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

Permit Term October 2005 to October 2010

First Annual Report
October 21, 2006

Submitted to:
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SHA State Highway Administration
Maryland Department of Transportation

Executive Summary

The Maryland State Highway Administration (SHA) is submitting this annual report for the NPDES Phase I Permit that was issued in October 2005. This annual report covers the time period January 2005 to October 2006. This timeframe includes not only the permitted year from October 2005 to October 2006, but also covers the interim negotiation period from the last annual report for the previous permit term. 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 reporting period.

Source Identification – Source identification efforts continued with the last two Phase I counties, Carroll and Charles, being assigned in August and September. The work should be completed in early 2008. In the interim period between the last permit period and this annual report, Harford and Frederick county source identification was completed. SHA is also well on our way to implementing a procedure for completing the new impervious accounting requirement.

Discharge Characterization – This permit moves beyond the identification of runoff pollutants toward using available data in order to improve understanding and efforts in achieving better water quality. SHA has completed several studies and organized new ones to meet this condition. We are also reviewing available data in order to focus our efforts toward those activities that prove most effective and to improve our processes and programs.

Management Program – Several components comprise this condition and SHA has programs in place that fulfill most of the requirements of these programs. We have also continued to expand our efforts by taking steps over the last two years to incorporate components not addressed by previous NPDES permit requirements such as deicing and street sweeping into our thinking and decision making.

Watershed Assessment – For this permit term, SHA will increase our contact and involvement with local NPDES officials in coordinating watershed restoration projects and to fit our restoration efforts into locally established and quantifiable restoration goals. Our focus over the next year concerning this permit condition is to begin development of a watershed-based planning guideline (EPA Grant) and to document local NPDES jurisdiction watershed restoration goals and priorities.

Washington Metropolitan Watershed – SHA Restoration Projects

Watershed Restoration –SHA currently has thirty-nine restoration projects, in nine watersheds, in various stages of development and construction. These projects include BMP retrofits and enhancements as well as stream stabilization and restoration. This, combined with future partnerships with local NPDES jurisdictions, will exceed the twenty-five retrofit requirements for the permit period.

Assessment of Controls – The Long Draught Branch Stream Restoration project located in the Washington Metropolitan Watershed, will be constructed and monitored for the required physical, chemical and biological criteria during this permit term. The design of this project reached 60% completion and a monitoring plan was developed over this reporting period.

Program Funding – This program is well equipped with both funding and consultant resources to accomplish the requirements of the permit. Over the next year, funding analysis and tracking tools will be developed for those areas that we are not currently tracking in order for us to provide with future reports the funding data required.

Total Maximum Daily Loads – By adhering to the requirements of the phase I permit, SHA is controlling stormwater pollution to the maximum extent practicable.

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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 first annual report for the re-issued permit. The last annual report was submitted for the year 2004 activities and efforts to secure the new permit took the place of an annual report for the year 2005. For this reason, this annual report will cover the period from January 2005 through October 2006.

This section lists the permit conditions and explains SHA activities over the last year and a half in order to remain 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.

A Administration of Permit

The organization for the NPDES permit administration for SHA has changed. A new organizational chart is attached. Specifically, Program Coordinator is now:

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

B Legal Authority

In applying for the first term of the phase one individual permit, we submitted information regarding the legal authority that SHA maintains in controlling pollutants, illicit discharges, spills, dumping and disposal of materials other than stormwater discharge, or other restricted activities, within the bounds of our properties. We have reviewed this information and take this opportunity to restate our assessment of legal authority.

The following statement of legal authority was developed by the Assistant Attorney General and submitted with our original permit application for the 1999 permit.

> *"The applicant can operate pursuant to legal authority established by statute, ordinance or series of contracts, which authorizes or enables the applicant at a minimum to:*

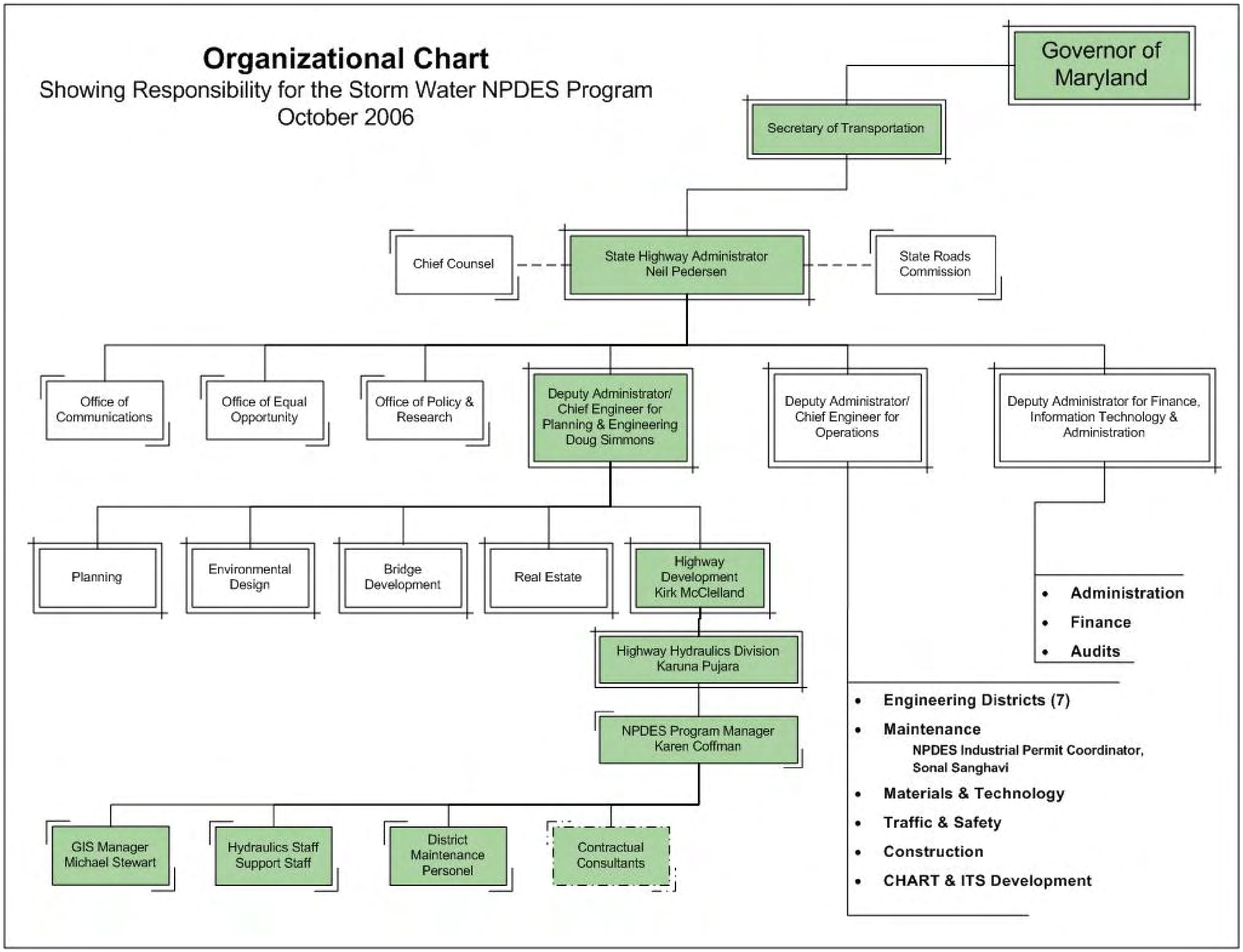


Figure 1-1 Organizational Chart for NPDES Permit Administration

"(A) Control through ordinance, permit, contract, order or similar means, the contribution of pollutants to the municipal storm sewer by storm water discharges associated with industrial activity and the quality of storm water discharged from sites of industrial activity:

"The only legal manner in which a person may discharge or increase storm water runoff/volume into SHA's Municipal Storm Water Management System is by connection via access control permit issued in accordance with COMAR 11.04.05.06.C and D (commercial access) and 11.04.06.02.G (residential access). SHA assures that these permits limit volume and quality of stormwater input from adjacent properties. In addition, with respect to storm water runoff as a result of construction activity on state highways, SHA may, through contract, impose restrictions within the contract documents and , if violations with respect to storm water discharge is discovered, SHA may issue a stop work order which required the contractor and/or its subcontractors to cease and desist until the violations are corrected.

"(B) Prohibit through ordinance, order or similar means; illicit discharges to the municipal separate storm sewer:

"SHA does not enact ordinances per se, but may terminate or suspend a commercial or residential access permit as discussed above if a permit condition is violated or, as appropriate, may sue for injunctive relief to assure compliance in accordance with Maryland Transportation Code Annotated Section 8-625 (b). In the event the illicit discharge is caused by its contractor under a construction or maintenance project on a state highway, the procurement officer may issue a stop work order as discussed above which is an administrative order. The illicit discharges by persons other than permit holders or contractors (i.e., vehicles or pedestrians using the highway system) are prohibited by Md. Environ. Code Ann. §4-410-413; and Md. Transp. Code Ann. §21-1111(d) (dumping trash and oil into the storm sewer).

"(C) Control through ordinance, order or similar means the discharge to a municipal separate storm sewer of spills, dumping or disposal of materials other than storm water:

"These concerns are covered in the previous paragraph.

"(D) Control through interagency agreements among co-applicants the contribution of pollutants from one portion of the municipal system to another portion of the municipal system:

"The State Highway Administration occasionally enters into memoranda of agreement with other agencies, counties and/or municipalities and would, by contract, provide for the coordination required by this subparagraph.

"(E) Require compliance with conditions in ordinances, permits, contracts or orders:

"As discussed above, SHA may require compliance with conditions in its permit and contracts by suspending privileges thereunder or issuing stop work or other appropriate orders in order to obtain compliance. Additionally, SHA may resort to legal action in the courts to enforce compliance.

"(F) Carry out all inspection, surveillance and monitoring procedures necessary to determine compliance and noncompliance with permit conditions including the prohibition on illicit discharges to the municipal separate storm sewer:

"Compliance with permit conditions are determined routinely by inspections by SHA employees or consultants. Ordinarily, the permits issued are for construction of road access on to a state highway, which roads are subsequently dedicated to a public entity (i.e., a county dedication) or are part of a parking area open to the public. To our knowledge, there are no properties or developments for which permits are issued that are of such a nature as to prohibit subsequent inspection by state highway personnel."

We have requested the current Assistant Attorney General review this statement of legal authority in light of any changes to codes and Administration policy that might alter the effectiveness of the current statement. We will address adjustments in the statement with MDE if necessary.

C Source Identification

Source identification deals with identifying sources of pollutants and linking these sources to specific water quality impacts on a highway district basis. Generally this effort would look to land uses within the watersheds contributing to major outfalls. Because SHA deals mainly with roadway facilities, the associated pollutant sources are fairly consistent: roadway impervious surfaces and associated highway runoff pollutants.

The exception to this is some district offices and maintenance facilities that are recognized as facilitating industrial activities. Storm drain systems associated with these facilities are permitted under separate individual or general stormwater industrial permit coverge. However, the systems associated with industrial activities are identified, located, inspected and documented as part of this permit effort.

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.

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

Source identification requirements were completed on many counties prior to this permit term. Since the sixth annual report for 2004 was submitted, SHA has completed the databases for the most recently assigned counties, Harford and Frederick. Currently, counties with completed source identification databases include (in order of completion):

- Howard,
- Montgomery,
- Anne Arundel,
- Prince George's,
- Baltimore,
- Harford, and
- Frederick.

Dry Swale in Howard County during Field Inspection

We have completed office identification work and assigned the last two phase one counties for field location, inspection and GIS development. The source identification will be completed on these counties in January 2008. This will complete the permit requirement for source identification. These final counties are:

- Carroll, and
- Charles.

Figure 1-2 summarizes the status of the source identification effort by SHA. Specific information on each county is listed below.

Howard County - The inventory, database and GIS model of drainage features along 182 miles of SHA roadway was completed in January 2001. Updates to the database and GIS model were

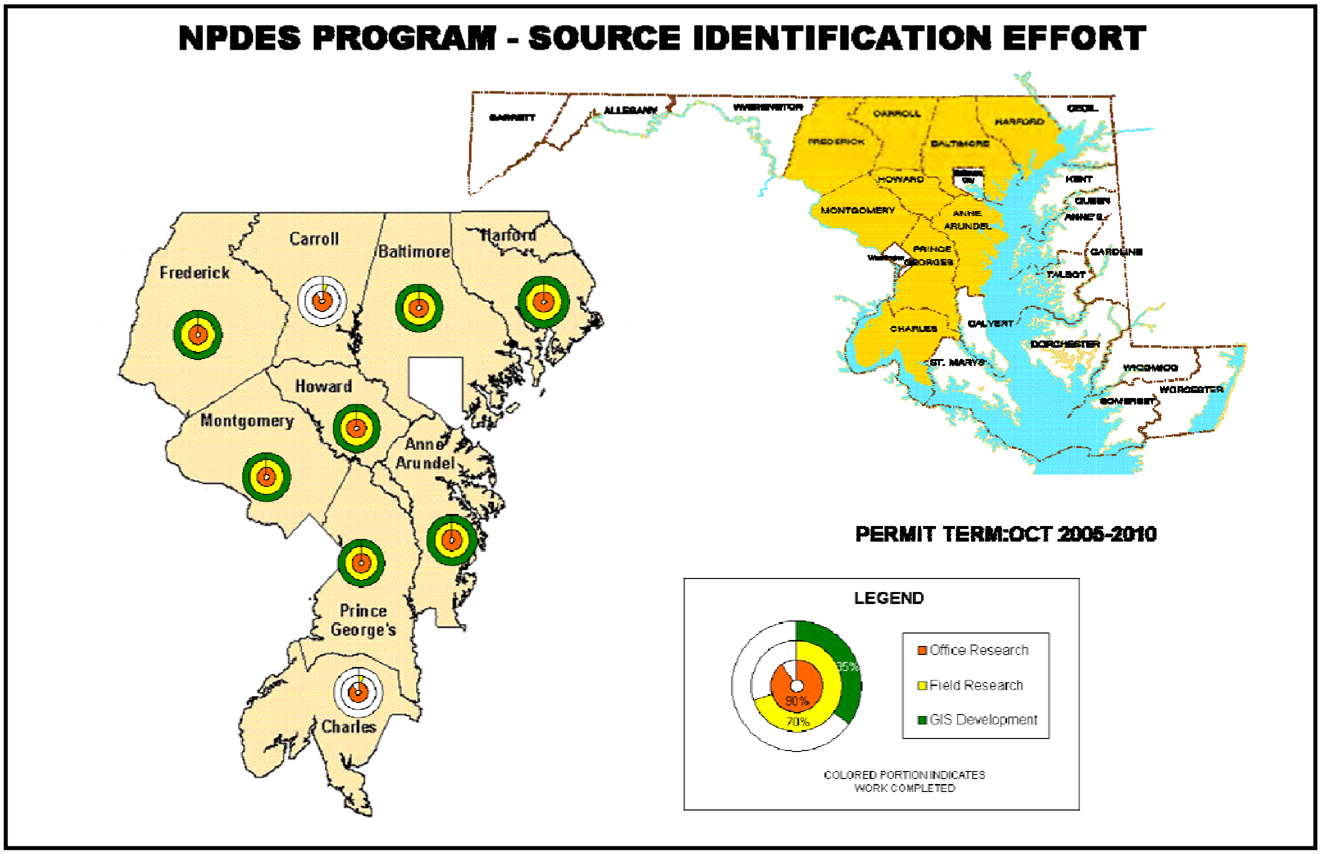


Figure 1-2 Source Identification and GIS Development Status

completed in January 2005. The current number of BMPs identified for this county is 258.

Montgomery County - The inventory, database and GIS model of drainage features along 357 miles of SHA roadway was completed in January 2001. Updates for the database and GIS model were completed in September 2006. The current number of BMPs identified for this county is 375.

Anne Arundel County - The inventory, database and GIS model of drainage features along 365 miles of SHA roadway was completed in August 2003. The current number of BMPs identified for this county is 428. Updates for this county are scheduled to begin in June 2007.

Prince George's County – The inventory, database and GIS model of drainage features along 353 miles of SHA roadway was completed in March 2003.. The current number of BMPs identified for this county is 191. Updates for this county are scheduled to begin in June 2007.

Baltimore County – The inventory, database and GIS model of drainage features along 377 miles of SHA roadway was completed in March 2004. The current number of BMPs identified for this county is 169.

Harford County – The inventory, database and GIS model of drainage features along 272 miles of SHA roadway was completed in August 2005. All available as-built construction drawings were researched then field verified. The current number of BMPs identified for this county 114.

Frederick County – The inventory, database and GIS model of drainage features along 353 miles of SHA roadway was completed in August 2006. All available as-built construction drawings were researched then field verified. The current number of BMPs identified is 110.

Carroll County – The 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. Number of facilities identified during the as-built inventory is 36. The database and GIS model for drainage features will be completed in January 2008.

Charles County – The 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. Number of facilities identified during the as-built inventory is 107. The database and GIS model for drainage features will be completed in January 2008.

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. Data shared is compatible with most other NPDES jurisdictions.

Geospatial Database Development

SHA is in the process of finalizing a geospatial database for the source identification data (90% complete). Utilizing the ESRI Geodatabase data format, SHA is working towards implementing an enterprise ArcSDE environment to store all of the source identification data. Currently the data for Montgomery and Frederick Counties have been migrated to this format. Efforts to migrate the existing databases and GIS information to the

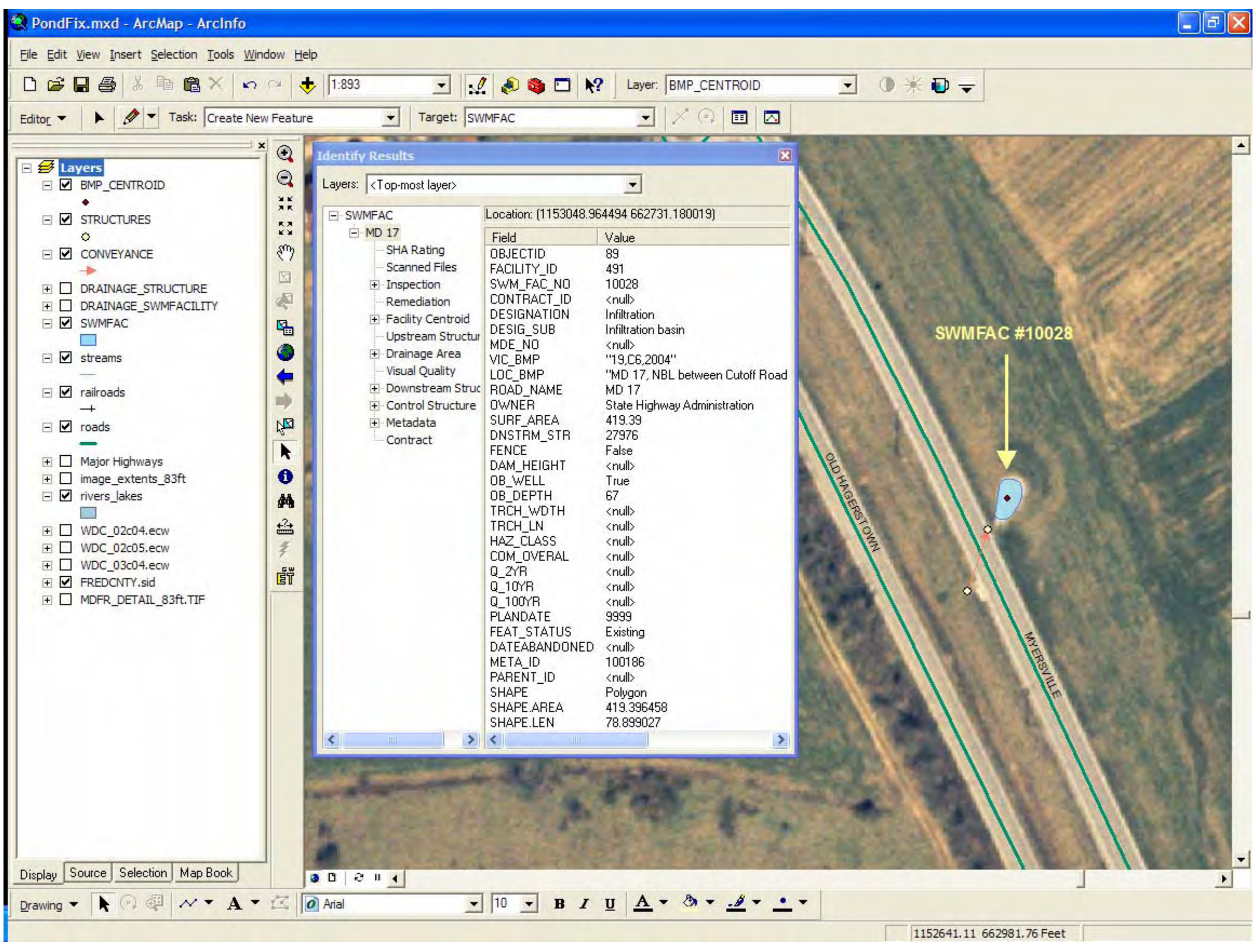


Figure 1-3 Example of Geodatabase Data Display

geodatabase will be completed as counties are assigned for source identification updates. See Figure 1-3 for an example of the geodatabase data display.

GIS Viewer Application

A GIS viewer application tool is being developed (20% complete) to utilize the power of the enterprise GIS system and allow SHA to manage the BMP maintenance program efficiently. The viewer application will allow SHA staff to view, analyze, and query the GIS data as well as manage updates.

The viewing application will assist SHA in the preparation of the annual report by utilizing custom designed queries and reports. As an example, SHA will provide MDE with the Annual Report Database in Microsoft Access Format. Populating of the database will be performed by creating a database schema that mimics the MDE format on the SHA data server. A custom query will be developed that will extract the required data out of the geodatabase and disseminate it through the MDE database as appropriate. Once the GIS viewer application is complete, creating the MDE database on an annual basis will be as simple as identifying the Counties to be extracted, and executing the command. See Figures 1-4 and 1-5 for examples of the GIS viewer display.

Standard Procedures Manual

A new *Standard Procedures Manual* is under development (60% complete) and will address all the data collection issues necessary to ensure that future source identification updates comply with the geodatabase requirements. We will also be developing a *SHA NPDES GIS User's Manual* and a *SHA NPDES GIS Administrator's Manual*. These two manuals will complement the GIS tools with user and administrator instructions.

