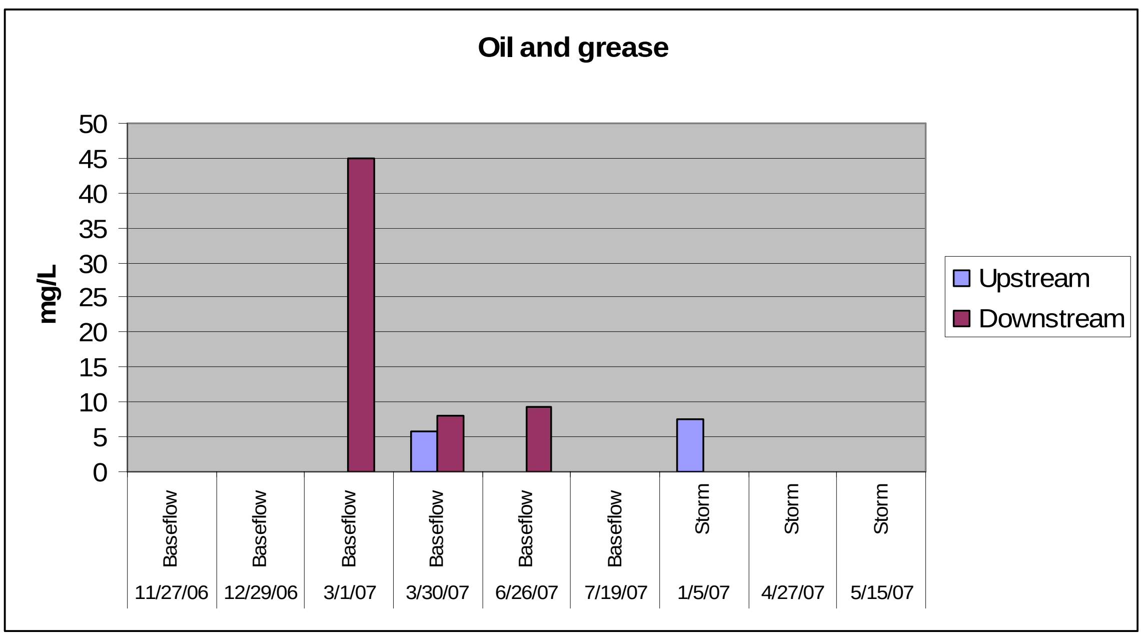
	Date		Nitrogen, Total Kjeldahl (mg/L) Upstream	Downstream
Baseflow	11/27/06		0.23	0.17
	12/29/06		0.37	0.34
	3/1/07		0.67	0.78
	3/30/07		0.53	0.53
	6/26/07		0.91	0.98
	7/19/07		0.52	0.52
		MEAN	**0.54**	**0.55**
		MEDIAN	**0.53**	**0.53**
		MIN	**0.23**	**0.17**
		MAX	**0.91**	**0.98**
Storm event	1/5/07		0.67	0.72
	4/27/07		0.61	1.26
	5/15/07		3.23	3.73
		MEAN	**1.50**	**1.90**
		MEDIAN	**0.67**	**1.26**
		MIN	**0.61**	**0.72**
		MAX	**3.23**	**3.73**