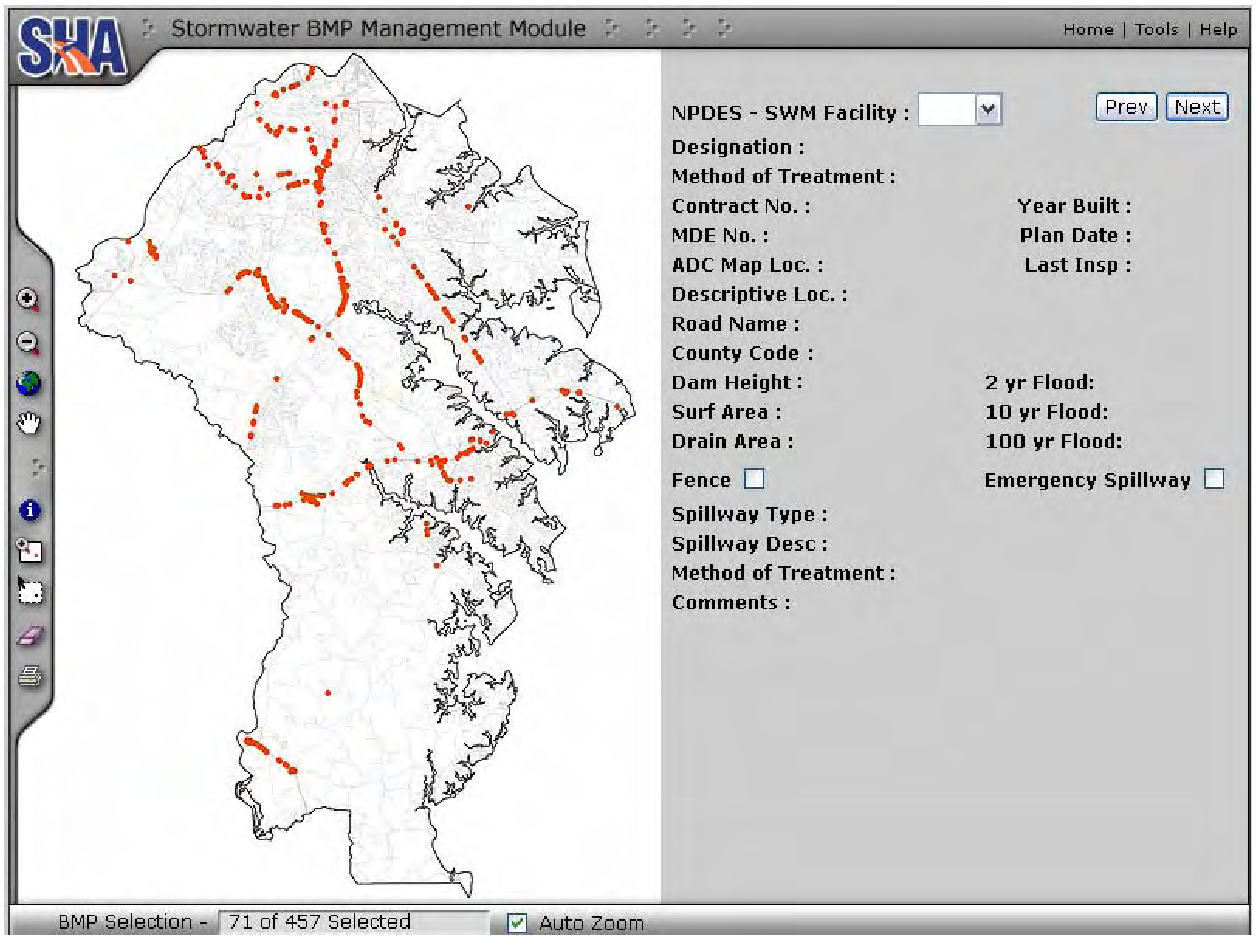


Figure 1-4 GIS Viewer Application Navigation Screen Concept

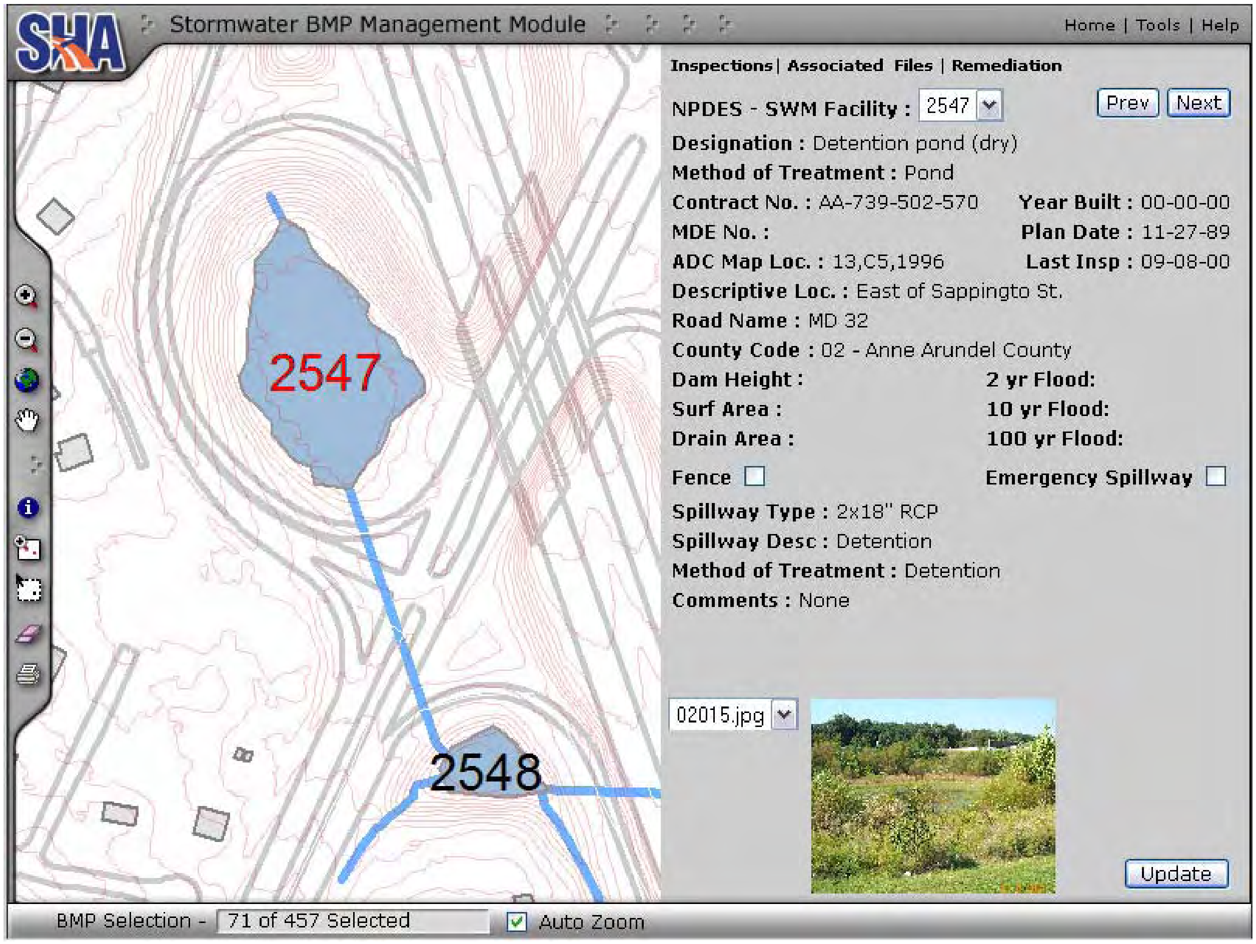


Figure 1-5 GIS Viewer Application SWM BMP Management Module

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. The following county database updates were completed since the last annual report:

- Howard, and
- Montgomery.

Future updates will be performed according the Table 1-1.

Table 1-1. Source ID Update Schedule

County	Source ID Complete	1st Update	2nd Update
Howard	**01/2001**	**01/2005**	*01/2009*
Montgomery	**01/2001**	**09/2006**	*09/2009*
Anne Arundel	**08/2003**	*6/2007*	
Prince George’s	**03/2003**	*6/2007*	
Baltimore	**03/2004**	*12/2007*	
Harford	**08/2005**	*08/2008*	
Frederick	**09/2006**	*09/2009*	
Carroll	01/2008		
Charles	01/2008		

Note: **Bold text** is actual completion dates.
Regular text is projected completion dates.
Italicized text is projected initiation dates.

C.1.d Submit Source Identification Data

Examples of the source identification data for Harford and Frederick Counties are included in Appendix A. Examples of updated source identification data are also included for Montgomery and Howard Counties.

When available, examples of data for Carroll and Charles Counties will be submitted.

C.2 Submit BMP Data

Data is included on the enclosed CD for the Urban BMP Database according to Part IV and Attachment A of the permit. This data includes BMP data for counties that were completed since the last delivery (Harford and Frederick) and counties that were updated since the last delivery (Howard and Montgomery).

C.3 Create an 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.

Work Plan

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

1. Pilot Studies – Study the best method to proceed in developing the impervious layer that provides most accuracy at efficient cost.
2. Impervious Layer Methodology – Based upon results of pilot studies, determine best method to develop impervious surface layer.
3. Impervious Accounting Protocol – Develop a protocol for the impervious layer production and the accounting process.
4. Develop protocol to track funding and develop fiscal analysis annually.
5. Develop Schedule to ensure completion by 10/2009.
6. Implement protocol and schedule.
7. Track progress and report annually.

Pilot Studies and Impervious Layer Methodology

SHA conducted several pilot studies in 2005 in order to discern the best method to produce the impervious surface layer and accounting data. SHA evaluated the studies by comparing time/personnel resources involved, data accuracy and cost in determining a methodology that is best suited to proceed with completing this requirement.

Areas in Montgomery, Anne Arundel and Queen Anne's counties were used in the pilot studies. The methodologies explored the pros and cons of manual heads up digitizing versus an automated program such as Feature Analyst (a Visual Learning Systems product). These studies include:

- *Impervious Area Protocol Study, Montgomery County, Maryland*, KCI Technologies, Inc., February 2005.
- *Impervious Area Accounting Pilot Study, Anne Arundel County, Maryland*, McCormick Taylor, July 2005;
- *Impervious Area Accounting Study- Corsica River Watershed, Queen Anne's County, Maryland*, McCormick Taylor, September 2005;
- *Impervious Area Accounting Study- Indian Creek Watershed, Prince George's County, Maryland*, McCormick Taylor, December 2005.

The heads-up digitizing pilot studies involved utilizing planimetric edge of roadway data supplied by the Counties. The edge of roadway data was compared to aerial photography to locate missing roadway features. It was frequently found that the edge of roadway data was in fact edge of travel lane and not edge of shoulder. Therefore, to adequately model the amount of impervious area, the edge of roadway data needed to be shifted manually. Additionally, sidewalks were not always included in the planimetric data and needed to be added in manually. Although this is a valid process, the manual effort is time consuming and subject to operator error.

Feature Analyst is a remote sensing application that works with standard aerial photography. A process of 'teaching' the application is utilized to instruct it what the visual signature of impervious area looks like in the photography.

Example of Source Data for Feature Analyst Process

The application then evaluates the imagery and returns back a GIS file indicating the location of all of the impervious area. An iterative approach is used to fine tune the rules that the application uses to identify impervious area. The benefit of the program is that once the teaching is complete, it becomes a semi-automated process to analyze multiple images, as long as they have similar spectral information.Comparing the two methods, Feature Analyst provides very good results at a significantly lower cost. SHA is currently looking into performing a Feature Analyst analysis of Montgomery County to further prove the methodology and provide pasis for protocol development. Appendix B contains screen shots from a Microsoft Power Point presentation prepared by KCI Technologies concerning the use of Feature Analyst.

The conclusion is that SHA will pursue the Feature Analyst method in developing the impervious surface layers for the nine NPDES Phase I counties.

Impervious Accounting Protocol

A protocol that will detail the process to be followed in developing the impervious accounting has yet to be developed and is our next step to be undertaken. Beyond developing the surface layer, the impervious account will also look at quantifying the total amount of impervious owned by SHA, the amount of that impervious receiving stormwater treatment and the amount not receiving stormwater treatment. This data is required to be organized according to SHA engineering district. The resulting protocol will address and resolve several issues such as:

- 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. This is a key issue in defining the impervious accounting process and SHA will pursue resolving this issue as a first priority in completing an impervious accounting protocol.

- Identify process for updating impervious layer and accounting data as projects are designed and constructed and to integrate the concept of impervious accounting into the project development process. This includes district special projects, construction modifications and as-builts, as well as planning and design projects.
- Integrate impervious accounting with the current SHA/MDE water quality banking agreement and process.
- Develop 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.
- Design a database for tracking and reporting. The database should also address accounting for watersheds versus engineering districts.
- Develop procedure and standards for generating treated impervious layers.
- Develop quality assurance mechanisms.
- Integrate impervious accounting database and process with current SHA GIS data and tools including GIS viewer application.
- Develop process, database and GIS user documentation.

We anticipate completing the protocol development process by 10/2007, and submitting the final protocol with the next annual report. Generation of impervious surface layers will proceed while this protocol is being developed.

Impervious Accounting Schedule

Table 1-2 provides a schedule for completing the impervious accounting effort. Generally we foresee a two month turnaround for each county for each activity. Adjustments will be made to the order or times as necessary in order to meet the October 2009 deadline required by the permit.

D Discharge Characterization

The previous permit term required characterization of runoff from SHA specific land uses. The characterization was three-fold: a best management practice (BMP) performance study, long-term discharge characterization of an outfall and associated in-stream monitoring station, and comparison of SHA monitoring data with national studies. This work is complete.

Table 1-2. Proposed Impervious Accounting Schedule

Activity	Impervious Surface Layer	Treatment Accounting
Montgomery	11/2006	10/2007
Frederick	1/2007	10/2007
Prince George's	1/2007	*10/2007*
Charles	1/2007	
Carroll	4/2007	
Howard	4/2007	
Anne Arundel	4/2007	
Baltimore	7/2007	
Harford	7/2007	

Note: **Bold text** is actual completion dates.
Regular text is projected completion dates.
Italicized text is projected initiation dates.

The final discharge characterization reports were delivered to MDE and include:

- *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.

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. In addition to the research documented above, SHA has also obtained a copy of a three volume document from FHWA that was compiled in corporation with the US Geological Survey entitled *The National Runoff Data and Methodology Synthesis, Publication No FHWA-EP-03-054 -055, -056, 2003*. This document provides information on the existing knowledge of the characteristics of highway runoff and ways to assess and mitigate for possible adverse effects on receiving channels.

SHA is in the process of studying the information contained in all of these documents with the goal of developing further studies and areas of investigation, improving our knowledge of highway pollutant characteristics, understanding the sources of highway pollutants, understanding processes for treating or removing these pollutants from the highway discharge waters, and integrating these lessons into our design, construction and maintenance processes.

In cooperation with the literature and research documented above, we are also pursuing further research studies through the University of Maryland and other engineering consultants in order to improve our 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. These studies target the effectiveness of BMPs in treating stormwater pollutants specific to highway pollutant runoff. Current studies include:

Low Impact Development Implementation Studies at Mt. Rainier, MD Completed

This study, which was discussed in the 2003 and 2004 annual reports in detail, was completed by the end of 2005. The final report, prepared by the University of Maryland is included in Appendix C The abstract from that final report is included here:

> "The impact of two management practices, gutter filters and bioinlets, on stormwater highway runoff quality at an ultra urban area in Mt. Rainier, MD, was evaluated. The analyses were divided into 3 phases: before construction (Phase 1, 32 events), gutter filters only (Phase 2, 17 events), and gutter filters and bioinlets (Phase 3, 14 events). Comparisons between Phases 1 and 3 resulted in Total Suspended Solids (83%), cadmium (86-89%) and lead (84%) demonstrating statistically significant reductions using the student's t test and the Mann-Whitney U test on the mean event mean concentration (EMC). Total Kjeldahl Nitrogen (12%), nitrite (42%) and copper (29%) demonstrated statistically significant reduction, while Total Phosphorus (20-40%) indicated an increase in EMC by the Mann-Whitney U test after Phase 3, but these values were insignificant based on the student's t test. Results support the application of these stormwater management practices in urban areas."

Grass Swale Study Completed

This study was initiated 2004 and completed in early 2006. The full report is included as Appendix D and the abstract from that report is provided below. Discussion of the study is also included in Part 3, Stormwater Management Program.

> "Due to growing awareness of non-point source pollution treatment, 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. Results of this comparison for 22 rainfall events over 1.5 years show significant peak reduction (50-53%), delay of the peak flow (33-34 min) and reduction of total volume (46-54%). 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."

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 State Highway Administration has a strong environmental commitment. SHA has implemented 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 Stewardship Projects

SHA also often goes beyond the regulatory required minimum mitigation by providing more environmental mitigation than required. One example is the Inter-County Connector (ICC) project and the many environmental stewardship projects that have been incorporated into the project. These stewardship projects exceed the required environmental regulations by targeting additional stormwater management, stream enhancement and restoration, and wetland creation projects within surrounding areas.

Aedes vexans is thought to be a bridge vector between birds and mammals.

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 also is pursuing research and development studies to improve our understanding of the impacts certain BMPs have on the environment. Current studies under way include:

Mosquito Surveillance/Control Program – This three-year study conducted by Millersville University for Maryland 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.

The first year of the study (2003) was devoted to studying the larval and adult mosquito population dynamics associated with three types of BMP including shallow marsh, retention and detention ponds. The second and third years (2004-2005) expanded the program to include infiltration trenches and infiltration basins and included two phases, a surveillance phase and a control phase. The objectives of the surveillance phase included an assessment of larval and adult mosquito diversity among the identified BMPs and a comparison of the spatial and temporal distributions of mosquito larvae among these types of BMPs. The control phase involved initiating an abatement program, determining the efficacy of larval control among the types of stormwater BMPs examined in the study, and providing an integrated pest management program for mosquito control.

Conclusions are documented in the report *Mosquito Surveillance/Control Program* included in Appendix E. Several points are noteworthy:

- The first year study provided data indicating that those mosquito species implicated in the transmission of WNV among birds and mammals are on average not a significant percentage collected.

- Temporal population dynamics of mosquito larvae among shallow marsh, retention and detention ponds indicated that a frog feeding mosquito species, *Culex territans* was the dominant mosquito larva produced by all BMP types.

- Of the larval species collected those species generally considered to be bridge vectors (from birds to mammals), are *Aedes vexans* and *Ae. albopictus*. *Ae. vexans* inhabits floodwater areas and was considered the focal bridge vector of this study. *Ae. albopictus* inhabits containers and was not considered in the study analysis.

- The mosquito abatement targeting larval control using the biological larvicide *Bacillis thuringiensis* var. *israelensis*, (Bti) had a 98-100% efficacy rating.

- Detention/extended detention (no permanent water) and infiltration basins that displayed regularly fluctuating water level produced large numbers of WNV bird and mammal feeding mosquito species.

- Shallow marsh and retention (permanent water) ponds typically produced mosquitoes that play minor or no role in the transmission of WNV.

- Anecdotal evidence over the span of this project has shown that BMP types that have evolved to hold water indefinitely such as shallow marshes, generally have a higher abundance of natural predators (such as dragonfly and waterboatmen insects) of larval mosquitoes.

- See the suggested Integrated Pest Management (IPM) Program on page 32 of the study for more information and conclusions.

SHA will continue our efforts in studying mosquito issues and the proper design of BMPs to reduce the potential for mosquito habitat that has few predators.

Thermal Impact of Underground Stormwater Management Storage Facilities on Highway Stormwater Runoff – This is a new study that has recently gotten under way. The goal of the study is to identify and document the thermal reduction effects on stormwater in underground storage facilities. Three sites will be identified and monitoring equipment will be 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.

Environmental Design and Maintenance Guidelines

Another way SHA is incorporating environmental design practices into our BMP designs is through the Visual and Environmental Quality and Safety (VEQ-S) Program that was developed to respond to the need for incorporating environmental, context sensitive, safety and visual concerns into stormwater management facility engineering. This program has several functions that are listed below and described in greater detail in Part 3, Stormwater Facility Program. Review guidelines and checklist are available in Appendix F.

- Provide design guidance,
- Review and comment on projects under design,
- Develop inspection criteria and integrate into the BMP field inspection manual,
- Develop retrofit and enhancement projects for existing BMPs,
- Provide construction oversight,
- Develop policies and standards.

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 has also revised its 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. A copy of the SHA ESC Quality Assurance Rating special provision is included in Appendix G.

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.

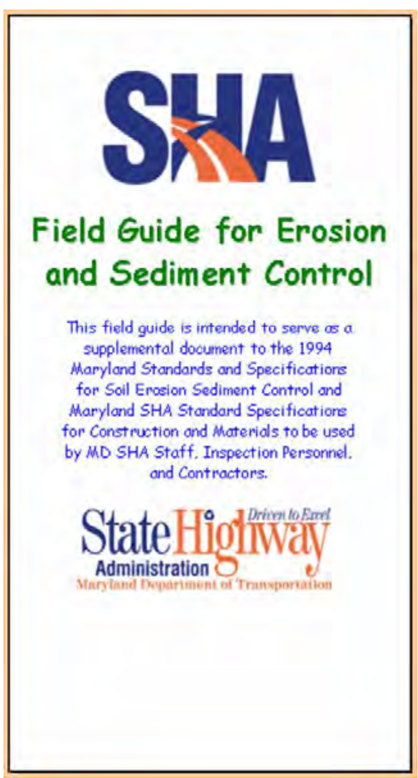
Another improvement to our ESC efforts is that we are now requiring designers to provide offsets and stationing on the limit of disturbance (LOD) on ESC design plans. This will give the construction contractor information in order to accurately stake out and place the LOD in the field. Ultimately, this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

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

SHA ESC Field Guide
The SHA has completed a field guide to distribute to construction engineers, certified ESC managers and inspectors, and ESC designers that provides essential information in an easy to access and carry handbook. Copies of this guide are currently being produced and will be available by the end of 2006.



Cover Page of SHA ESC Field Guide due out by the end of 2006.

E.2.b Responsible Personnel Certification Classes

SHA sponsored and performed training for a number of Responsible Personnel Certification Classes over the past two years. At a minimum, one training session was held each month: approximately twelve sessions annually. This training is conducted by SHA for SHA personnel, consultants and contractors. A total of 233 people were certified in 2005 and a total of 516 people were certified in 2006.

A copy of the database of trained personnel is included on the CD included as an attachment. MDE should be aware that the format of this database does not match the MDE requirements specified in Attachment A to the Phase I permit. The format of the SHA responsible personnel database is shown in Table 1-3.

SHA Basic Erosion and Sediment Control Training (BEST)
In addition to Green Card Training classes, SHA 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. SHA has presented this training to 518 people in 2005 and 820 people in 2006.

The Level II training is intended for ESC design professionals and course material is currently under development. The Level II training will begin in 2007.

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;*

Table 1-3 SHA Responsible Personnel Certification Information Database Format

Field	Field Name	Field Type	Width	Description
1	TITLE	Text	3	MR, MS, MRS
2	FIRSTNAME	Text	20	First name in CAPS
3	LASTNAME	Text	25	Last Name in CAPS
4	ADDRESS	Text	50	Full Address in CAPS
5	CITY	Text	35	City in CAPs
6	STATE	Text	2	State in CAPs
7	ZIP	Text	50	Zip Code in CAPS
8	DATE	Date/Time	Short Date	Date of Class
9	PHONE	Number	Double	Phone Number
10	CERTNUM	Number	Double	Unique Certification Number
11	COMPANY	Text	50	Employer
12	INSTRUCTOR	Text	20	Instructor – MDE Personnel or County Personnel
13	COMMENTS	Text	100	Comments

Suspended sediment can reduce density and diversity of fish species (from 'Green Card' Training material)

Example of Sediment Basin (from SHA BEST Training Material)

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. Maintenance and remediation efforts are accomplished after the inspection data has been evaluated and ranked according to SHA rating criteria. The SHA Stormwater Facility Program consists of four basic components:

- Inspection and rating;
- Maintenance and remediation;
- Visual, Environmental & Safety Quality; and
- Research and development.

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 two years is included in that section.

As-Built Certification Process

One significant addition to the SHA Stormwater Facility Program is the development of an 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 is included in Appendix H.

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.

Montgomery County Sweeping Study
Montgomery County contacted SHA and requested that they be allowed to place a sampler in one of our inlets in order to facilitate a sweeping study they are conducting. They also conducted a literature survey a summary of which they shared with us. We will work with them to continue their efforts in this study. See photos below.

Location of inlet with sweeping study sampling equipment.

Inlet used in sweeping study.

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 Meadow Establishment

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

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.

E.4.d NPDES Industrial Permit Coverage

SHA has evaluated our facilities, identified those that qualify as industrial and obtained all NPDES industrial permit coverage where necessary. Table 1-5 identifies the industrial facilities and the type of permit obtained.

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 previous annual reports, SHA performed detailed site assessments in the winter of 2001 at maintenance facilities covered under an Industrial Discharge Permit. Information gathered during these site assessments was used to prepare Stormwater Pollution Prevention Plans (SWPPP) and identify pollution prevention Best Management Practices (BMPs). See Appendix I for a summary of the BMPs for each maintenance facility. In addition, initial pollution prevention training was conducted with SHA staff at those facilities in 2002.

Table 1-4. 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.

Table 1-5. 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

In the summer of 2005, SHA performed a second round of site assessments to update SWPPPs and conduct pollution prevention training with SHA staff. The SWPPPs were expanded to include Spill Prevention, Control, and Countermeasure (SPCC) plans. See Appendix J for sample SWPPP and SPCC Plan. Figure 1-6 summarizes the statewide status of the Industrial NPDES elements by District.

SHA continued to develop BMPs by designing and implementing capital improvements. The following details maintenance facility improvements since the last annual report submitted in January 2005.

Completed Projects:

- Public sanitary sewer connection to the wastewater discharges from Wash Bay and Maintenance Bay for maintenance facilities at La Plata, Owings Mills and Snow Hill. These improvements converted these permits from Individual to General NPDES permit status.
- Maintenance Bay floor drain connection to public sanitary sewer at Denton maintenance facility.
- Upgrade of oil-water separators for maintenance facilities at Centreville, Churchville, Hanover, and Keyser's Ridge maintenance facilities.
- Wash Bay needs assessments at specific shops.
- Battery Storage / Spill Kit procurement contracts secured for all maintenance facilities.

On-Going Projects:

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

Initiated Projects:

- Salt contamination remediation design completed for Stevensville maintenance facility.

- Erosion control design initiated for eroded area at Annapolis maintenance facility.
- Wash Bay retrofit design completed at Prince Frederick maintenance facility.
- Wash Bay retrofit design underway for Salisbury, Chestertown, Hagerstown and La Vale maintenance facilities.
- Initiated 3rd round of SWPPP updates.
- Initiated SPCC development pilot at facilities above petroleum storage thresholds.
- Satellite maintenance facility pollution prevention investigations underway.
- UST inspection / inventory initiated for maintenance facilities with vehicle fueling stations.

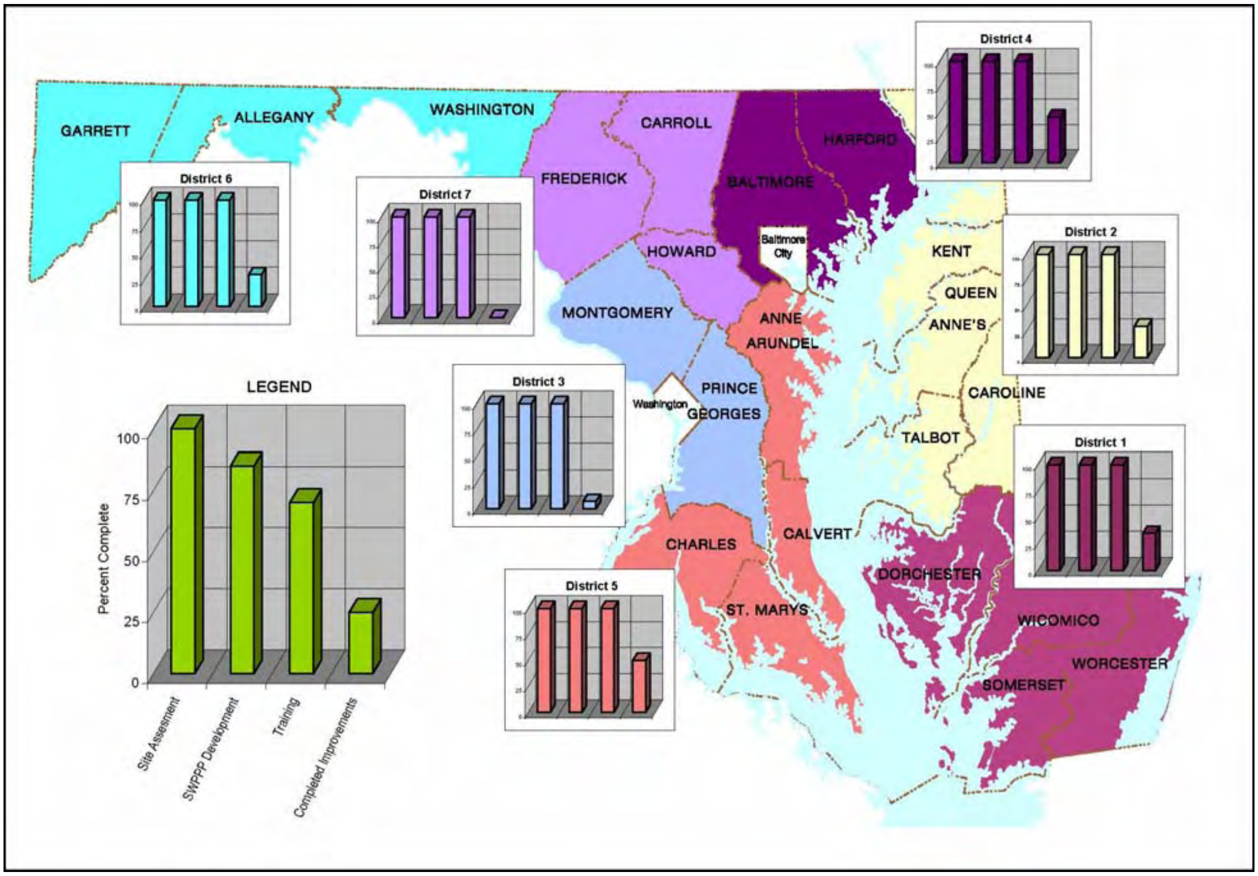


Figure 1-6 Industrial Stormwater NPDES Program Status

- Oil/water separator repair initiated at Chestertown maintenance facility.
- Stormwater management retrofit at the Glen Burnie maintenance facility.

Table 1-6 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.

To further enhance permit compliance 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 is underway and focuses on SHA's primary maintenance facilities. Subsequent phases will expand the CFEMS to other SHA facilities and operations. Keeping in mind that SHA already has a number of environmental compliance programs in place, the initial development efforts will include identifying applicable regulatory requirements, identifying regulated infrastructure and operations, and review of existing operational and compliance procedures. This information will be used to assess and retain the procedures that work, improve those that do not, and standardize procedures and responsibilities across SHA. Additional capital improvements that relate to stormwater pollution prevention will likely emerge from the CFEMS development efforts described above.

Table 1-6 Capital Expenditures for Pollution Prevention BMPs

Fiscal Year	Expenditure
2005	$613,210 - actual
2006	$592,873 - actual
2007	$647,677 - anticipated

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

SHA has developed a program and protocol for inspecting, maintaining, repairing and remediating outfall structures within our right-of-way. This program is called the Storm Drain and Outfall Inspection and Remediation Program (SOIRP). This program was discussed in the last annual report (*Sixth Annual Report*, 2004) and the outfall inspection protocol was included in that report. Minor modifications are being implemented to that protocol and the revised version will be available in 2007 and will be submitted with the next annual report.

Generally, two levels of outfall inspections and screenings have been employed by SHA for complying with this permit condition:

- **Outfall Screenings** – This includes visual inspection of 36 inch or greater pipe outfalls a minimum of three days after a storm event. If flow is found the outfall is screened according to procedures described in the *Draft Manual of Practice Identification of Illicit Connections* (EPA, 1990).

- **Full Outfall Inspections** – This involves expanding the outfall screening protocol to include a detailed structural, functional and environmental assessment of storm drains and outfalls, including outfalls less than 36 inch diameter.

Over the last Phase I permit cycle, SHA found infrequent water quality problems. To create a more effective program, this protocol was expanded to include outfalls deemed by local jurisdictions or SHA as being in hotspots, such as industrial and commercial land uses. Additionally

Table 1-7 Outfall Inspection Ratings

County	Outfall Inspection Ratings: No Rating	1	2	3	4	5	Total Inspected	Number of Pipes
Montgomery	357	682	8	19	22	3	1,091	15,756
Frederick	979	2,560	330	152	126	9	4,156	7,280
Baltimore	678	1,669	38	24	25	3	2,437	14,306
Harford	294	609	499	215	50	23	1,690	4,161
Howard	347	288	138	119	14	1	907	2,127
Totals	**2,655**	**5,808**	**1,013**	**529**	**237**	**39**	**10,281**	**43,630**

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.

Table 1-8 Hotspot Inspections in Montgomery County

Hotspot	Location	Type of Outfall	Flow Condition	Structural Condition
1	MD 586/MD 97 near the mall behind Baptist Church of Wheaton (ADC 36 H2)	Type C Endwall; 60"RCP	The pipe had 1" of flow	Normal.
	Test Results: The chemical tests for copper, chlorine, phenols, and detergents were clean; pH = 7.5.			
2	MD 185 Southbound, North of Independence Street (ADC 30 C7)	Type B Endwall; 48" RCP	The pipe had 1" of flow	Normal
	Test Results: The chemical tests for copper, chlorine, phenols, and detergents were clean; pH = 7.6			
3	MD 410, across from Falkland Lane (ADC 36 K10)	Type C Endwall; 36" RCP	The pipe had 1" of flow	Normal
	Test Results: The chemical tests for copper, chlorine, phenols, and detergents were clean; pH = 7.6			
4	MD 355 Southbound, between Dorset Ave and Oliver Street (ADC 41 B2)	Concrete box culvert; stream crossing?	The pipe had 1" of flow	Severe downstream channel erosion
	Test Results: The chemical tests for copper, phenols, and detergents were clean and chlorine = .3mg/L; pH = 7.2. Strong sewage odor			
5	Maple Ave at Sligo Creek Parkway.(ADC 37 D11)	Type C Endwall; Twin 66" RCPs	The pipe had 2" of flow	severe downstream channel erosion
	Test Results: The chemical tests for copper, chlorine, phenols, and detergents were clean; pH = 7.6.			

certain rural areas, where public sewer is not an option, are being considered hotspots.

E.5.b Document each Outfall's Attributes

Inspections using the SHA SOIRP Program outfall inspection protocol were conducted on the five counties listed in Table 1-7, Montgomery, Baltimore, Frederick, Harford and Howard. Data was gathered and placed in a database using the Storm Drain/Outfall Inspection Form (included in the 2004 annual report) which includes structural and functional attributes. Information on environmental attributes is gathered if it is determined that the outfall needs repair. In the case of needed repairs, the outfalls are evaluated and ranked as to the level of environmental permitting and right-of-way needs required to adequately address the necessary repairs. Outfalls requiring no or minimal environmental permits are repaired using our open-ended construction contracts. Those requiring major permitting and/or right-of-way are designed and advertised through the federal aid advertisement procedures.

The ratings in the SOIRP Program are similar to those used in the SWM facility field inspections: the higher the rating number, the worse the condition of the pipe outfall. Ratings of 3 to 5 are re-inspected and a plan for repair is generated for those deemed to need repair. SHA is currently evaluating those outfalls in Table 1-7 that have ratings of 3 to 5 and putting together a strategy to perform the repairs, if necessary.

E.5.c Illicit Connection Investigations

The SOIRP outfall inspection protocol includes illicit discharge protocol and reporting requirements if illicit connections are suspected including storm drain maps, chemical testing, dye screening and other viable means. Table 1-9 details the screening performed and those requiring documentation during this reporting period.

Table 1-9 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
Totals	**515**	**260**	**22**

Also, there were five hotspots identified in Montgomery County and none in the other counties inspected during this report term. Table 1-8 provides information on these hotspots and photographs are also included below. All hotspots were tested and all fell within the acceptable chemical sampling limits (Table 1-10). Hotspot 4 had severe downstream erosion and a strong smell of sewage. Hotspot 5 had severe downstream erosion. SHA has set up an on-call task with Greenman Pedersen, Inc. and Chesapeake Environmental Management, Inc. to investigate and resolve illicit discharge issues. They are investigating these two hotspot area issues and a report of the resolution will be included in the next annual report.

Table 1-10 Acceptable Chemical Sampling Limits

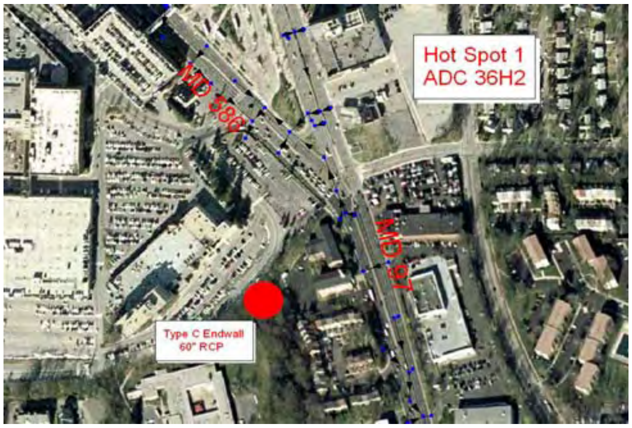
pH	6.5 – 8.5
Phenol	< 0.17 mg/L
Chlorine	< 0.40 mg/L
Detergents	< 0.50 mg/L
Copper	<0.21 mg/L

E.5.d Use Appropriate Enforcement Procedures

The twenty-two discharge reports generated for this report period are being reviewed by SHA to determine the appropriate action to be undertaken. Actions will include enforcement procedures and referring violators to MDE if necessary. A report of actions ultimately taken and resolution of the illicit discharges will be included in the next annual report.

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 Detection and Elimination is included on the attached CD.

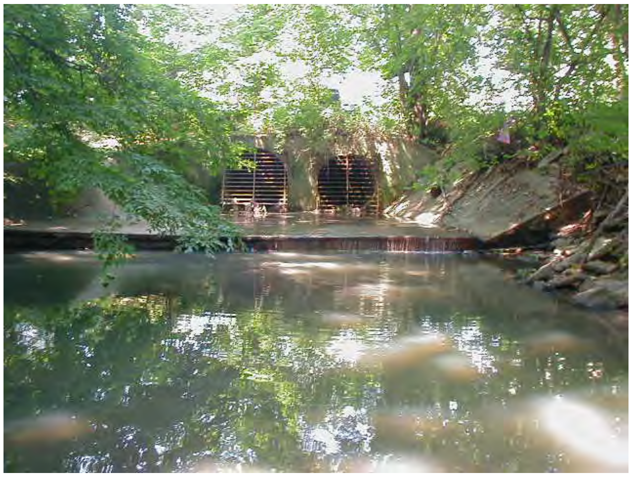


Montgomery County Hotspot # 1

Montgomery County Hotspot # 2

Montgomery County Hotspot # 3

Montgomery County Hotspot # 4



Montgomery County Hotspot # 5

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 Third Annual Earth Day Celebration on Tuesday, April 18, 2005 at the SHA headquarters complex. 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 Friday, April 21 to remove litter under the Jones Falls Expressway and at Liberty Reservoir. 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.

- **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.

- **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 2005, 15 groups participated in community planting projects. In 2006, 13 groups participated in community planting projects.

- **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.

  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.

Participants at an SHA sponsored community Partnership Planting Program project.

Litter and debris accumulated in a SWM BMP.

- **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. This effort will:
  - Print 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 and Chinese.
  - Paid media placement throughout the State, providing safety tips and environmental information, which will include thirty to sixty second pubic service announcements to air between August 2006 and January 2007 during various times to reach licensed drivers. Ads will also be targeted during sports events, such as football games, and outdoor community activities. Public service announcements will involve elected public officials, government representatives and driver education schools.
  - Construction of 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.
  - Printing of 500,000 bumper and window stickers for Maryland vehicles to be distributed at area restaurants with anti-litter messaging.
- **The 2006 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 2005, 12 engineers attended these modules. In 2006, 91 individuals attended these modules.

- **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.

- **Statewide Vegetation Management Training (2006)** – This training provides annual vegetation management updates and 23 out of 28 shops participated in the training (one session per shop) with 115 people attending.

- **Annual Vegetation Management Conference (2006) –** 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 2005, 85 people attended. The 2006 conference is scheduled for October 25 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 2005, 84 individuals attended these trips. In 2006, 79 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.

  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 next series of trainings is scheduled for the spring of 2007.

- **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 1-7 Patuxent River Area Watershed

F.3 Impervious Area Retrofits

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. Site searches are under way in the following watersheds:

- Patuxent River Area (02-13-08)
- Youghiogheny River Area (05-02-02
- Pocomoke River Area (02-13-02)
- Upper Potomac River Area (02-14-05)

These and future watershed site searches will be used to serve both to locate SWM water quality bank mitigation sites and to locate sites for NPDES water quality credit.

The Patuxent River Area Watershed is within NPDES Phase I coverage area and an initial site search for the Lower Patuxent Area (see Figure 1-7) has been completed with two Calvert County sites being located and slated for retrofit/mitigation projects. The site search for the rest of the watershed will be completed in June of 2007 and retrofits will be identified and pursued at that time. SHA will apply for Transportation Enhancement Program (TEP) funds for construction of NPDES retrofit projects. A watershed site search report and breakdown of mitigation verses retrofit sites will be supplied.

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 proposes to pursue two specific activities over the next year in order to address this condition: begin a study for watershed-based decision process and document watershed goals and priorities.

EPA Grant

During the last reporting period SHA applied for and received a grant from EPA to develop a watershed-based approach to stormwater management. This study looks at ways to implement a watershed decision-making process within SHA, local jurisdictions and the regulatory agencies. The basis of this study is viewing the watershed holistically when planning and implementing stormwater management facilities. This study recognizes that choices concerning types of BMPs and their placement should not be restricted to roadway right-of-way but should be based on the goal of improving the watershed rather than meeting regulatory requirements for a particular project. This is a three-year study and the product at the end will be a guideline document and recommendations for further study.

Document Watershed Goals and Priorities

SHA as well as MDOT has been participating with other counties and jurisdictions in watershed efforts. During this term, systematic efforts will be made to actively pursue contacting the local jurisdictions and documenting their watershed goals and priorities during the coming year. This documentation and periodic updates to it will be used throughout the remainder of the permit term to develop partnerships and future restoration projects.

SHA also is employing the analysis ability of GIS software to understand our role in watershed health. Figure 1-8 is one analysis that looks at roadway impervious, TMDL impairments and SHA proposed major and minor projects within the phase I NPDES jurisdictions. SHA is looking at how to best employ these tools and methods to improve our decision making processes.