Oil and Grease

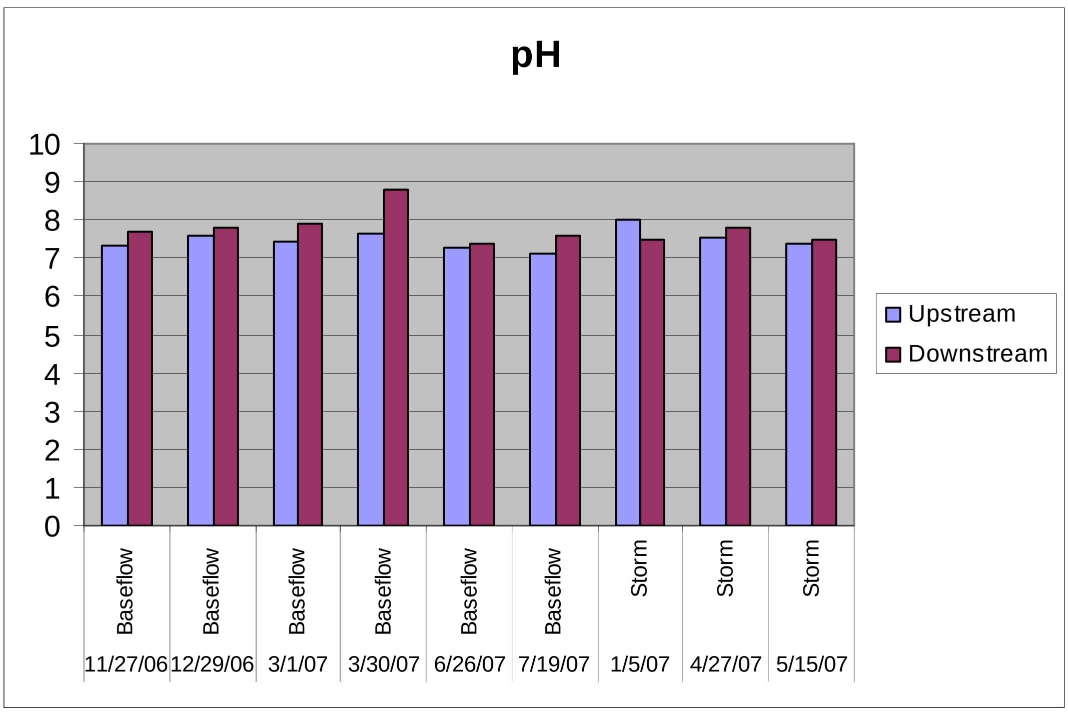
	Date		Oil & Grease (mg/L) Upstream	Downstream
Baseflow	11/27/06		ND	ND
	12/29/06		ND	ND
	3/1/07		ND	45.00
	3/30/07		5.90	8.10
	6/26/07		ND	9.30
	7/19/07		ND	ND
		MEAN	**0.98**	**10.40**
		MEDIAN	**0.00**	**8.10**
		MIN	**0.00**	**0.00**
		MAX	**5.90**	**45.00**
Storm event	1/5/07		7.60	ND
	4/27/07		ND	ND
	5/15/07		ND	ND
		MEAN	**2.53**	**0.00**
		MEDIAN	**0.00**	**0.00**
		MIN	**0.00**	**0.00**
		MAX	**7.60**	**0.00**

ND: Indicates that the compound was analyzed for but not detected (ND assessed as 0)



pH

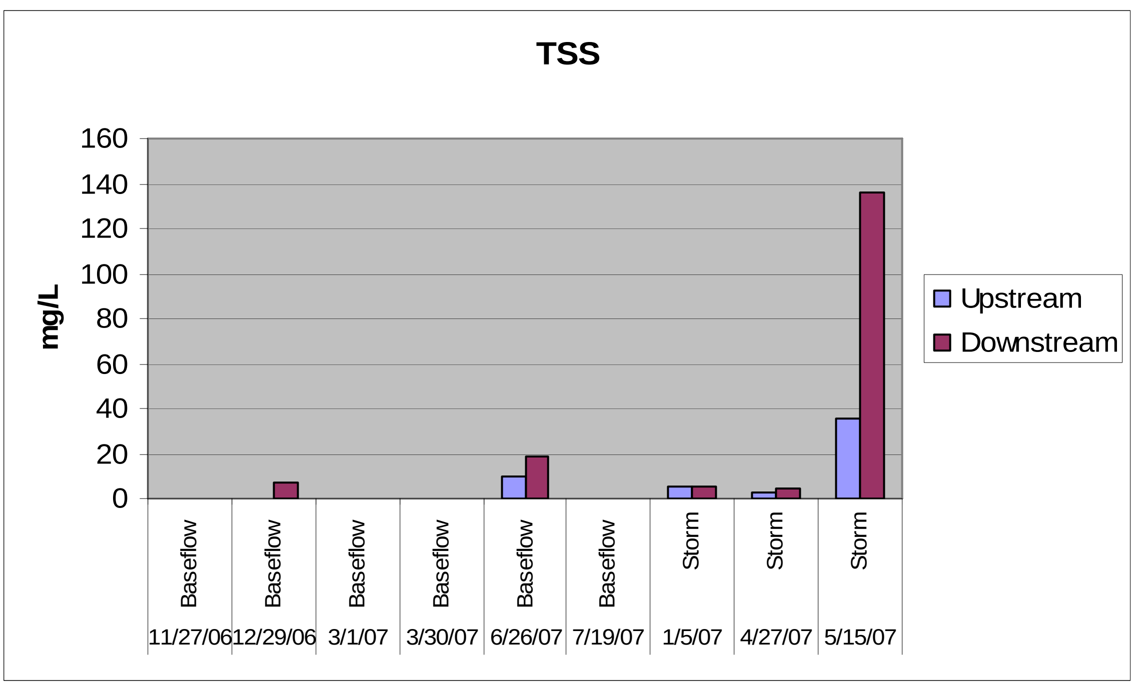
	Date		pH	
			Upstream	Downstream
Baseflow	11/27/06		7.31	7.69
	12/29/06		7.57	7.80
	3/1/07		7.41	7.88
	3/30/07		7.67	8.82
	6/26/07		7.29	7.38
	7/19/07		7.11	7.60
		MEAN	**7.39**	**7.86**
		MEDIAN	**7.39**	**7.80**
		MIN	**7.11**	**7.38**
		MAX	**7.67**	**8.82**
Storm event	1/5/07		8.00	7.5
	4/27/07		7.52	7.78
	5/15/07		7.37	7.50
		MEAN	**7.63**	**7.59**
		MEDIAN	**7.52**	**7.50**
		MIN	**7.37**	**7.50**
		MAX	**8.00**	**7.78**