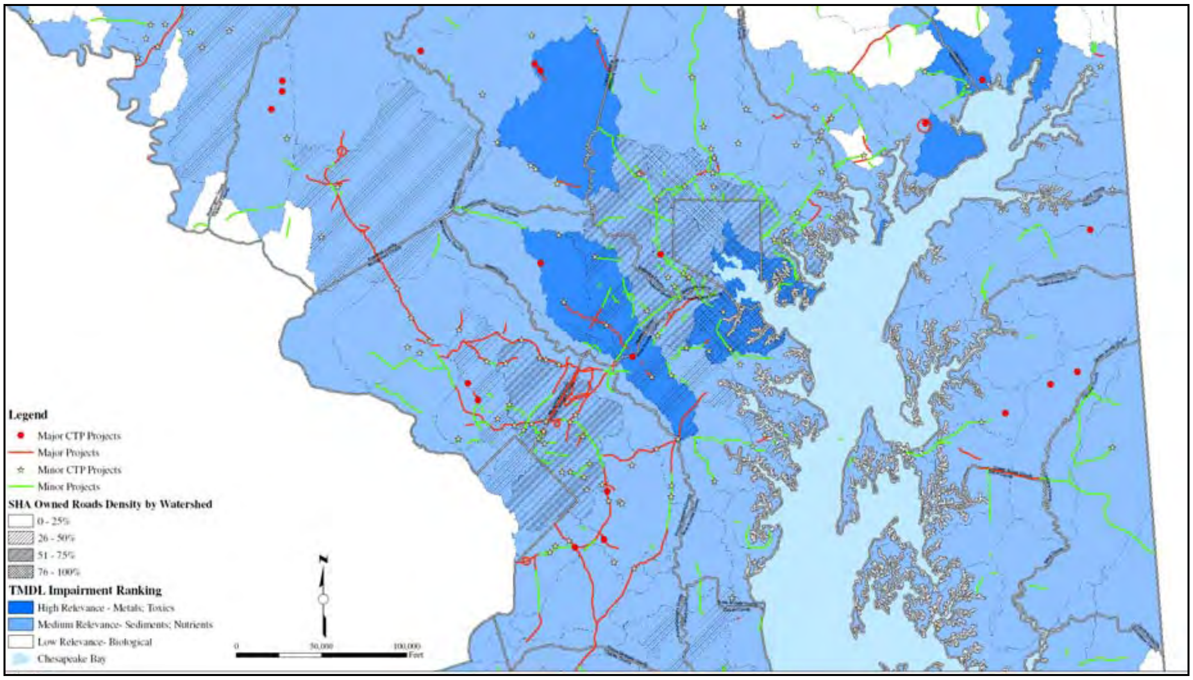


Figure 1-8 GIS Watershed-Based Analysis of Road Density, TMDL Impairments and SHA Proposed CTP Projects

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 thirty-nine retrofit projects in various stages of planning, design and construction. Documentation on these projects was provided to MDE under separate cover that included a list of the projects and copies of design reports and plans. Below is an abbreviated list of the proposed projects by watershed.

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 2111 – Functional Enhancement
16 2112 – Functional Enhancement

West Chesapeake Bay – 02-13-10

17 BMP 2019 – Functional Enhancement
18 BMP 2022 – Functional Enhancement
19 BMP 2027 – Functional Enhancement
20 BMP 2029 – Functional Enhancement
21 BMP 2031 – Functional Enhancement
22 BMP 2088 – Functional Enhancement
23 BMP 2481 – Functional Enhancement
24 BMP 2522 – Functional Enhancement
25 BMP 2273 – Functional Enhancement
26 BMP 2491 – Functional Enhancement

Patuxent River – 02-13-10

27 BMP 16059 – Functional Enhancement
28 BMP 16202 – Functional Enhancement
29 BMP 2488 – Functional Enhancement
30 BMP 16217 – Functional Enhancement
31 BMP 16219 – Functional Enhancement
32 BMP 16380 – Functional Enhancement
33 Unnamed Tributary to Rocky Gorge Reservoir adjacent US 29 – Stream Stabilization

Lower Potomac River – 02-14-01

34 BMP 16456 - Functional Enhancement

Washington Metropolitan – 02-14-02

35 16607 – Functional Enhancements
36 16609 – Functional Enhancements
37 16653 – Functional Enhancements
38 Long Draught Branch Restoration/ Stabilization – Stream stabilization

Middle Potomac River – 02-14-03

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

A 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. Future reports will also detail watershed goals and priorities as discussed in F.4 above.

G.2 Contribute to Local NPDES Watershed Restoration Activities

See proposed documentation activity in F.4 above.

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

- **Weems Creek Watershed – AA County.** SHA funded a watershed assessment study and actively participated in a multi-agency effort to address watershed water quality concerns in this watershed. SHA also provided funding for stormwater retrofits at Navy-Marine Corps Memorial Stadium for construction of ponds and bioretention facilities. SHA contributed to funding for stabilization of Porter Drive outfall in Annapolis.

- **South River Federation – AA County.** In support of a desire to improve water quality in South River, SHA implemented efforts to enhance two SHA facilities, BMP 2491 and BMP 2506. The design is completed, permitted and construction will proceed shortly. See Figure 1-9 for locations of projects within the South River watershed.

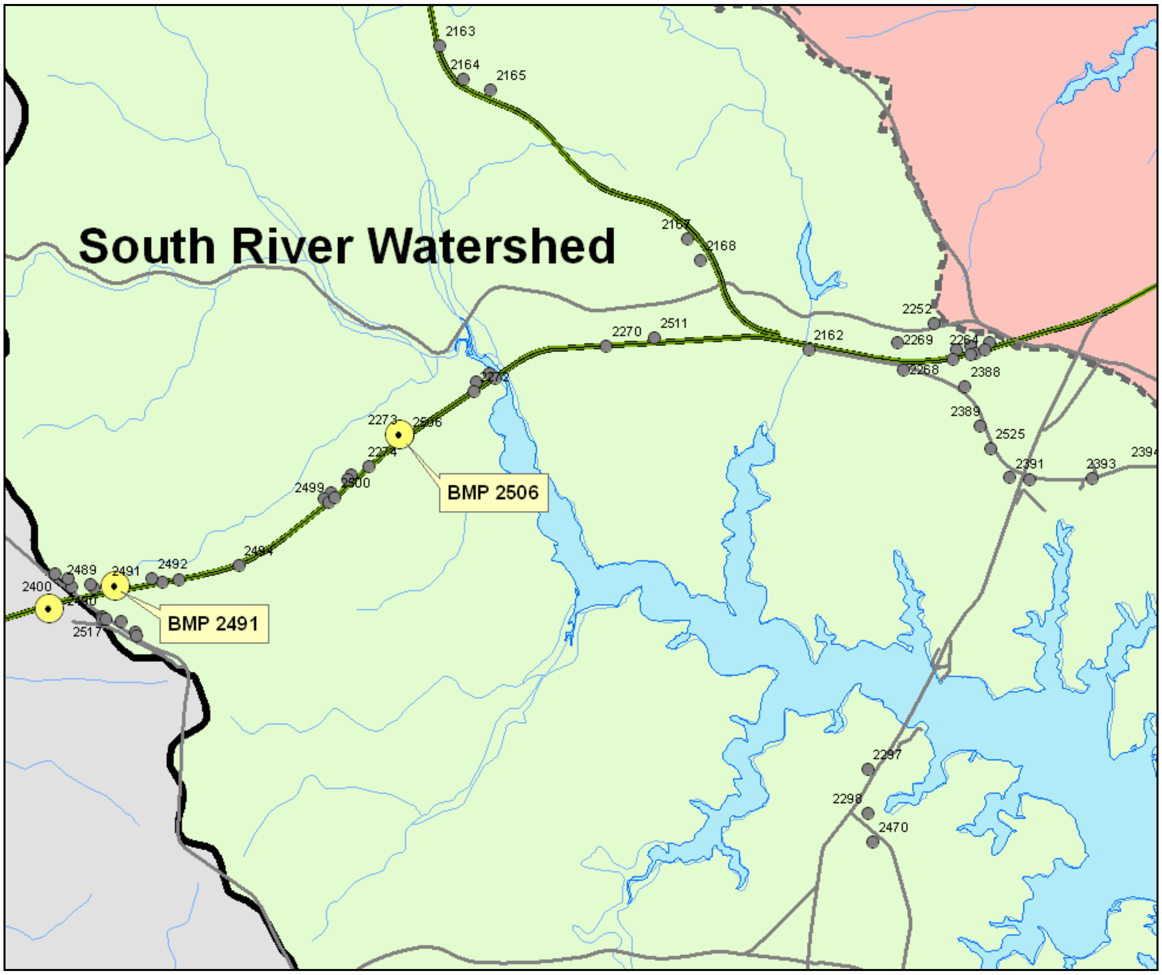


Figure 1-9 South River Watershed Projects

- **Whitehall Creek Watershed – Anne Arundel 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 with matching TEP funds of more than $1M 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 initiated and coordinated stream stabilization projects in the following watershed as TEP projects to improve water quality. Funding has been acquired and design is underway.
  - **Tributary to Tuscorora Creek (MD 340)** – Ballenger Creek, Middle River
  - **Tributary to Rocky Gorge Reservoir (US 29)** – Patuxent River Watershed
  - **Tributary to Towson Run (MD 136)** – Jones Falls, Patapsco River

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

SHA proposed to use the Long Draught Branch Restoration/Stabilization project as our long-term monitoring project. This site received concurrence from MDE under the recommendation that we pursue a relationship with Montgomery County to ensure this project will meet their restoration goals. We will pursue this before moving forward with the final design for the project.

Watershed Description

Long Draught Branch (See Figure 1-10) is a tributary to Great Seneca Creek, which discharges directly to the Potomac River. It is also the primary feed to Clopper Lake which lies approximately 2500 feet downstream of the project. This stream reach is within the Seneca Creek segment of the Washington Metropolitan Watershed sub-basin (02-14-02) and is designated as Use IV waters. Clopper Lake has an established TMDL identified as impaired by nutrients.

Description of Work

The Long Draught Branch watershed has a drainage area of 512 acres at the upstream end of the project (Clopper Road, MD 117 crossing) and the percent impervious within this watershed is

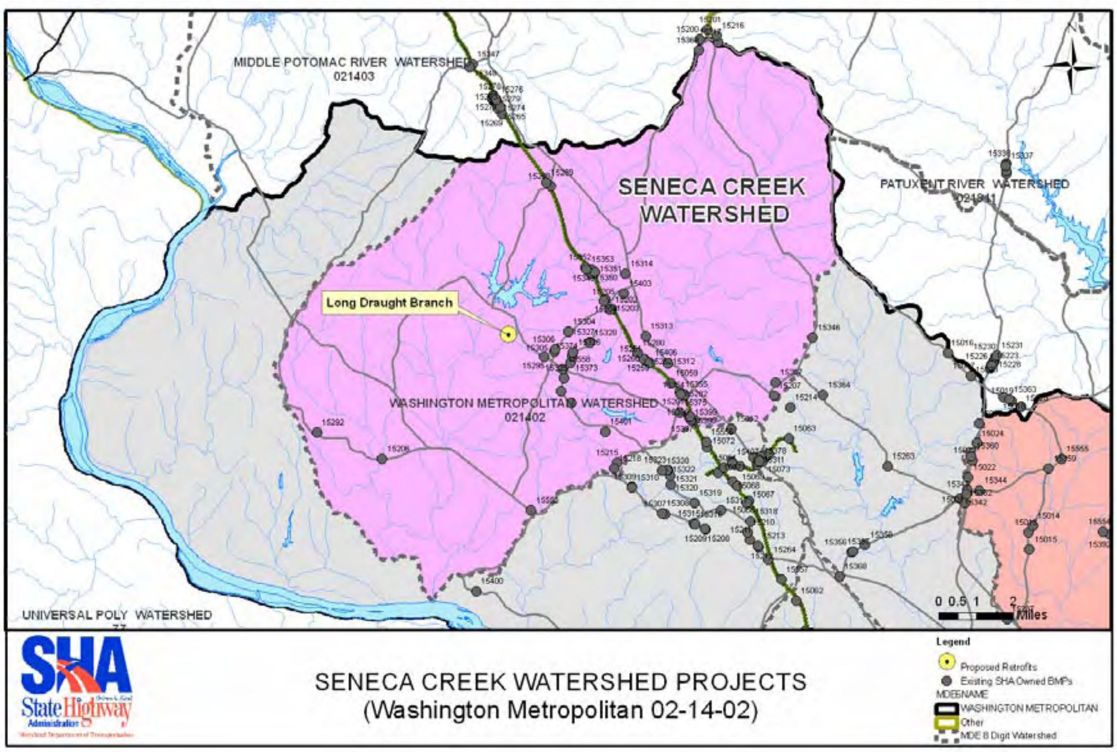


Figure 1-10 Long Draught Branch Project and SHA Owned BMPs within Seneca Creek Segment

approximately 34 percent. The main stem channel length of long Draught Branch is approximately 2,400 feet. Some of the existing site issues to be considered in the design include bank armoring, two sewer crossings, an apartment complex within close proximity, in-channel debris dam, head-cut lowering streambed by three feet, pedestrian bridge, several storm drain outfalls, drastic change in geomorphic state from degrading to aggrading channel, failed on-line historic SWM facility dam and large quantity of deposited sediment and debris. Figure 1-11 shows photographs of existing conditions.

The proposed design provides a natural channel that creates a wider floodway in order to reduce the boundary shear stress and hydraulic depth to the extent feasible given the urban context. The site constraints make it impossible to lower the floodway stresses and depths for all storm events. However the proposed design lowers stresses imposed on the active channel and floodway. A copy of the full design report was delivered to MDE under separate cover.

Preliminary Schedule

This project is schedule for advertisement December 2007 and it will be constructed as part of the MD 117 roadway project. Given this tentative advertisement schedule, we anticipate the construction notice-to-proceed to be June 2008 (outside the stream closure period of March 1 to May 31). Construction is anticipated to be completed by October 2008.

H.2 Monitoring Plan

SHA has included our monitoring plan for the Long Draught Stream project in Appendix K. Figure 1-12 is a plan of the proposed monitoring locations.

Timing on this project is adequate to allow for pre-construction monitoring, and post-construction monitoring through this permit term. Monitoring Requirements:

Pre-restoration monitoring will occur from November 2006 to February 2008. While construction is underway monitoring will stop and begin again once construction is complete. Post-restoration monitoring is anticipated to occur from October 2008 to October 2010. Monitoring will include all the criteria listed in the permit condition.

H.3 Annual Data Submittal

Monitoring data will be submitted annually in the database format stipulated in the permit.

Upstream Project Limit – MD 117, Clopper Road Crossing

Study Reach D showing channel migration and high bank erosion area.

Figure 1-11 Existing Conditions at Long draught Branch

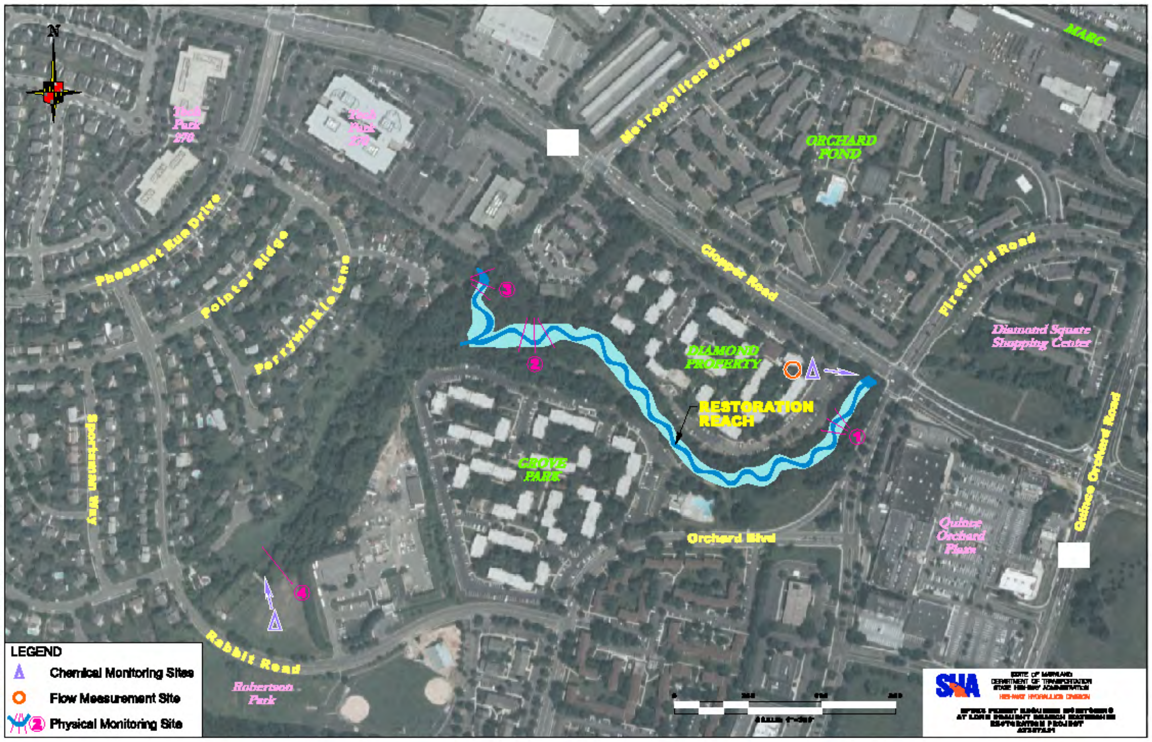


Figure 1-12 Long Draught Branch Monitoring Plan

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.

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. Therefore we are not submitting Table J, fiscal analysis, with this annual report.

We are working on a tool to track these expenditures and will have the information available to submit with the next annual report in 2007. Included in the information submitted with next year's report will be the information for year one as well.

According to our current records, the total spent from Fund 74 for NPDES and BMP Programs for FY05 is $ 3.4 million and for FY06 is $7.26 million.

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 TMDLs developed for impaired water bodies.

As SHA begins systematic efforts to work with local jurisdictions, TMDL related efforts will become more systematic as well. 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 is working closely with MDE on TMDL efforts for Corsica River Watershed and providing active advisory participation in working with Ms. Danniel Lucid as well as Mr. Adam Rettig of MDE and the Town Manager of Centerville.

PART TWO

Special Programmatic Conditions and Responses

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 fully committed to reducing the discharge of nutrients and sediments to the Chesapeake Bay. The fact that the State and Federal highway network traverses all the major Bay tributaries in Maryland points out the important role we have in impacting the success of statewide tributary strategies. In Part 1 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.

PART THREE

Stormwater Management Facility Program

3.1 Introduction

This section of the report summarizes Maryland SHA's Stormwater Management (SWM) Facility Program activities between January 2005 and October 2006. This is the fourth supplement report that complements the Annual Report as required by SHA's NPDES Municipal Separate Storm Sewer System (MS4) permit.

SHA has estimated to own about 2,000 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 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 enhancement, and
- Research and development.

The program focuses on the remediation and enhancement of BMPs. This in turn requires the continuous improvement of the BMP Inspection system; and also the data management tools to track BMP data, facility performance, and remediation action tracking. SHA continues to develop a prioritization system for remedial activities, and to develop new technologies for repairing or retrofitting BMPs through visual and functional enhancement projects. The SWM Facility Program includes research on performance and efficiency of commonly used BMPs.

3.2 Inventory and Inspection

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

3.2.1 Inspection Protocol

The objective of SHA's SWM Facilities Program is to identify and prioritize maintenance and remedial activities. The key is to achieve detailed and consistent inspection results.

Field Inspection Rating

The initial assessment of a SWM facility is a field inspection where individual parameters are *scored* (scale 1 to 5) then used to establish an overall BMP performance *rating*. The parameters in general cover Overall Site, Water Quality, Embankment-Structural, and Riser-Structural. The rating categories are:

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

B **Minor Problems** – this are observed, however, BMP is functioning as designed. Key parameter(s) require follow-up assessment or monitoring.

C **Moderate Problems** – are observed, however BMP is functioning as designed, but some parameters indicate performance is 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 impending deterioration and/ or failure. Remedial action(s) should be performed immediately.

The inspection protocol is summarized in a guidance document "*Best Management Practices Field Inspection Manual*", dated October 2000. The manual documents the methodologies used in the field for identifying, locating, and inspecting SWM facilities statewide. SHA is being 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 a qualitative evaluation for maintenance and remediation by assigning a remedial rating. This is based on overall 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 **Non-Routine Maintenance or Repair** – is needed to return 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 facility is not maintainable and will not provide sufficient benefits if retrofitted due to the lack access, limited space and minimum impervious area treatment.

3.2.2 Inventory

BMP Inventories are 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 2006.

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	375	566
	Prince George's	191	
4	Baltimore	169	283
	Harford	114	
5	Anne Arundel	428	561
	Calvert	15	
	Charles	107	
	St. Mary's	11	
6	Allegany	37	66
	Garrett	11	
	Washington	18	
7	Carroll	36	404
	Frederick	110	
	Howard	258	
State			**2,133**

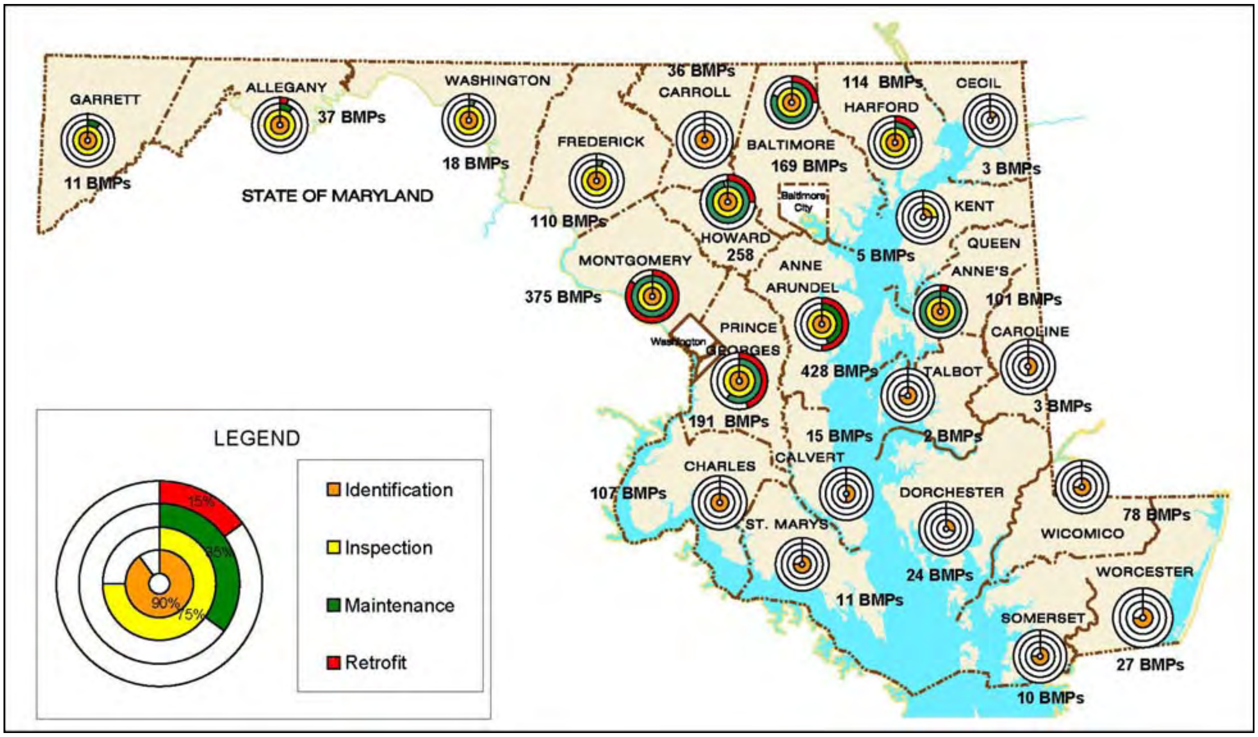


Figure 3-1 Statewide SWM Facility Program Status

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.

3.2.3 Field Inspection

The detailed inventories relating to counties listed as Phase I and II MS4 jurisdictions in SHA's permit are being performed as part of the source identification of SHA's roadways. In addition, SHA is inventorying and inspecting for non-MS4 counties. SHA previously completed the countywide identifications and inspections in Montgomery, Howard, Anne Arundel, Prince George's Queen Anne's Counties and Baltimore. In this reporting period the counties investigated were Harford, Garrett, Allegany and Washington. The BMPs were re-inspected in Howard and Montgomery County, as well as additional BMPs were added. The work performed in Harford and Western Maryland Counties is summarized in Table 3-2. In Frederick County, the BMPs were inventoried, but the inspections are not finalized. Inventory and inspections are also underway in Carroll and Charles Counties.

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**	0	2	8	0	0
Extended Detention	**13**	1	4	4	4	0
Retention	**4**	1	3	0	0	0
Infiltration Basin	**0**	0	0	0	0	0
Infiltration Trench	**5**	2	3	0	0	0
Shallow Marsh	**0**	0	0	0	0	0
Other	**5**	4	1	0	0	0
Totals	**37**	**8**	**13**	**12**	**4**	**0**
Garrett County						
Detention	**1**	1	0	0	0	0
Extended Detention	**2**	1	1	0	0	0
Retention	**2**	0	1	1	0	0
Infiltration Basin	**0**	0	0	0	0	0
Infiltration Trench	**4**	1	3	0	0	0
Shallow Marsh	**0**	0	0	0	0	0
Other	**2**	2	0	0	0	0
Totals	**11**	**5**	**5**	**1**	**0**	**0**
Harford County						
Detention	**17**	5	6	6	0	0
Extended Detention	**3**	2	1	0	0	0
Retention	**9**	3	5	1	0	0
Infiltration Basin	**23**	7	8	7	0	1
Infiltration Trench	**59**	12	24	9	14	0
Shallow Marsh	**3**	3	0	0	0	0
Other	**0**	0	0	0	0	0
Total	**114**	**32**	**44**	**23**	**14**	**1**
Washington County						
Detention	**7**	1	6	0	0	0
Extended Detention	**0**	0	0	0	0	0
Retention	**2**	0	2	0	0	0
Infiltration Basin	**2**	0	0	1	1	0
Infiltration Trench	**4**	0	2	1	1	0
Shallow Marsh	**0**	0	0	0	0	0
Other	**3**	2	0	1	0	0
Total	**18**	**3**	**10**	**3**	**2**	**0**

3.3 Maintenance and Remediation

This section summarizes the status of SHA's maintenance and remedial responses to deficiencies identified through the inspection of SWM facilities. The program's primary goal is to keep SHA's stormwater facilities operating as designed and to strategically enhance their functions to meet today's standards. 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, the once the statewide inventory and inspection database is completed, the SWM routine maintenance tasks will be managed by individual SHA District maintenance offices. Table 3-3 lists the total 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 January 2005 and October 2006.

Table 3-3 Minor Maintenance Summary

County	District	BMPs Requiring Routine Maintenance	BMPs Maintained Jan. 2005 to Sept. 2006
Allegany	6	13	0
Anne Arundel	5	121	48
Baltimore	4	57	46
Garrett	6	5	0
Harford	4	50	6
Howard	7	76	74
Montgomery	3	27	13
Prince George's	3	62	31
Queen Anne's	2	12	12
Washington	6	10	0
Total		**433**	**230**

Table 3-4 Minor Maintenance Cost Year 2005 / 2006

Funding Allocation	Funding Amount
Anne Arundel County	$121,137
Baltimore County	$48,368
Howard County	$40,429
Montgomery County	$5,817
Prince George's County	$44,067
Queen Anne's County	$12,978
Total	**$272,796**

3.3.2 Major Maintenance

SHA initiated major maintenance tasks that address significant deficiencies at BMPs. 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.

SHA continues performing detailed field assessments for BMPs identified for major maintenance. A summary report is prepared for each BMP that provides sketches using as-built plans, photographs, cost estimate, repair recommendations, specifications and maintenance of traffic procedures. An example of the assessment report and a work order for the contractor is included in Appendix 3-A. 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 January 2005 and October 2006 an Table 3-6 summarizes the associated costs in each county.

Table 3-5 Major Maintenance Summary

County	District	BMPs Requiring Major Maintenance	BMPs Maintained to Date
Allegany	6	12	0
Anne Arundel	5	73	56
Baltimore	4	44	13
Garrett	6	1	0
Harford	4	29	6
Howard	7	75	5
Montgomery	3	12	1
Prince George's	3	49	27
Queen Anne's	2	82	0
Washington	6	3	0
Total		**380**	**108**

Table 3-6 Major Maintenance Cost – Year 2005/2006

Funding Allocation	Funding Amount
Anne Arundel County	$177,025
Baltimore County	$25,519
Harford County	$8,227
Howard County	$3,648
Montgomery County	$500
Prince George's County	$81,188
Total Costs	**$ 296, 107**

Figure 3-2 shows an emergency repair of eroding an embankment at BMP 2250 located at MD 10 in Arundel County. Figure 3-3 documents stabilization of the eroded roadway embankment and installation of a drop structure at the inflow pipe.

3.3.3 Infiltration Trench Remediation

SHA targeted remedial actions for infiltration trenches since they represent almost half of SHA's current SWM facilities inventory. The infiltration trenches were 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.

SHA continues the effort to investigate the long term performance of infiltration trenches in previous years SHA performed *Infiltration Trench Study* to investigate the functionality of this SMW Facility and the study was includes in the previous report. Another previously presented assessment was *Forensic Analysis of Infiltration Trenches* to determine possible mode of failure.

SHA has developed a systematic process for field assessment and remediation work order of infiltration trenches. Several failed infiltration trenches were converted into different BMP types to better fit the site conditions and to meet the current design standards. Typical retrofits include sand filters and dry swale. However, recent efforts focus on restoring performance of functional infiltration trenches by replacing the infiltration media.

In addition, during field inspections approximately 30 trenches, located throughout various counties, were without an observation well. In order to determine the functionality of the trench, test pit had to be excavated. If the trench was more than 50% full of water, no observation well was installed, and the trench was considered for abandonment or retrofit. The remaining 50% of trenches without wells were sufficiently dry enough to have an observation well installed. The Figure 3-4 shows installation of monitoring well by the SHA contractor.

March 2006

April 2006

June 2006

August 2006

Figure 3-2 SWM Pond (BMP 2250) - Embankment Major Repair

Figure 3-3 SWM Pond Slope Stabilization

Figure 3-4: Installation of Infiltration Trench Monitoring Well and Media Replacement

3.3.4 SWM Retrofit and Functional Enhancement Projects

MD SHA has actively continued design as well as construction phases of *SWM Functional Enhancement Projects* partially funded through 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 current standards required by MDEs 2000 *Maryland Stormwater Design Manuas*, Volumes I and II and MDE's *Guidelines for State and Federal Projects*, dated July 1, 2001. The new design criteria include groundwater recharge volume, and water quality volume. The design objective is to enhance water quality treatment at existing stormwater management ponds, infiltration basins and trenches. The proposed enhancement effort primarily consists of new grading, stabilization of existing structures, and a native species landscaping plan. In addition, these projects are intended to improve aesthetic value and provide refuge to local wildlife habitat as well as provide consistent water quality benefits.

In previous reports, SHA provided a list of BMP retrofit/enhancement sites proposed in Anne Arundel and Prince Georges Counties. The project commitments in Prince Georges County were successfully met and kept on schedule and within budget. The Anne Arundel County project has been separated into 2 phases due to the permitting issues and each phase is advertised at different time. The status of all enhancement projects is summarized in the Table 3-7.

Table 3-7: BMP Enhancement Projects Summary

No.	Project	County	Number of BMP Facilities	Contract Number	Construction Cost Estimate	Status
1	Functional Enhancement of Infiltration Basins - Phase 1, 2, 3	Howard Montgomery	36*	AT4375174 HO6945174 MO3645174	$1,345,404	Construction completed
2	Functional Enhancement of SWM Facilities	Prince Georges	9	PG6235174	$2,034,545	Construction to be completed in Spring 2007
3	MD 100 at I-95 NW and MD 100 at Meadow Ridge Road	Howard	2	HO3145174	$226,512	Construction completed
4	Functional Enhancement of SWM Facilities Phase 1	Anne Arundel	4	AA3495174	$998,821	Opened for Bids
5	Functional Enhancement of SWM Facilities Phase 2	Anne Arundel	7	AA3495174	$930,814	Advertisement Date 7/2007
6	Functional Enhancement of SWM Facilities Along US 50	Anne Arundel	5	AA4195174	$560,252	Advertisement Date 11/14/2006
7	Stormwater Functional Enhancements in Allegany County	Allegany	3	AL3555174	$828,324	Advertisement Date 08/05/2008
	Total		**66**		**$6,924,672**	

* Phase 1 and 2 (14 facilities) reported as completed in the last Annual Report (2004)

Infiltration trench at US 301

Bioretention under construction

Figure 3-5 Reconstruction of Infiltration Trench at US 301 (BMP 16219)

Infiltration trench at US 301

Dry swale after construction

Figure 3-6 Reconstruction of Infiltration Trench at US 301 (BMP 16217)

During construction

After construction

Figure 3-7 Functional Enhancement of SWM Extended Detention Pond at MD 100 and I-95 in Howard County (BMP 13210)

Figures 3-5, 3-6 and 3-7 show the construction progress of SWM facility enhancements in Prince Georges County.

Since SHA's intent is to duplicate this effort with the ability to design, build and implement another successful enhancement project, in the year 2005 and 2006 the primary focus was on retrofit design in Anne Arundel and Allegany Counties as summarized in Tables 3-8 and Table 3-9.

Proposed projects included infiltration basin enhancements to increase treatment from 1/2 to 1 inch of runoff and as well as retrofit of stormwater management ponds to improve water quality treatment to meet current standards. Most selected sites are in environmentally sensitive watersheds. The sites provide control and treatment of highway runoff, but are based on older design standards and have marginal water quality treatment. The enhancements focus on maximizing pollutant removal efficiencies and improving functionality by upgrading facilities 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 addition, more effective and multifunctional management of stormwater runoff will minimize possible impacts to public and private properties, reduce effects of highway runoff such as local flooding, as well as improve water quality and enhance the aesthetic quality of communities.

Table 3-8 BMP Enhancement Sites in Anne Arundel County

No .	BMP No.	SWM Facility	SHA Road	Proposed Enhancement
1	2273	Infiltration Basin	US 50	Pocket Wetland (W-4)
2	2481	Infiltration Basin	US 50	Micropool Extended Detention (P-1)
3	2522	Infiltration Basin	US 50	Micropool Extended Detention (P-1)
4	2488	Infiltration Basin	US 50	Pond/Wetland System (W-3)
5	2491	Infiltration Basin	US 50	Pocket Sand Filter (F-5)

Table 3-9 BMP Enhancement Sites in Allegany County

No.	BMP No.	SWM Facility	SHA Road	Proposed Enhancement
1	1033	Extended Detention	I-68	Extended Detention w/ Shallow Marsh
2	1056	Extended Detention	US 220	Shallow Wetland
3	1057	Extended Detention	US 220	Extended Detention w/ Shallow Marsh

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, Patuxent River and Evitts Creek. 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. The proposed enhancement project 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.

3.4 Visual and Environmental Quality and Safety (VEQ-S) in SWM Design

It is important that stormwater management facilities fit within the surrounding environmental and community context. It is also important to protect the public, maintenance personnel and inspectors from physical safety hazards associated with the functioning and site components of these facilities. For these reasons, SHA has implemented the VEQ-S program. The program seeks to integrate Landscape Architectural principles with hydraulic engineering.

3.4.1 VEQ-S Inspection Criteria

VEQ-S inspection criteria was developed and submitted with the last annual report. A pilot using the VEQ-S criteria was conducted with the Harford County inspections and we are now reviewing the pilot information and updating the criteria to incorporate into our field inspection manual. The Carroll and Charles county inspections will include these criteria.

3.4.2 VEQ-S Enhancements

SHA continues to apply for and use Transportation Enhancement Program funds to provide VEQ-S enhancements to existing SWM BMPs. Currently eight facilities are under construction as identified in Table 3-10. The improvements being incorporated into these retrofits include installation of maintenance access, planting native marsh species, installing native meadows, eradicating invasive species, and removing woody species from embankments and outfall structures. Table 3-11 provides a summary of the project information.

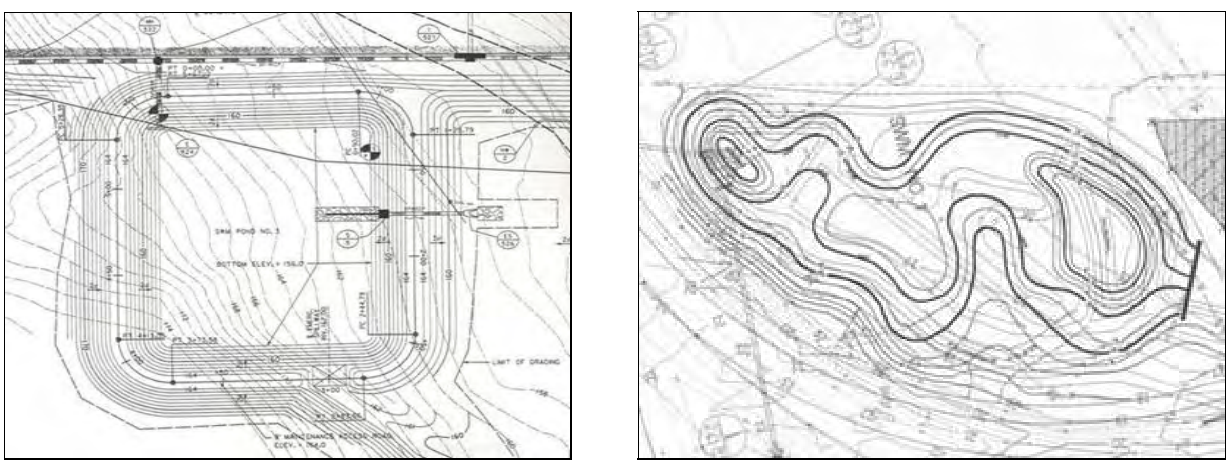


Figure 3-8 Comparison of Square versus Curvilinear BMP Design (from VEQ-S Reviewer Guidelines)

Table 3-10 VEQ-S BMP Enhancement Sites in Baltimore and Harford Counties

No .	BMP No.	SWM Facility	SHA Road	Proposed Enhancements
1	03281	Infiltration Basin	I-695 Inner Loop	Maintenance access road, provide opening in traffic barrier, raise embankment top to maintain 2 ft. freeboard for 100 year storm, native emergent plantings into micro-pool and forebay, live fascine installed at base of cut slopes, removal of woody plants from embankment, seeding embankment, clear 15 ft. woody-free zone at base of embankment, general landscape planting.
2	12076	Shallow Marsh Detention Basin	US 1, Hickory Bypass	Stabilize inflow outfall, install marsh plantings, seed embankment.
3	12075	ED Pond	US 1 Hickory Bypass	Maintenance access road with curb cut and concrete apron, provide opening in traffic barrier, native emergent planting, seed basin bottom with native tall forbs mix, live fascine at base of cut slopes, remove woody plants from embankment and outfall structure, clear 15 ft. woody-free zone, seed embankment, general landscape planting
4	12069	ED Pond	US 1 Hickory Bypass	Maintenance access road, native emergent planting, seed basin bottom with native tall forbs mix, livs fascine at base of cut slopes, woody species removed from SWM embankment and outfall structure, clear 15 ft. woody-free zone at base of embankment, seed embankment, general landscape planting.
5	12072	ED Pond	US 1 Hickory Bypass	Maintenance access road and turnaround, enlarge pond to accommodate access road, live fascine at base of cut slopes, seed basin bottom (no permanent pools), general landscape planting.
6	12073	ED Pond	US 1 Hickory Bypass	Maintenance access road, provide opening in traffic barrier, seed basin bottom with native tall forbs, live fascine at base of cut slopes, native emergent planting at micropool and forebay, general landscape planting.
7	12081	ED Shallow Marsh	US1 & MD 924 Interchange	Native emergent plants and shrubs, live fascine at base of cut slopes, general landscape planting.
8	12082	ED Shallow Marsh	US 1 & MD 24 Exit Ramp	Maintenance access road, cattail eradication, native emergent plants.

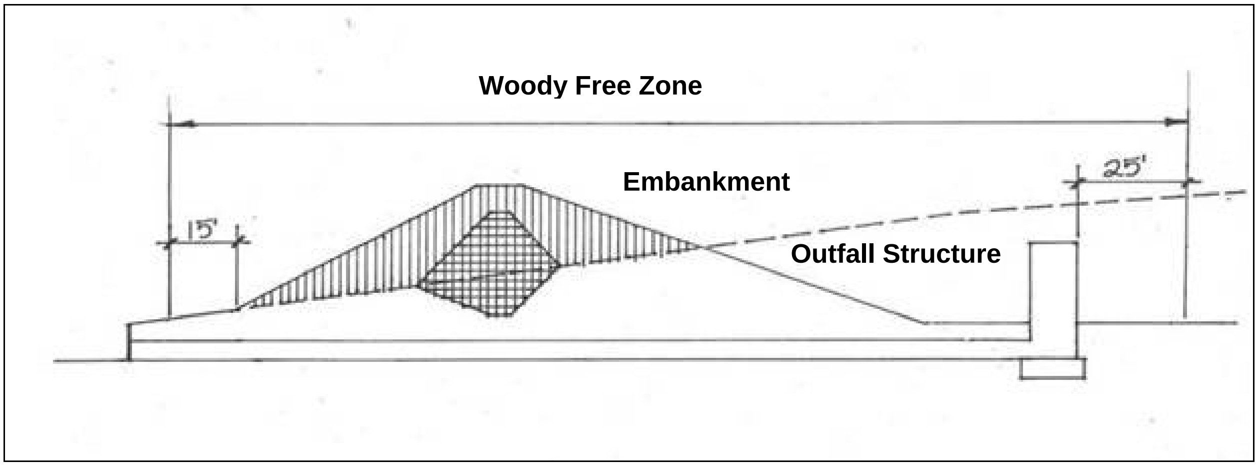


Figure 3-9 Pond Code 378 Woody Planting Restrictions at SWM Embankment (from VEQ-S Reviewer Guidelines)

Table 3-11 VEQ-S BMP Enhancement Projects Summary

No.	Project	County	Number of BMP Facilities	Contract Number	Construction Cost Estimate	Status
8*	Stormwater Improvements to 8 Facilities in District 4	Baltimore Harford	8	AT7995225	$774,701.15	Under Construction, Construction to be Completed in Spring 2007

* See Table 3-7 for Numbers 1-7

3.4.3 VEQ-S Review Process and Guidelines

In addition to the VEQ-S field inspection criteria, SHA has developed and implemented a review process to routinely review projects currently under design for provision of VEQ-S standards and design features. Consultant landscape architectural reviewers are assigned projects to review and provide comments. This process has not only been implemented for our regular advertisement projects, but also into the design/build process. For 2005 /2006, 40 projects were reviewed.

A review guideline document and checklist have been written and are attached as Appendix F to this report. The document is entitled, *Stormwater Management Facility Visual and Environmental Quality and Safety Criteria: Review Guidelines* and it is being made available not only to the reviewers, but to designers, and also to both SHA employees and consultants. Figures 3-8 and 3-9 are taken from the review guidelines. These guidelines will be updated periodically as new information becomes evident.

A VEQ-S design guideline document is also under development and is targeted for completion in 2007. Workshops and training will be developed and presented to accompany the release of the design guidelines.

3.4.4 Safety Policy

A separate policy is being drafted for SHA Administration review and approval that addresses the issue of physical safety for the public, maintenance personnel and BMP inspectors. This is in response that the added scrutiny that the NPDES program requirements have placed on stormwater BMPs, and the necessity to ensure the safety of all who may access the BMP site. The safety policy deals with steepness of slopes, grading, depth of permanent water, height and design of riser structures and other hydraulic structures and safety at temporary (ESC facilities) BMPs. These safety concepts have been included into the reviewer's guideline and will be incorporated into the design guidelines that are under development.

3.4.5 SWM Minimum Planting Standards

Minimum planting standards (Figure 3-10, Tables 3-12 and 3-13) were also developed for use at SWM facilities. There are no minimum planting requirements in the *2000 Stormwater Design Manual* and developing this standard was important to ensure that a certain level of natural environmental consideration be designed into SWM facilities. Plants provide nutrient removal, shade, particulate pollutant removal, wildlife habitat and natural heritage continuation. It is also important that native plants be used and that the plants selected are native to the particular area. This avoids the accidental introduction of invasive species, ensures greater likelihood of plant survival and adaptability, and allows the facility to merge into the adjacent landscape.