Total Suspended Solids (TSS)

	Date		TSS (mg/L) Upstream	Downstream
Baseflow	11/27/06		ND	ND
	12/29/06		ND	7.0
	3/1/07		BQL	BQL
	3/30/07		ND	ND
	6/26/07		10.0	19.0
	7/19/07		ND	ND
		MEAN	**1.7**	**4.3**
		MEDIAN	**0.0**	**0.0**
		MIN	**0.0**	**0.0**
		MAX	**10.0**	**19.0**
Storm event	1/5/07		5.0	5.3
	4/27/07		2.3	4.7
	5/15/07		36.0	136.0
		MEAN	**14.4**	**48.7**
		MEDIAN	**5.0**	**5.3**
		MIN	**2.3**	**4.7**
		MAX	**36.0**	**136.0**

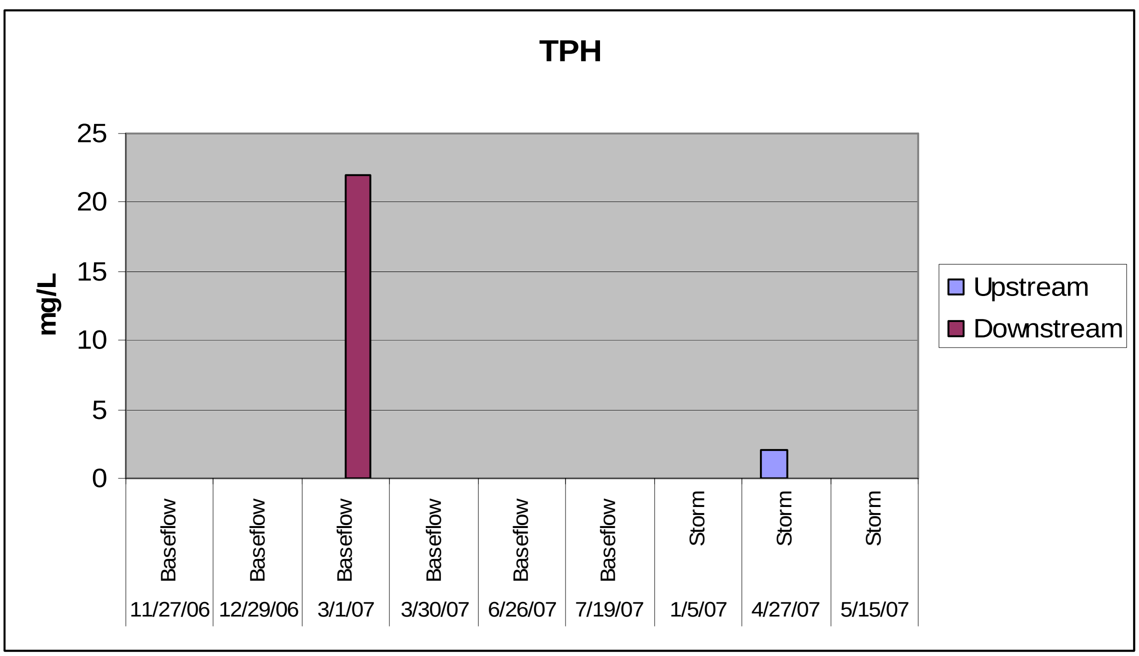
ND: indicates that the compound was analyzed for but not detected
BQL: Below quantitation limit
(ND and BQL were assessed as 0)