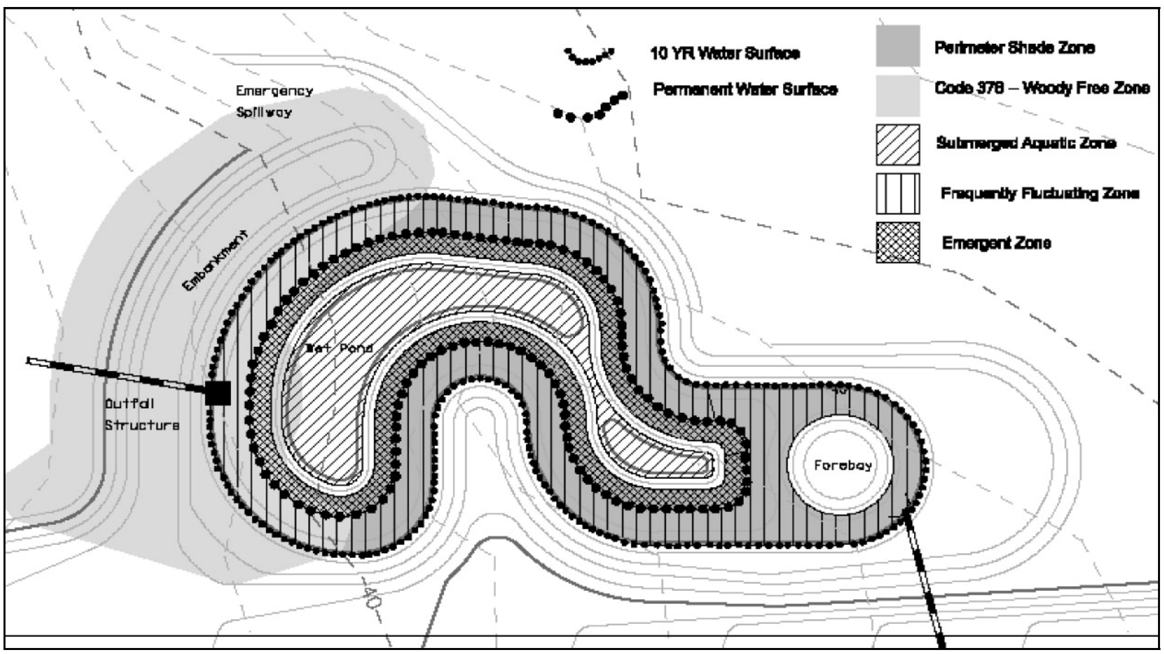


Figure 3-10 SWM BMP Planting Zones

Table 3-12 – Minimum Planting Requirements for SWM Pond and Wetland Hydrologic Zones

Min. Quantity/ Placement Considerations	Min. Size/Rate	Root Condition
Submerged Aquatic Zone **(4 ft. or greater depth permanent water)**		
• 1 plant per 9 cu. ft. of water volume for water depths 4 ft. or deeper. • Min. 2 species with no one species being greater than 60% of the total plants	8 in. ht./length	Bare root
Emergent & Floating Aquatic Zone **(up to 18 in. depth permanent water)**		
• 24 in. centers max. spacing (2.9 plants per 10 sq. ft.) • Min. 3 species shall be provided with no one species being greater than 50% of the total plants in this zone • Min. 30% of the species shall be broadleaved or floating leaved	24 in. ht.	Container grown
Frequently Fluctuating Zone **(permanent water surface to 10 yr. water storm elev.)**		
<u>Live Fascines or Wattles</u> • 3 species in each fascine bundle • Place parallel to contours • Min. one layer of fascines at water's edge • Do not use when facility is lined	4 in. diameter by 6 ft. length	Bound bundles
<u>Plug Planting</u> • Min. 3 species of plugs shall be provided with no one species being greater than 50% of the total plants in this zone • Plugs shall be spaced at max. 24 in. centers (2.9 plants per 10 sq. ft.)		
<u>Seed and Mulch</u> • Shall be included to provide permanent stabilization • SWM Seed Mix • SHA Special Purpose Mix • Mulch shall be according to SSCM 2001, Section 705.03.01(f). • No straw mulch shall be used at SWM facilities	16 lbs./ac. 10 lbs/ac.	
Perimeter Shade Planting **(emergent & floating aquatic zone to 10 yr. water storm elev.)**		
<u>Canopy Trees</u> • 1 tree if areas is ≤ 4,000 SF (measured at 10 YR water surface contour line) • 3 trees if (4,000 SF < area ≤ 8,000 SF) • 5 trees if (8,000 SF < area ≤12,000 SF) • If area > 12,000 SF, add 1 additional tree for each additional 4,000 SF • If facility is lined, no trees or woody shrubs allowed within limits of liner	3 inch cal.	B & B
<u>Understory or Flowering Trees</u> • 2 if area is ≤ 4,000 SF, add 1 additional tree for each additional 1,000 SF • Multiple stemmed trees shall have a min. of 3 trunks.	2 in. cal.	B & B
<u>Woody Shrubs</u> 5 for every understory or flowering tree required	24 in. ht. or spread	Container Grown
<u>Planting Bed Preparation</u> • Mulched beds shall not be used at SWM facilities below the 10 YR water surface elevation. Instead, individual plants shall be installed in plant pits that are not mulched. • Areas between planting pits shall be stabilized with seed and mulch		
<u>Seed and Mulch</u> See Frequently Fluctuating Zone seed and mulch requirements.		

Table 3-13 – Minimum Planting Requirements for SWM Filtering Practices

Min. Quantity/ Placement Considerations	Min. Size/Rate	Root Condition
Surface Sand Filter		
Sod • Flow shall be diverted from filter practices until 2 in. ht. of permanent turf stabilization has been established • In cases where flow cannot be diverted, sod shall be applied to the filter surface • Sod shall be applied to all grass weirs except emergency spillways (which shall be established in permanent turf).	Section 708 Section 920 (SSCM 2001)	
Seed and Mulch • SWM Seed Mix • Special Purpose Mix • No straw mulch shall be used at SWM facilities.	8 lbs / ac. 10 lbs / ac.	
Bioretention		
Trees • min. 0.76 trees per 100 SF (filter surface area measurement) • If the facility has underdrains or is lined, large canopy trees shall not be placed directly in the bioretention facility. Instead, they shall be used adjacent to the facility to provide shade to understory plants. In this case, plant large trees 5 feet away from the perimeter of the filter medium/underdrains or liner.	2 inch cal.	B&B
Shrubs • Min. 2.8 shrubs per 100 SF (filter surface area measurement)	24 in. ht. or spread	Container Grown
Herbaceous layer • 3 perennials or grasses can be substituted for 1 required shrub • No more than 50% of plants shall be perennial or grasses	#1 container	Container Grown
Mulch • 3 in. depth shredded hardwood mulch, evenly distributed and raked smooth	Section 920 (SSCM 2001)	

3.5 Other Topics

3.5.1 Data Management

To-date SHA has performed inventory of drainage infrastructure in seven counties and for BMPs in all twenty-three counties. In addition, SHA has performed initial and cyclical inspections of BMPs. This work involves the continuous creation and updating of GIS data for source identification and database records for inspections and remediation activities. SHA has recently created an 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 result was 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.

In addition, SHA is preparing updates to the Standard Procedures Manual to improve the standardization of all relevant data. This will document the updates on the data collection as the result of the Geodatabase and SHA's continued efforts to improve the NPDES Program

3.5.2 BMP Research – Grass Swale Study

Grass swales have been used for the conveyance of highway runoff as well as for water quality treatment through sedimentation, filtering by the grass blades, infiltration, and biological processes. However, limited performance data regarding swale pollutant removal efficiencies and design parameters is available. The design criteria need to be better understood to allow some flexibility in designing swales and accommodate practical applications, since in some instances, local site conditions may be best suited for the construction of a swale with parameters outside of required ranges.

Therefore, SHA initiated a Grass Swale Study to evaluate highway runoff pollutant removal efficiency of grass-lined channels. The long term objective of this project is to systematically quantify the effects of grass swales operational parameters for water quality improvement. These parameters include pre- treatment buffer, swale vegetation type, vegetation height, swale length, side slopes (2:1 to 4:1), longitudinal slopes (2 to 6%), and bottom width (1 to 8 ft). Water quality improvement performance curves from roadway runoff events can be produced to account for these variables. In addition, design and/or performance relationships can be developed. Water quality parameters to be examined include total suspended solids (TSS), oil and grease, total phosphorus, nitrate- N, ammonia-N, total Kjeldahl nitrogen (TKN), lead, copper, and zinc. Since flow rates through the swales are being recorded, the total pollutant mass reduction can be calculated.

The monitoring location for this project is MD Route 32 near Savage. This is a four-lane highway (two in each direction) with limited access. The sampling areas are just east of the Vollmerhausen Road overpass. Two swales are constructed in the highway median to receive runoff laterally from the southbound roadway lanes (Figure 11). The first is a swale constructed based on MDE guidelines, with a sloped grass pretreatment area between the roadway and the swale. The second swale, to the west, was identically constructed, but without the pretreatment area (known as SHA swale). Both swales run 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). Sampling areas were designed so that all three drainage areas are similar and therefore comparable (Direct 60,800 ft^2, SHA swale 42,464 ft^2, and MDE swale 65,910 ft^2). Sampling occurs at a V-notch weir located at the end of each swale.

SHA grass swale | *MDE grass swale* | *Channel for direct runoff*

Figure 3-11 Grass Swale Study at MD 32

The system is designed as an input/output study. The runoff flow and pollutant load determined in the flow directly off the highway is considered as equal to the total input flow to each swale. This value is compared to flow and water quality measured at the outlet of each swale. The detailed report summarizing the study results is included in the Appendix D.

After a year of data collection, the grass swale study indicates positive reduction of pollutant mass and mean concentrations for many of the water quality constituents. Total suspended solids, nitrite, and the metals show statistically significant reductions in total mass. TSS are being removed at a mean rate of 73-84%. Metals were all significantly removed by the swales in terms of mass, with zinc showing the highest removal (75-85% mean), followed by copper (47-70%) and lead (59-73).

Chloride represents the one pollutant that shows very different results than all other measured constituents. The grass swales appear to be exporting chloride mass and increasing the resulting chloride N-EMC throughout the duration of this study. These results suggest that a large reservoir of chloride accumulates in the roadside grass and soil during winter salting operations and slowly releases chloride during storm events throughout the year.

In summary, the study results conclude that pretreatment area may add some improvements to highway runoff water quality, however there are other factors, such as channel length, slope, vegetation and soil conditions have more significant impact on the pollutant removal efficiency.

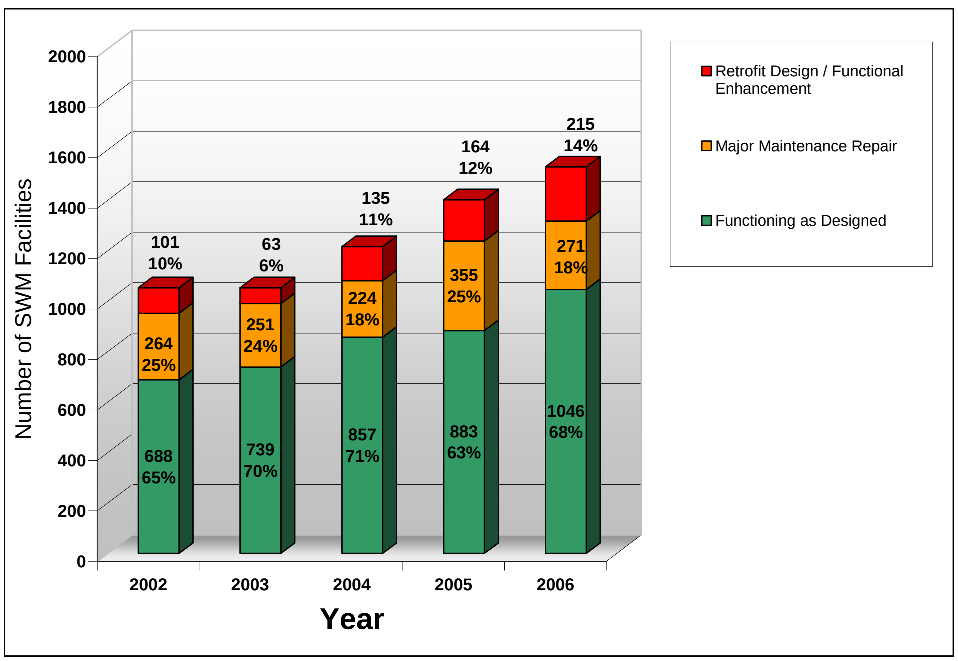


Figure 3-12 Progress in SWM Facility Program

3.6 Summary

SHA has works diligently to develop sound protocols for inventorying and inspecting SMW facilities. This leads to the development of a responsive maintenance program to sustain BMP performance, but also includes functional and visual enhancements to improve SWM. SHA also progressively researches SWM facility performance. SHA utilizes data management technology to manage and utilize BMP data. Tools were 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 Facility performance.

SHA's business plan goes beyond the NPDES permit by promoting the statewide inventory and management of BMPs and a high-level of SWM performance. Figure 3-12 summarizes the progress by SHA in continually inventorying and maintaining BMPs statewide.

As SHA continues to inventory and inspect BMPs statewide, the SWM Facility Program will evolve to maintaining and improving the existing inventory as well as the proactive creating on BMPs to meet watershed needs.

List of Part 3 Appendices

APPENDIX 3-A:

Example AA Major Maintenance Report

BMP# 2391

Anne Arundel County Major Maintenance

BMP ID # 2391
Inspection Date: 4/06/04
Inspection Team: G. Iskra / M. Waters
Location: MD 665 and MD 2 interchange
Function: Retention Pond (Wet)
SHA Rating: III
Previous Inspection Rating: B
SHA Contract #: AA 309-503-572
Recommended Pond Remediation Category: III
Assessment Report Contact: Charles McCulloch
Contact Phone Number: 410-265-9500

Site Conditions:

General Constructability Observations: BMP #2391 is located inside the onramp to westbound MD 665 from MD 2 south. The field inspection indicated that this facility is a retention pond. The previous inspection of the facility encountered ongoing construction which included the installation of a 60” RCP, and a curb opening, plus associated riprap and a peninsula berm to increase the detention time. Recently it appears that a 27” HDPE pipe had been installed. In addition to the mentioned 60” RCP and 27” HDPE inflows, there are two additional inflow pipes, and 2 riprap channels from curb openings. The curb openings are experiencing heavy erosion and the riprap is being carried down the channel on the north side of the BMP. Southwest of this curb opening is an area where the runoff is flowing over the curb and causing erosion on the facility slope. On the north east of the BMP there is an 18” RCP inflow with a headwall. The 30” RCP inflow, located in the southwest of the BMP, had separated at least one joint and caused erosion in the vicinity of the headwall. The headwall has also failed because the soil had been eroded as can be seen in Photos 9, 10, and 11. East of the 30” RCP, the slope above a 27” HDPE pipe appears to be unstable and the outfall of the pipe has a sediment build up and erosion at the edges of the gabion cages. Erosion has also occurred around some fence posts. A small gap in the fence line also appears east of the HDPE pipe which wildlife has used to access the water in the BMP. Another form of wildlife making a permanent home in the pond is a beaver whose home is north of the peninsula in the pond.

Access and MOT: Permanent access to this site is available but it is not easily utilized. Steep slopes extending to the fence surround the facility and the slopes are unstable in certain areas. The traffic control will be required since the site will be accessed from the ramp, but staging may not be possible in the pond area. Equipment will have to access the facility through the fence gate located on the south west side of the BMP or a crane will be required to place equipment and materials needed to complete the recommendations for remediation. The crane would be necessary if access cannot be gained with an excavator. A portable variable message sign is recommended. Lane closures will probably not be needed, flagging will be required while moving vehicles down the steep slopes. Any MOT will have to be permitted by the district office.

Recommendations for Remediation:

This BMP will need maintenance to bring it up to standards. The 30” RCP inflow, that has heavy erosion around it, will require major maintenance to correct the problem that exists now. The following correction actions need to be addressed:

1. Install a manhole at the location of the existing endwall and extend the system with 40 LF 30” HDPE pipe placed at a 0.5% slope to the invert of the pond to correct the erosion around the 30” RCP and headwall (see Photo 9, 10, 11).

2. Remove the 4” diameter tree blocking the gate in the fence around the facility (see Photo 4). Regrade a total of 900 SF and stabilize the slopes of the facility in various areas using type ‘A’ stabilization matting. Specifically, these areas include the fence gate (10’ by 10’), around the HDPE inflow pipe (20’ by 30’), and around the south east corner where there is a gap in the fence (20’ by 10’).

3. Repair the riprap at the curb openings on the north side of the facility.

4. Remove trash and debris from inflows and orifice.

5. Repair a 2' by 5' area (10 SF) of erosion around 3 fence poles along the eastern side of the facility. Place topsoil, seeding, and type 'A' stabilization matting in the area of repair (see Photo 13).

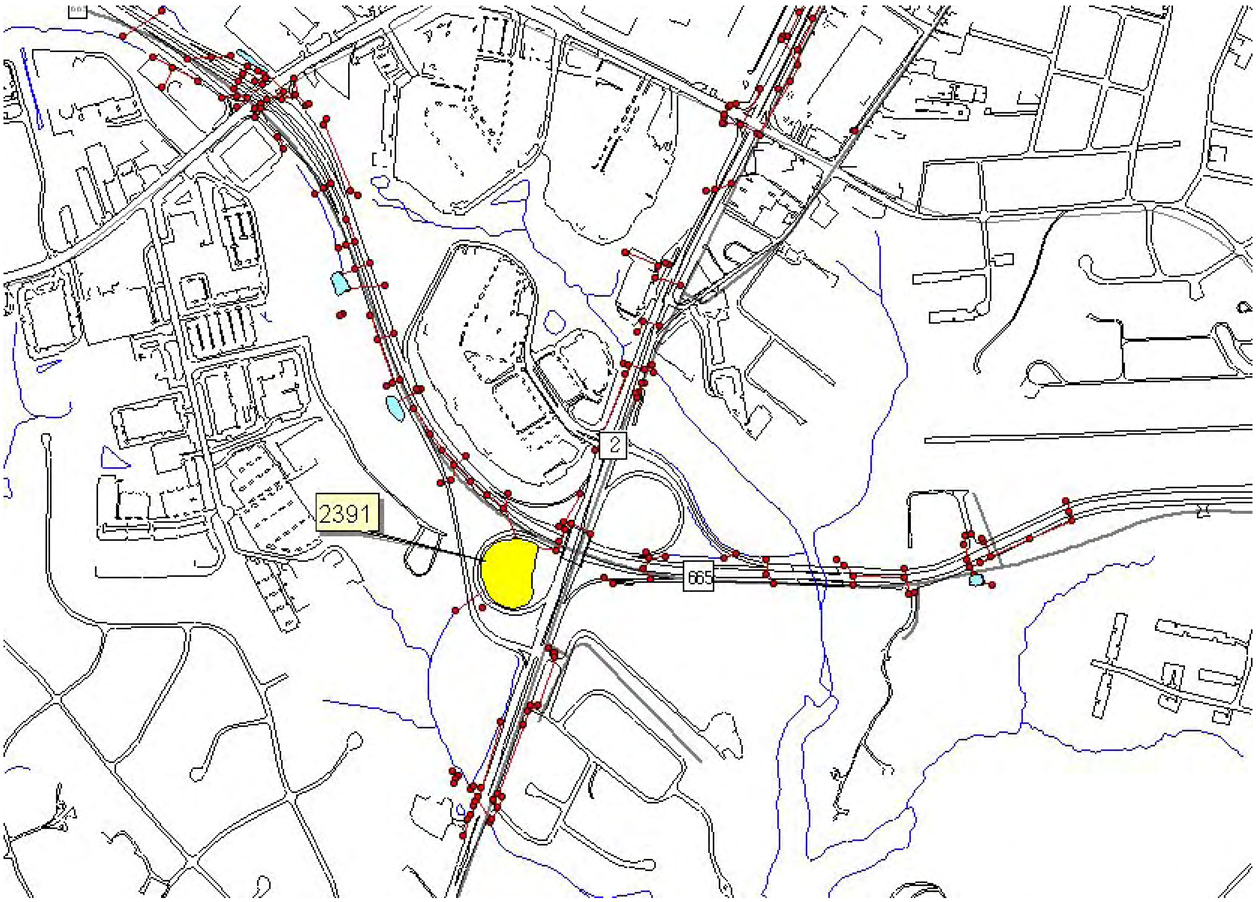
6. Install a new curb 3' opening and 30' riprap channel to better accommodate the heavy flow on the north side of the facility.