Total Petroleum Hydrocarbons (TPH)

	Date		TPH (mg/L) Upstream	Downstream
Baseflow	11/27/06		ND	ND
	12/29/06		ND	ND
	3/1/07		ND	22.0
	3/30/07		ND	ND
	6/26/07		ND	ND
	7/19/07		ND	ND
		MEAN	**0.0**	**3.7**
		MEDIAN	**0.0**	**0.0**
		MIN	**0.0**	**0.0**
		MAX	**0.0**	**22.0**
Storm event	1/5/07		2.0	ND
	4/27/07		ND	ND
	5/15/07		ND	ND
		MEAN	**0.7**	**0.0**
		MEDIAN	**0.0**	**0.0**
		MIN	**0.0**	**0.0**
		MAX	**2.0**	**0.0**

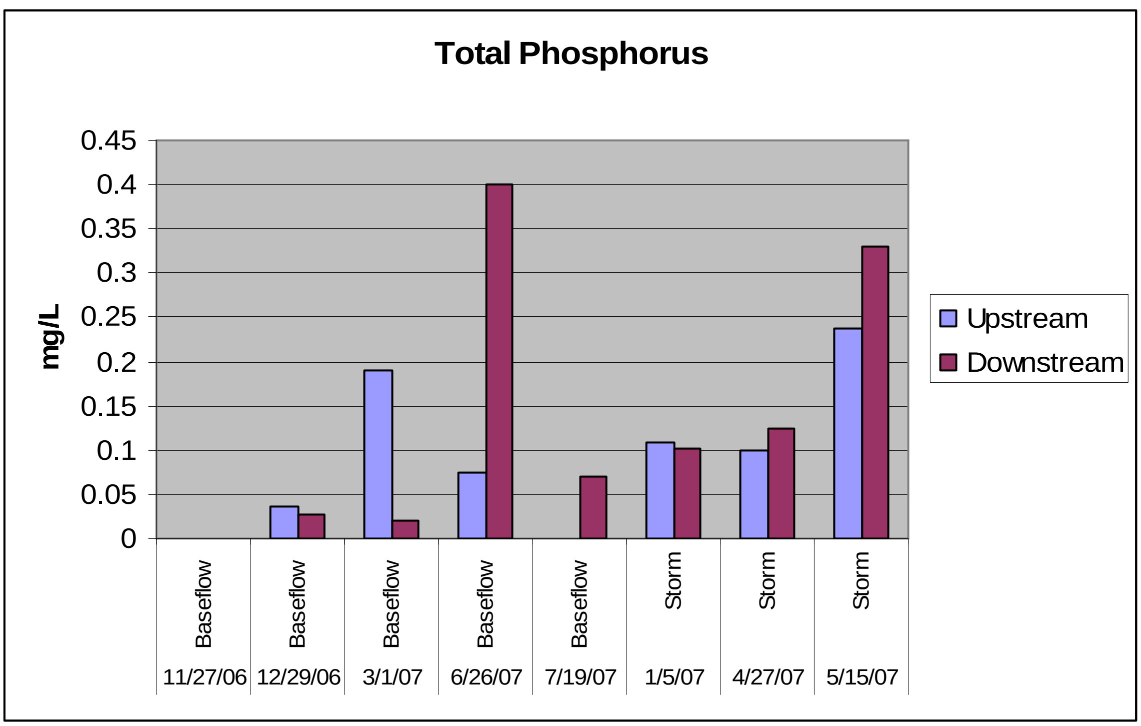
ND: indicates that the compound was analyzed for but not detected
(ND assessed as 0)