7. Fix gap in the fence on the southeast side of the BMP by adding a new fence post and fencing (see Photo 13).

8. Remove gabions. Install a riprap channel to the invert of the pond, approximately 30' in length 10' wide.

Materials for Construction:

Materials	Quantity	Units
4" Topsoil	35	CY
Type 'A' Stabilization Matting	104	SY
Seeding	930	SF
30" HDPE Pipe	40	LF
48" Drop Manhole (6' Deep)	1	EA
Class I Riprap	44	SY
Geotextile Class SE	44	SY
6' High Fence	5	LF



BMP # 2391 Location Map

Photo 1 – Debris in the riprap from the curb opening on the west side of the facility

Photo 2 – Vegetation growth on the east side of the pond area

Photo 3 – The south side of the facility

Photo 4 – Steep slope with a tree at the entrance with no chain and lock on the west side of the BMP

Photo 5 – 27" HDPE pipe inflow with unstable slope on the south side of the facility

Photo 6 – 60" RCP inflow and 3' curb opening and rip rap channel inflow on the west side of the BMP

Photo 7 – Control structure with trash rack on the south west side of the facility

Photo 8 – Control structure interior

Photo 9 - Heavy erosion around broken 30" RCP inflow on the south side of the BMP

Photo 10 – Damaged headwall to the 30" RCP inflow

Photo 11 – Separated 30" RCP pipe causing heavy erosion

Photo 12 – 27" HDPE pipe inflow and recently re-graded slope on the south side of the BMP

Photo 13 – Fence gap and failing slope on the south east side of the facility

Photo 14 – Beaver habitat in the center of the BMP

Photo 15 – Heavy trash and sediment in the area of the 18" RCP inflow on the north side of the BMP

Photo 16 – 36" RCP inflow and a riprap inflow on the north side of the facility

Photo 17 – Erosion around and in the riprap inflow on the north side of the facility

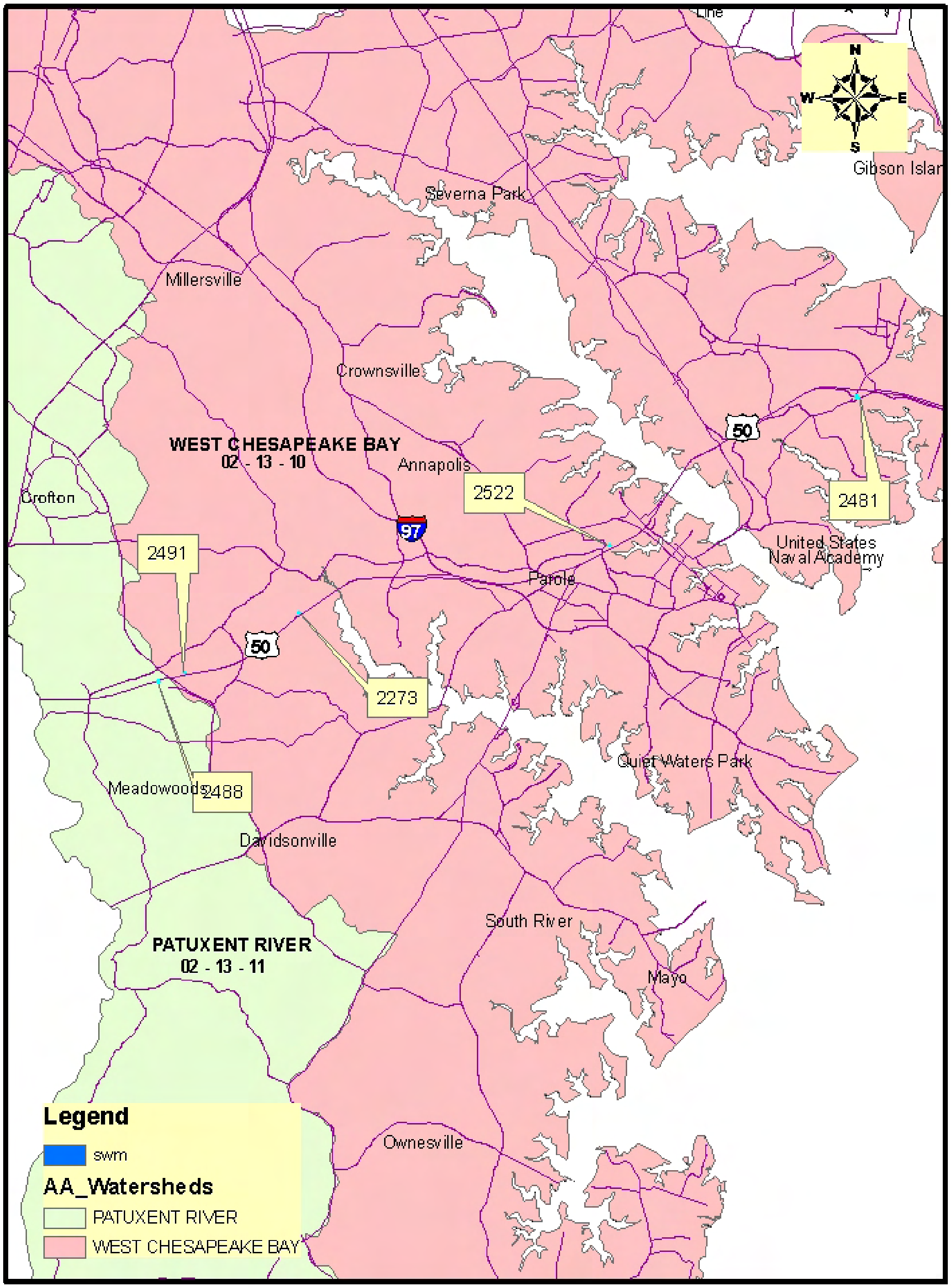
APPENDIX 3-B:

Functional Enhancements of SWM Facilities along US 50 in AA County

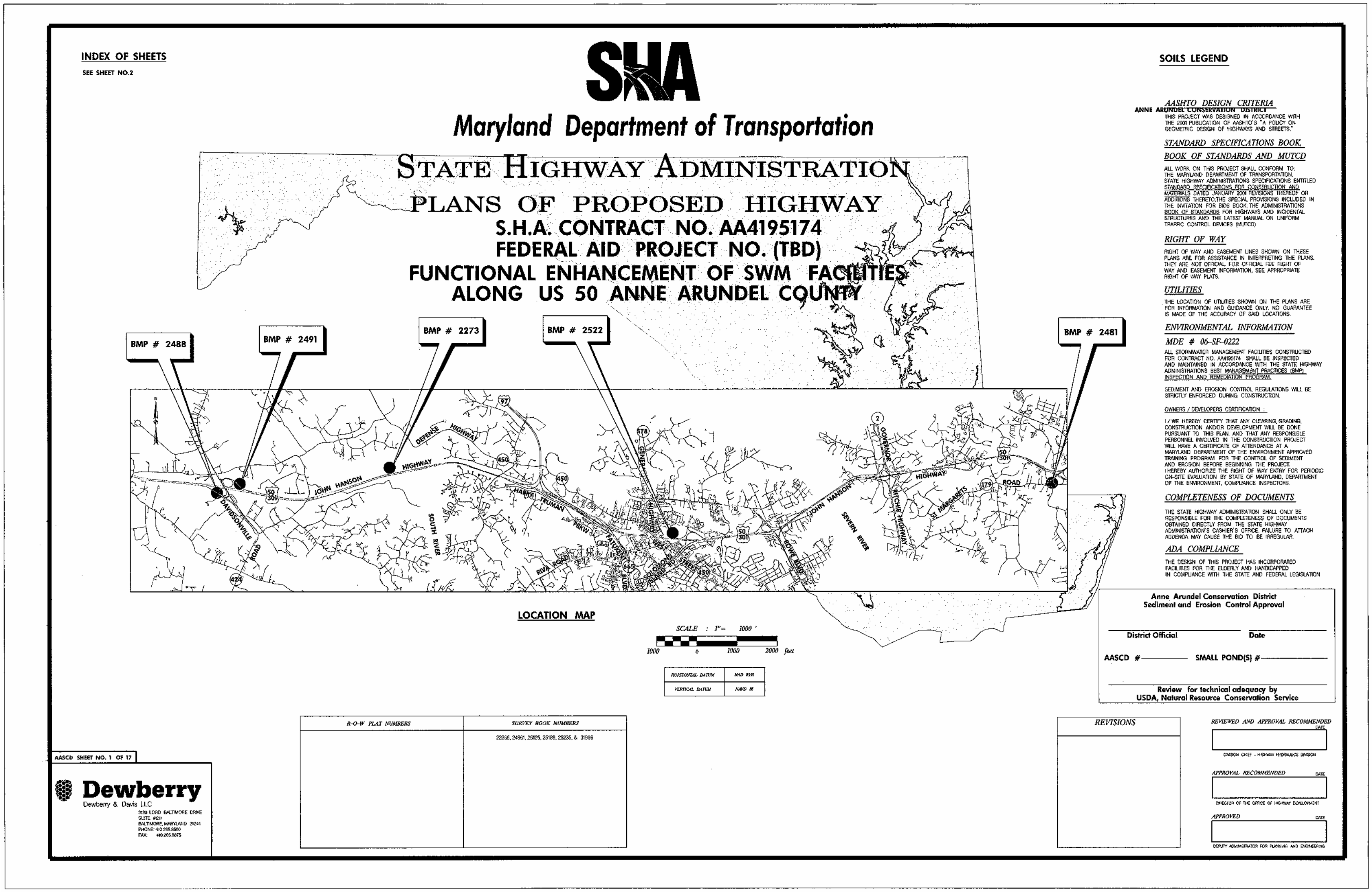
BMP # 2481

BMP # 2488

BMP # 2491

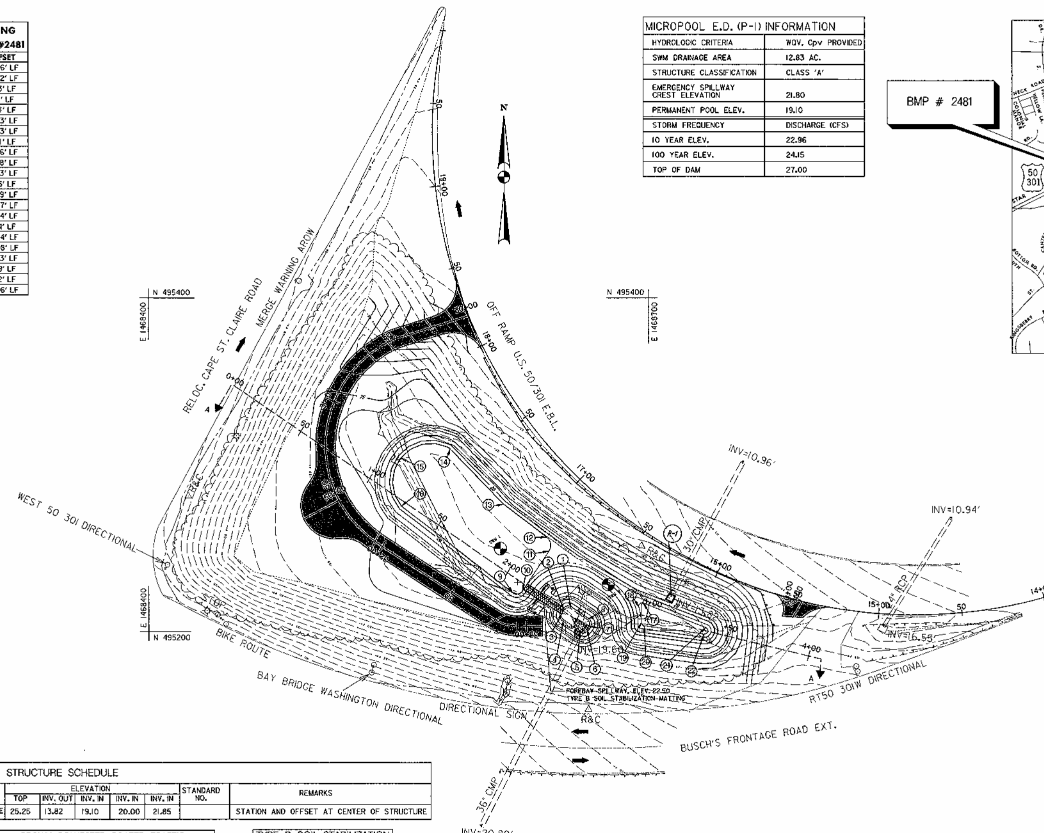


Functional Enhancement Projects- Anne Arundel County

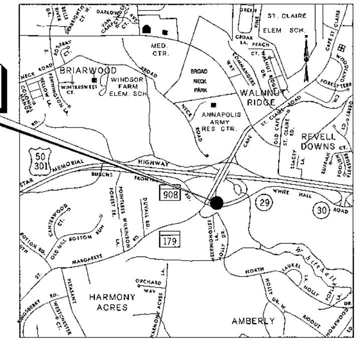


INDEX OF SHEETS
SEE SHEET NO.2
SHA
Maryland Department of Transportation
STATE HIGHWAY ADMINISTRATION
PLANS OF PROPOSED HIGHWAY
S.H.A. CONTRACT NO. AA4195174
FEDERAL AID PROJECT NO. (TBD)
FUNCTIONAL ENHANCEMENT OF SWM FACILITIES
ALONG US 50 ANNE ARUNDEL COUNTY
BMP # 2488
BMP # 2491
BMP # 2273
BMP # 2522
BMP # 2481
JOHN HANSON HIGHWAY
DEFENSE HIGHWAY
HARRY S. TRUMAN PKWY
SOUTH RIVER
RIVA ROAD
SEVERN RIVER
ROAD
LOCATION MAP
SCALE : 1"= 1000 '
1000 0 1000 2000 feet
SOILS LEGEND
AASHTO DESIGN CRITERIA
ANNE ARUNDEL CONSERVATION DISTRICT
THIS PROJECT WAS DESIGNED IN ACCORDANCE WITH THE 2001 PUBLICATION OF AASHTO'S "A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS."
STANDARD SPECIFICATIONS BOOK, BOOK OF STANDARDS AND MUTCD
ALL WORK ON THIS PROJECT SHALL CONFORM TO: THE MARYLAND DEPARTMENT OF TRANSPORTATION, STATE HIGHWAY ADMINISTRATIONS SPECIFICATIONS ENTITLED STANDARD SPECIFICATIONS FOR CONSTRUCTION AND MATERIALS DATED JANUARY 2001 REVISIONS THEREOF OR ADDITIONS THERETO;THE SPECIAL PROVISIONS INCLUDED IN THE INVITATION FOR BIDS BOOK; THE ADMINISTRATIONS BOOK OF STANDARDS FOR HIGHWAYS AND INCIDENTAL STRUCTURES AND THE LATEST MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES (MUTCD)
RIGHT OF WAY
RIGHT OF WAY AND EASEMENT LINES SHOWN ON THESE PLANS ARE FOR ASSISTANCE IN INTERPRETING THE PLANS. THEY ARE NOT OFFICIAL. FOR OFFICIAL FEE RIGHT OF WAY AND EASEMENT INFORMATION, SEE APPROPRIATE RIGHT OF WAY PLATS.
UTILITIES
THE LOCATION OF UTILITIES SHOWN ON THE PLANS ARE FOR INFORMATION AND GUIDANCE ONLY. NO GUARANTEE IS MADE OF THE ACCURACY OF SAID LOCATIONS.
ENVIRONMENTAL INFORMATION
MDE # 06-SF-0222
ALL STORMWATER MANAGEMENT FACILITIES CONSTRUCTED FOR CONTRACT NO. AA4195174 SHALL BE INSPECTED AND MAINTAINED IN ACCORDANCE WITH THE STATE HIGHWAY ADMINISTRATIONS BEST MANAGEMENT PRACTICES (BMP) INSPECTION AND REMEDIATION PROGRAM.
SEDIMENT AND EROSION CONTROL REGULATIONS WILL BE STRICTLY ENFORCED DURING CONSTRUCTION.
OWNERS / DEVELOPERS CERTIFICATION :
I / WE HEREBY CERTIFY THAT ANY CLEARING, GRADING, CONSTRUCTION AND/OR DEVELOPMENT WILL BE DONE PURSUANT TO THIS PLAN, AND THAT ANY RESPONSIBLE PERSONNEL INVOLVED IN THE CONSTRUCTION PROJECT WILL HAVE A CERTIFICATE OF ATTENDANCE AT A MARYLAND DEPARTMENT OF THE ENVIRONMENT APPROVED TRAINING PROGRAM FOR THE CONTROL OF SEDIMENT AND EROSION BEFORE BEGINNING THE PROJECT.
I HEREBY AUTHORIZE THE RIGHT OF WAY ENTRY FOR PERIODIC ON-SITE EVALUATION BY STATE OF MARYLAND, DEPARTMENT OF THE ENVIRONMENT, COMPLIANCE INSPECTORS.
COMPLETENESS OF DOCUMENTS
THE STATE HIGHWAY ADMINISTRATION SHALL ONLY BE RESPONSIBLE FOR THE COMPLETENESS OF DOCUMENTS OBTAINED DIRECTLY FROM THE STATE HIGHWAY ADMINISTRATION'S CASHIER'S OFFICE. FAILURE TO ATTACH ADDENDA MAY CAUSE THE BID TO BE IRREGULAR.
ADA COMPLIANCE
THE DESIGN OF THIS PROJECT HAS INCORPORATED FACILITIES FOR THE ELDERLY AND HANDICAPPED IN COMPLIANCE WITH THE STATE AND FEDERAL LEGISLATION
Anne Arundel Conservation District
Sediment and Erosion Control Approval
District Official
Date
AASCD #
SMALL POND(S) #
Review for technical adequacy by
USDA, Natural Resource Conservation Service
R-O-W PLAT NUMBERS
SURVEY BOOK NUMBERS
22365, 24961, 25125, 25189, 25235, & 31986
AASCD SHEET NO. 1 OF 17
Dewberry
Dewberry & Davis LLC
3120 LORD BALTIMORE DRIVE
SUITE #211
BALTIMORE, MARYLAND 21244
PHONE: 410 265.9500
FAX: 410.265.8875
REVISIONS
REVIEWED AND APPROVAL RECOMMENDED
DATE
DIVISION CHIEF – HIGHWAY HYDRAULICS DIVISION
APPROVAL RECOMMENDED
DATE
DIRECTOR OF THE OFFICE OF HIGHWAY DEVELOPMENT
APPROVED
DATE
DEPUTY ADMINISTRATOR FOR PLANNING AND ENGINEERING

STATIONS & OFFSETS FOR GRADING FROM ℄ CONSTRUCTION BMP #2481		
POINT #	STATION	OFFSET
1	16+61.35	63.06′ LF
2	16+64.08	66.22′ LF
3	16+64.18	68.13′ LF
4	16+61.18	71.01′ LF
5	16+49.19	70.81′ LF
6	16+46.98	67.83′ LF
7	16+46.89	65.83′ LF
8	16+49.35	62.81′ LF
9	16+85.95	77.36′ LF
10	16+82.96	72.88′ LF
11	16+85.96	44.33′ LF
12	16+91.42	39.16′ LF
13	17+19.81	43.39′ LF
14	17+59.53	48.07′ LF
15	17+68.76	75.64′ LF
16	17+50.56	91.74′ LF
17	16+29.50	36.64′ LF
18	16+30.54	40.08′ LF
19	16+25.45	47.33′ LF
20	16+23.35	49.19′ LF
21	15+93.81	33.12′ LF
22	15+93.31	37.06′ LF

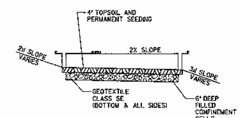


MICROPOOL E.D. (P-1) INFORMATION	
HYDROLOGIC CRITERIA	WQV, Cpv PROVIDED
SWM DRAINAGE AREA	12.83 AC.
STRUCTURE CLASSIFICATION	CLASS 'A'
EMERGENCY SPILLWAY CREST ELEVATION	21.80
PERMANENT POOL ELEV.	19.10
STORM FREQUENCY	DISCHARGE (CFS)
10 YEAR ELEV.	22.96
100 YEAR ELEV.	24.15
TOP OF DAM	27.00



VICINITY MAP

NOT TO SCALE



TYPICAL SECTION PROPOSED CELL CONFINED STABILIZED ACCESS ROAD

NOT TO SCALE

STRUCTURE SCHEDULE										
STRUCTURE	STATION	OFFSET FROM ℄	TYPE	ELEVATION					STANDARD NO.	REMARKS
				TOP	INV. OUT	INV. IN	INV. IN	INV. IN		
R-1	16+18	28′ LT	RISER STRUCTURE	25.25	13.82	19.10	20.00	21.85		STATION AND OFFSET AT CENTER OF STRUCTURE

TYPE K TRAFFIC BARRIER END TREATMENT OPTION 1 ANCHORAGE (EACH)		
FROM, OFFSET	STANDARD	QUANTITY
STA. 15+61, 18.5′ LT	MD 605.10	1
STA. 17+93, 2′ LT	MD 605.10	1

BROWN POLYESTER COATED TRAFFIC BARRIER W BEAM MD 605.25 (LF) 8′ POST		
FROM, OFFSET	TO, OFFSET	QUANTITY
STA. 15+61, 18.5′ LT	STA. 17+93, 2′ LT	245

TYPE B SOIL STABILIZATION MATTING (SY)		
STATION	OFFSET	QUANTITY
16+65	70′ LT.	12.50

CLASS I RIPRAP (SY)		
STATION	OFFSET	QUANTITY
16+50	68′ LT.	7.25

NOTES:

1. MAINTENANCE OF TRAFFIC SHALL CONFORM TO STD. No. 104.05-01 FOR SHOULDER WORK, EXP.- FREEWAY GREATER THAN 40 MPH.

Dewberry

Dewberry & Davis LLC
3120 LORD BALTIMORE DRIVE
SUITE #211
BALTIMORE, MARYLAND 21244
PHONE: 410.265.9500
FAX: 410.265.8875

CROSS REFERENCE		R/W PLAT NUMBER	REVISIONS
ITEM	SHEET NOs.		
TYPICAL SHEETS			
SUPERELEVATION SHEETS			
PIPE & DRAINAGE SCHEDULE			
GEOMETRIC LAYOUT SHEETS			
ROADWAY PLAN SHEETS			
ROADWAY PROFILE SHEETS			
TRAFFIC CONTROL SHEETS			
EROSION & SEDIMENT CONTROL			
SIGNING & MARKING PLANS			
LANDSCAPE PLAN SHEETS			
UTILITIES			

AASCD SHEET NO. 4 OF 17

SHA
STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION
HIGHWAY HYDRAULICS DIVISION

FUNCTIONAL ENHANCEMENT OF SWM FACILITIES ALONG US-50 ANNE ARUNDEL COUNTY

BMP# 2481 – STORMWATER MANAGEMENT PLAN – MICROPOOL E.D. (P-1)

SCALE 1″=30′ DATE 08/14/2006 CONTRACT NO. AA4195174

DESIGNED BY RSK
DRAWN BY RSK
CHECKED BY CM
F.A.P. NO.
COUNTY ANNE ARUNDEL
LOGMILE

DRAWING NO. SW - 01 OF 01 SHEET NO. 9 OF 32

PLOTTED: SATURDAY, AUGUST 12, 2006 AT 01:58 PM
FILE: L:\PROJECTS\B0124\TASK 16-AACO-4PONDS\CAD\CIVIL\DESIGN\BMP-2481\DESIGN\PSW-P001_2481.DGN

PLANT LIST FOR AQUATIC BENCH, THIS SHEET

KEY	QUANTITY	BOTANICAL NAME / COMMON NAME	SIZE	CONDITION	REMARKS
HM	295	HIBISCUS MOSCHEUTOS / SWAMP ROSE MALLOW	1 QUART	CONTAINER	SPACE 18" O.C.
IV	260	IRIS VERSICOLOR / BLUE FLAG	1 QUART	CONTAINER	SPACE 18" O.C.
JE	275	JUNCUS EFFUSUS / SOFT RUSH	1 QUART	CONTAINER	SPACE 18" O.C.
LC	290	LOBELIA CARDINALIS / CARDINAL FLOWER	1 QUART	CONTAINER	SPACE 18" O.C.
SV	450	SCRIPUS VALIDUS / SOFTSTEM BULRUSH	1 QUART	CONTAINER	SPACE 18" O.C.
SP	235	SCRIPUS PUNGENS / COMMON THREE SQUARE	1 QUART	CONTAINER	SPACE 18" O.C.