Total Phosphorus

	Date		Total Phosphorus (mg/L)	
			Upstream	Downstream
Baseflow	11/27/06		ND	ND
	12/29/06		0.036	0.027
	3/1/07		0.19	0.02
	3/30/07		NM	NM
	6/26/07		0.08	0.40
	7/19/07		ND	0.07
		MEAN	**0.06**	**0.10**
		MEDIAN	**0.05**	**0.05**
		MIN	**0.00**	**0.0**
		MAX	**0.19**	**0.4**
Storm event	1/5/07		0.11	0.10
	4/27/07		0.10	0.12
	5/15/07		0.24	0.33
		MEAN	**0.15**	**0.19**
		MEDIAN	**0.11**	**0.12**
		MIN	**0.10**	**0.1**
		MAX	**0.24**	**0.3**

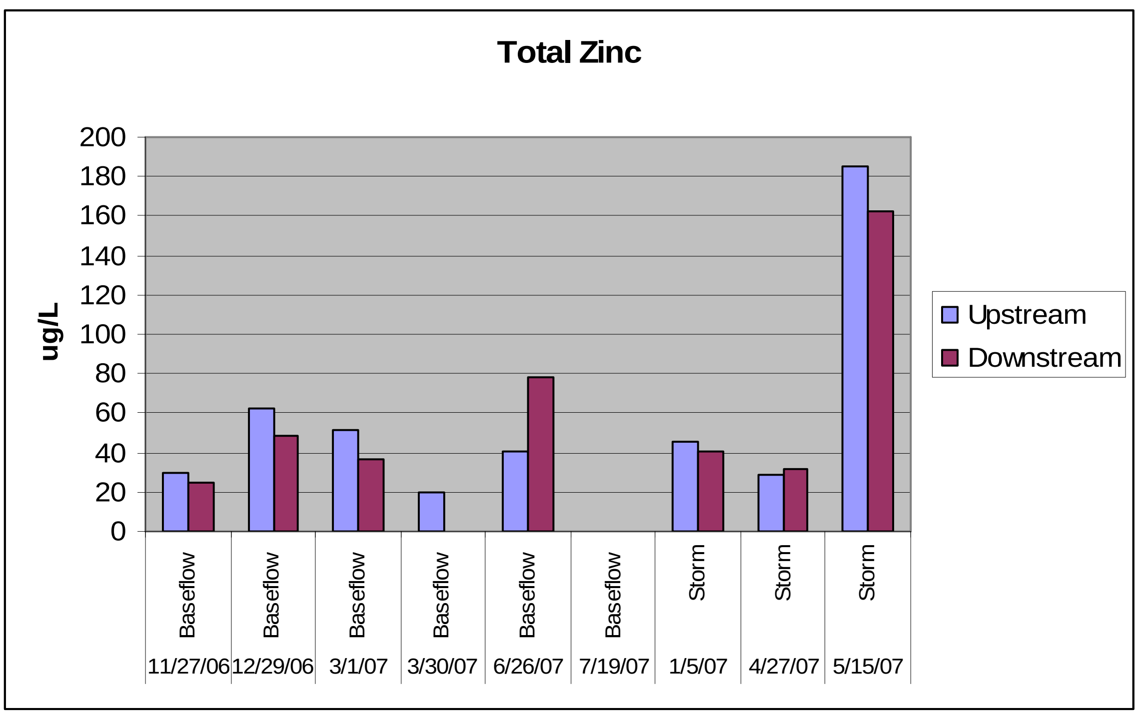
ND: indicates that the compound was analyzed for but not detected
NM: Not measured
(ND assessed as 0)



Total Zinc

	Date		Zinc (ug/L) Upstream	Downstream
Baseflow	11/27/06		29.3	24.8
	12/29/06		62.4	48.1
	3/1/07		51.6	36.3
	3/30/07		J-metals	J-metals
	6/26/07		40.7	78.5
	7/19/07		J-metals	J-metals
		MEAN	**46.0**	**46.9**
		MEDIAN	**46.0**	**46.9**
		MIN	**29.3**	**24.8**
		MAX	**62.4**	**78.5**
Storm event	1/5/07		45.6	40.1
	4/27/07		28.4	32.0
	5/15/07		185.1	161.9
		MEAN	**86.4**	**78.0**
		MEDIAN	**45.6**	**40.1**
		MIN	**28.4**	**32.0**
		MAX	**185.1**	**161.9**

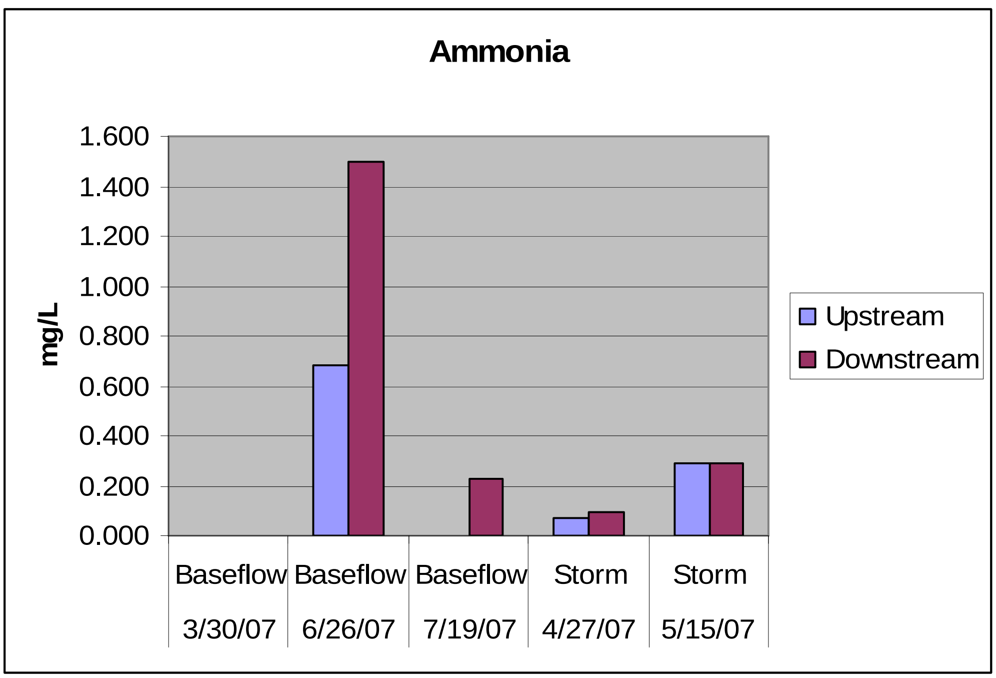
J-metals: indicates that the reported value was less than the reporting limit but greater than or equal to the IDL/MDL (J-metals assessed as 0)



Ammonia

	Date		Ammonia (mg/L)	
			Upstream	Downstream
Baseflow	11/27/06		NM	NM
	12/29/06		NM	NM
	3/1/07		NM	NM
	3/30/07		ND	ND
	6/26/07		0.680	1.500
	7/19/07		ND	0.230
		MEAN	**0.227**	**0.577**
		MEDIAN	**0.113**	**0.403**
		MIN	**0.000**	**0.000**
		MAX	**0.680**	**1.500**
Storm event	1/5/07		NM	NM
	4/27/07		0.037	0.060
	5/15/07		0.221	0.740
		MEAN	**0.129**	**0.400**
		MEDIAN	**0.129**	**0.400**
		MIN	**0.037**	**0.060**
		MAX	**0.221**	**0.740**

NM: Not measured
ND: Indicates that the compound was analyzed for but not detected
(ND assessed as 0)



Orthophosphate

	Date		Orthophosphate (mg/L) Upstream	Downstream
Baseflow	11/27/06		NM	NM
	12/29/06		NM	NM
	3/1/07		NM	NM
	3/30/07		BQL	BQL
	6/26/07		ND	ND
	7/19/07		ND	ND
		MEAN	**0.000**	**0.000**
		MEDIAN	**0.000**	**0.000**
		MIN	**0.000**	**0.000**
		MAX	**0.000**	**0.000**
Storm event	1/5/07		NM	NM
	4/27/07		ND	ND
	5/15/07		0.058	0.017
		MEAN	**0.029**	**0.009**
		MEDIAN	**0.029**	**0.009**
		MIN	**0.000**	**0.000**
		MAX	**0.058**	**0.017**

NM: Not measured
ND: Indicates that the compound was analyzed for but not detected
BQL: Below Quantitation Limit
(BQL and ND assessed as 0)