PLANT LIST - TREES & SHRUBS, THIS SHEET

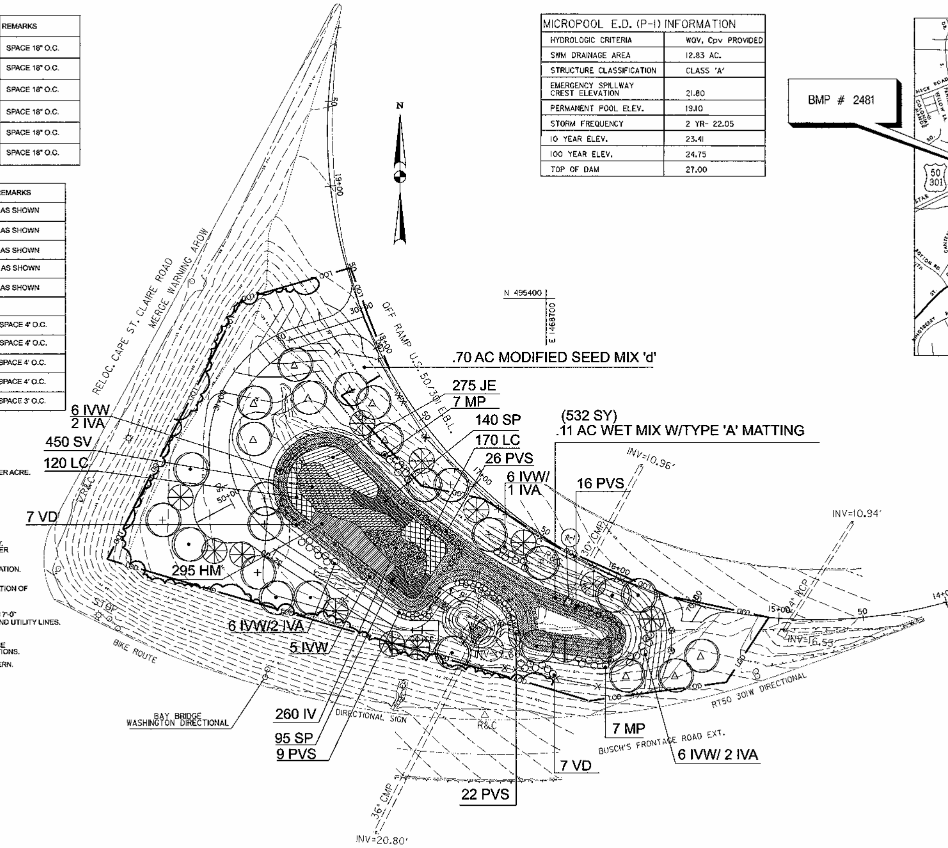
KEY	QUANTITY	BOTANICAL NAME / COMMON NAME	SIZE	CONDITION	REMARKS
(symbol)	8	ACER RUBRUM / RED MAPLE	21/2" CAL.	B & B	AS SHOWN
(symbol)	10	LIQUIDAMBAR STYRACIFLUA / SWEETGUM	21/2" CAL.	B & B	AS SHOWN
(symbol)	8	QUERCUS PALUSTRIS / PIN OAK	21/2" CAL.	B & B	AS SHOWN
(symbol)	2	TAXODIUM DISTICHUM / BALD CYPRESS	1 3/4" CAL.	B & B	AS SHOWN
(symbol)	12	AMELANCHIER CANADENSIS / SERVICEBERRY	6' HT.	B & B	AS SHOWN
(symbol)	2	MAGNOLIA VIRGINIANA / SWEETBAY MAGNOLIA	6' HT.	B & B	
IVA	7	ILEX VERTICELLATA 'APOLLO' / 'APOLLO' WINTERBERRY HOLLY	3' HT.	CONT.	SPACE 4' O.C.
IVW	29	ILEX VERTICELLATA 'WINTER RED' / 'WINTER RED' WINTERBERRY HOLLY	3' HT.	CONT.	SPACE 4' O.C.
MP	14	MYRICA PENSYLVANICA / NORTHERN BAYBERRY	3' HT.	CONT.	SPACE 4' O.C.
VD	14	VIBURNUM DENTATUM / ARROWWOOD	3' HT.	CONT.	SPACE 4' O.C.
PVS	73	PANICUM VIRGATUM / SWITCH GRASS	GAL.	CONT.	SPACE 3' O.C.

SEEDING NOTES:

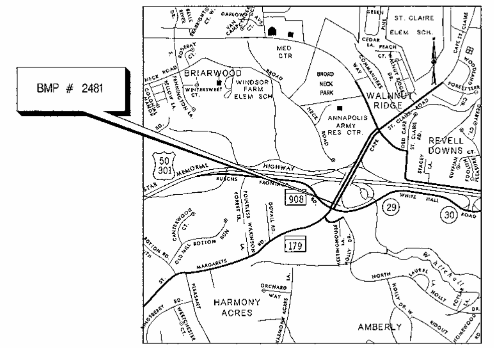
1. SEEDING RATE FOR WET MIX WITH TYPE 'A' MATTING SHALL BE 15.0 POUNDS PER ACRE (1.7) POUNDS FOR 0.11 ACRE SHORELINE FRINGE/HIGH MARSH AREA THIS PLAN SHEET. SEE SPECIAL PROVISIONS.
2. SEEDING RATE FOR MODIFIED COVER COMPANION SEED MIX 'd' SHALL BE 100.0 POUNDS PER ACRE. (70.0) POUNDS FOR 0.70 ACRE UPLAND AREAS THIS PLAN SHEET. SEE SPECIAL PROVISIONS

GENERAL NOTES:

1. PLANS ARE FOR LANDSCAPE PURPOSES ONLY. AS BUILT ROADWAY CONDITIONS MAY VARY. CONTRACTOR SHALL VERIFY CONDITIONS AND UTILITY LOCATIONS AND INFORM THE ENGINEER OF ANY DISCREPANCIES OR POTENTIAL PROBLEMS PRIOR TO PERFORMING THE WORK.
2. CONTRACTOR SHALL VERIFY LOCATIONS OF EXISTING UTILITIES PRIOR TO PLANT INSTALLATION. CONTRACTOR SHALL NOTIFY MISS UTILITY A MINIMUM OF 72 HOURS PRIOR TO DIGGING.
3. THE ADMINISTRATION IS TO BE NOTIFIED 48 HOURS BEFORE PLANTING BEGINS. THE LOCATION OF ALL PLANT MATERIAL IS TO BE APPROVED IN THE FIELD BY SHA LANDSCAPE OPERATIONS. CALL LANDSCAPE OPERATIONS AT 410-545-8590.
4. TREES SHALL NOT BE PLANTED WITHIN 7'-0" OF THE CENTERLINE OF SWALES, NOR WITHIN 7'-0" OF THE BACK OF TRAFFIC BARRIERS, NOR WITHIN 5'-0" OF THE CENTERLINE OF UNDERGROUND UTILITY LINES.
5. NO TREE OR SHRUB PLANTING PITS ARE TO BE LEFT OPEN OR UNATTENDED.
6. ALL AREAS THAT ARE DISTURBED DURING CONSTRUCTION AND ARE NOT SCHEDULED TO BE PAVED OR PLANTED SHALL BE SEEDED IN ACCORDANCE WITH MDSHA STANDARD SPECIFICATIONS.
7. QUANTITIES SHOWN ARE FOR THE CONTRACTOR'S CONVENIENCE. THE PLAN SHALL GOVERN.
8. LIVE FASCINES OR ANY WOODY VEGATATION IS NOT TO BE LOCATED WITHIN 25' OF THE PRINCIPAL SPILLWAY STRUCTURE OR PERFORATED UNDERDRAIN PIPE AND OR 15' FROM THE TOE OF ANY EMBANKMENT.



MICROPOOL E.D. (P-1) INFORMATION	
HYDROLOGIC CRITERIA	WQV, Cpv PROVIDED
SWM DRAINAGE AREA	12.83 AC.
STRUCTURE CLASSIFICATION	CLASS 'A'
EMERGENCY SPILLWAY CREST ELEVATION	21.80
PERMANENT POOL ELEV.	19.10
STORM FREQUENCY	2 YR- 22.05
10 YEAR ELEV.	23.41
100 YEAR ELEV.	24.75
TOP OF DAM	27.00



VICINITY MAP
NOT TO SCALE

NOTES:

1. MAINTENANCE OF TRAFFIC SHALL CONFORM TO STD. No. 104.05-01 FOR SHOULDER WORK, EXP.- FREEWAY GREATER THAN 40 MPH.

HUMAN & ROHDE, INC.
LANDSCAPE ARCHITECTS
512 VIRGINIA AVENUE
TOWSON, MARYLAND 21286
410 825 3885

SHA
STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION
HIGHWAY HYDRAULICS DIVISION

FUNCTIONAL ENHANCEMENT OF SWM FACILITIES ALONG US-50 ANNE ARUNDEL COUNTY

REVISIONS

BMP# 2481 - LANDSCAPE PLAN - MICROPOOL E.D. (P-1)

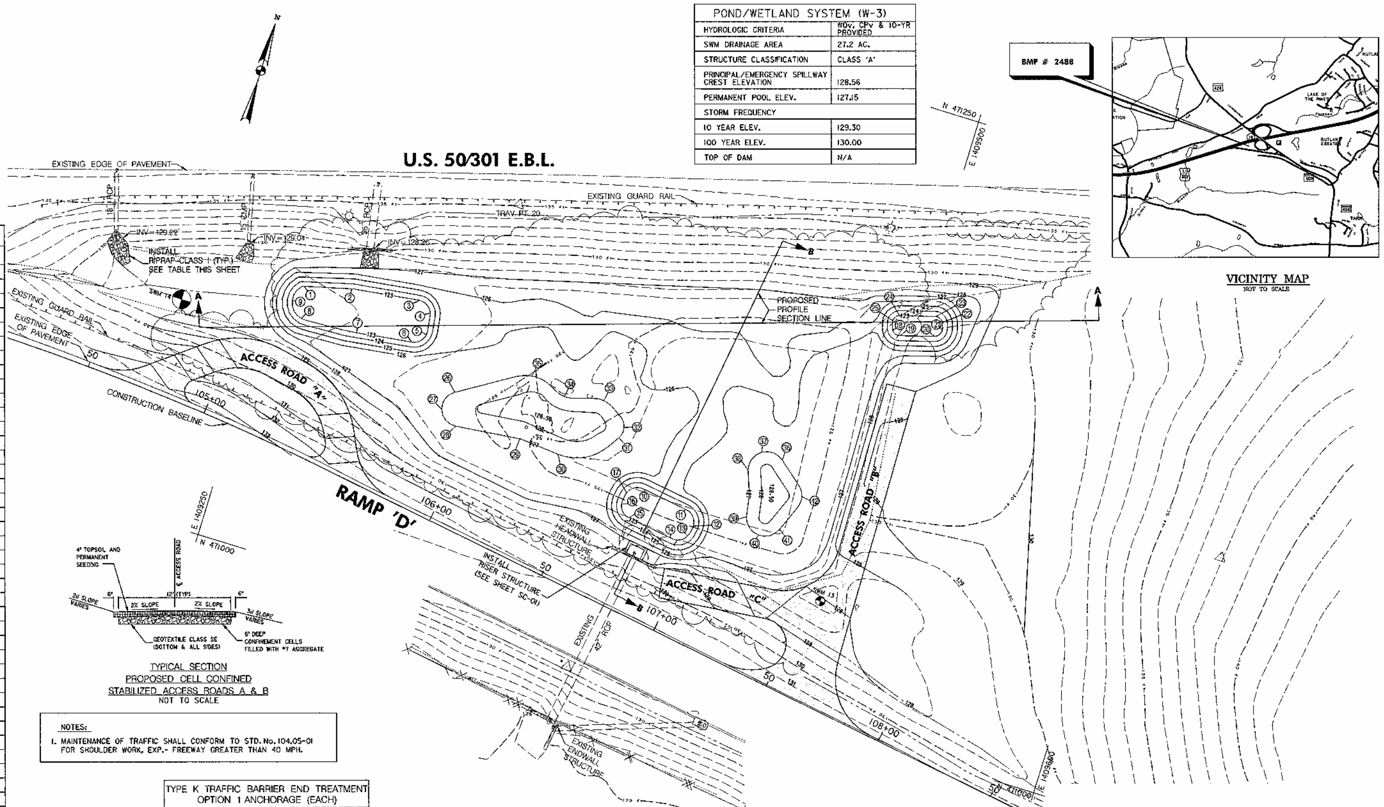
SCALE 1"-30' DATE 8-10-06 CONTRACT NO.

DESIGNED BY
DRAWN BY
CHECKED BY
F.A.P. NO.
COUNTY ANNE ARUNDEL
LOGMILE
HORIZONTAL SCALE
VERTICAL SCALE

DRAWING NO. LS-01 OF 01
SHEET NO. 13 OF 32
AASCD 8 17

PLOTTED: MONDAY, AUGUST 14, 2006 AT 11:25 AM
FILE: G:\PROJECTS-NEW\SHA PROJECTS\RT. 50 SWM\LANDSCAPE- BMP2481\2481-LANDSCAPE.DGN

BY: SALLY



COORDINATES FOR BMP # 2273		
POINT #	STATION	OFFSET FROM ℄
1	STA. 105+15.95	62.70' LT
2	STA. 105+32.63	69.83' LT
3	STA. 105+57.16	77.35' LT
4	STA. 105+63.73	80.99' LT
5	STA. 105+66.06	80.99' LT
6	STA. 105+61.61	61.08' LT
7	STA. 105+41.38	54.61' LT
8	STA. 105+19.90	50.62' LT
9	STA. 105+13.99	55.52' LT
10	STA. 106+71.89	49.21 ' LT
11	STA. 106+90.25	48.77' LT
12	STA. 105+95.78	44.70' LT
13	STA. 105+95.46	39.97' LT
14	STA. 105+89.45	36.37' LT
15	STA. 105+71.87	37.35' LT
16	STA. 105+66.13	39.94' LT
17	STA. 105+65.80	43.64' LT
18	STA. 107+32.74	150.32' LT
19	STA. 107+36.53	149.64' LT
20	STA. 107+48.99	155.44' LT
21	STA. 107+50.42	159.40' LT
22	STA. 107+49.28	161.70' LT
23	STA. 107+36.53	156.65' LT
24	STA. 107+32.66	156.65' LT
25	STA. 107+31.12	153.67' LT
26	STA. 105+88.99	50.56' LT
27	STA. 105+86.91	41.98' LT
28	STA. 105+94.73	38.47' LT
29	STA. 106+18.07	45.20' LT
30	STA. 106+34.56	46.45' LT
31	STA. 106+53.50	63.04' LT
32	STA. 106+53.61	67.63' LT
33	STA. 106+41.60	73.86' LT
34	STA. 106+26.60	68.37' LT
35	STA. 106+11.36	70.06' LT
36	STA. 107+16.16	83.95' LT
37	STA. 107+07.35	84.32' LT
38	STA. 107+05.51	74.41' LT
39	STA. 107+13.19	57.30' LT
40	STA. 107+20.77	52.91' LT
41	STA. 107+27.34	58.69' LT
42	STA. 107+29.48	74.41' LT

POND/WETLAND SYSTEM (W-3)	
HYDROLOGIC CRITERIA	WQv, CPv & 10-YR PROVIDED
SWM DRAINAGE AREA	27.2 AC.
STRUCTURE CLASSIFICATION	CLASS 'A'
PRINCIPAL/EMERGENCY SPILLWAY CREST ELEVATION	128.56
PERMANENT POOL ELEV.	127.15
STORM FREQUENCY	
10 YEAR ELEV.	129.30
100 YEAR ELEV.	130.00
TOP OF DAM	N/A

NOTES:

1. MAINTENANCE OF TRAFFIC SHALL CONFORM TO STD. No. 104.05-01 FOR SHOULDER WORK, EXP.- FREEWAY GREATER THAN 40 MPH.

TYPE K TRAFFIC BARRIER END TREATMENT OPTION 1 ANCHORAGE (EACH)		
FROM, OFFSET	STANDARD	QUANTITY
STA. 104+75, 13' LT	MD 605.10	1
STA. 104+93, 13' LT	MD 605.10	1
STA. 105+46, 13' LT	MD 605.10	1
STA. 105+61, 13' LT	MD 605.10	1

CLASS I RIPRAP (SY)		
STATION	OFFSET	QUANTITY
104+45	49' LT.	9
104+92	65' LT.	4
105+34	83' LT.	5
106+80	26' LT.	5

REMOVE EXISTING GUARD RAIL (LF)		
FROM, OFSET	TO, OFFSET	QUANTITY
STA. 104+75, 13' LT	STA. 104+93, 13' LT	18
STA. 105+46, 13' LT	STA. 105+61, 13' LT	18

STRUCTURE SCHEDULE										
STRUCTURE	STATION	OFFSET FROM ℄	TYPE	ELEVATION					STANDARD NO.	REMARKS
				TOP	INV. OUT	INV. IN	INV. IN	INV. IN		
W-1	106+80	62	WIER WALL	128.58	127.15	127.15				

Dewberry
Dewberry & Davis LLC

CROSS REFERENCE	R/W PLAT NUMBER	REVISIONS
ITEM / SHEET NOs.		
TYPICAL SHEETS SUPERELEVATION SHEETS PIPE & DRAINAGE SCHEDULE GEOMETRIC LAYOUT SHEETS ROADWAY PLAN SHEETS ROADWAY PROFILE SHEETS TRAFFIC CONTROL SHEETS EROSION & SEDIMENT CONTROL SIGNING & MARKING PLANS LANDSCAPE PLAN SHEETS UTILITIES		

SHA
STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION
HIGHWAY HYDRAULICS DIVISION

FUNCTIONAL ENHANCEMENT OF SWM FACILITIES ALONG US-50 ANNE ARUNDEL COUNTY

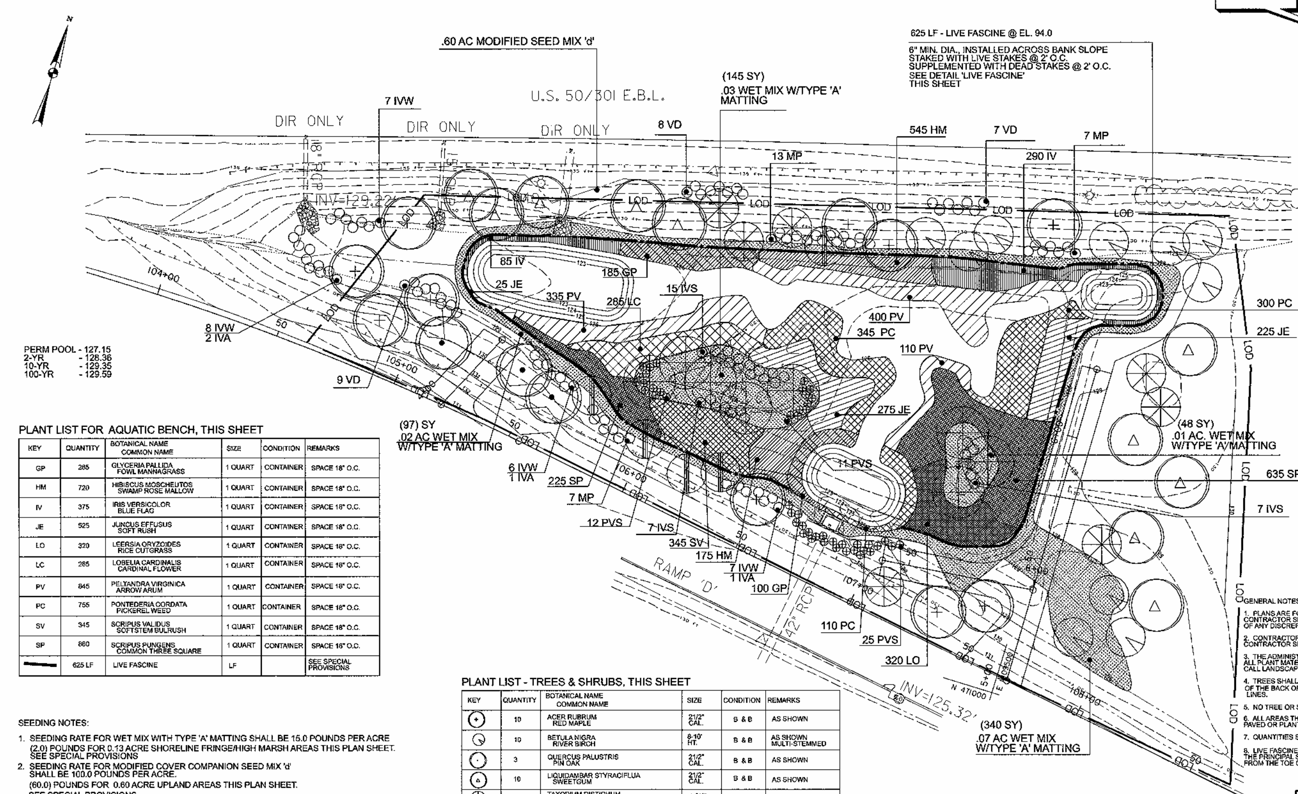
BMP # 2488 – STORMWATER MANAGEMENT PLAN – POND/WETLAND SYSTEM (W-3)

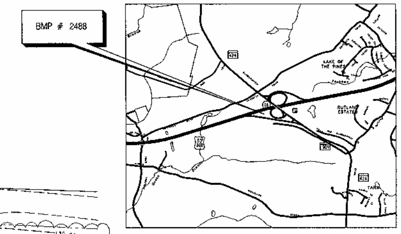
SCALE 1" = 20' DATE 08/14/2006 CONTRACT NO. AA4195174

DESIGNED BY MDW
DRAWN BY MDW
CHECKED BY RSK
F.A.P. NO.
COUNTY ANNE ARUNDEL
LOGMILE

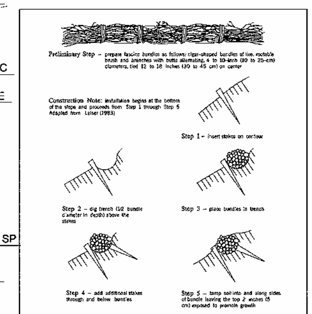
DRAWING NO. SW - 01 OF 01 SHEET NO. 15 OF 32

PLOTTED: SATURDAY, AUGUST 12, 2006 AT 02:01 PM





VICINITY MAP
NOT TO SCALE



DETAIL: LIVE FASCINES

PLANT LIST FOR AQUATIC BENCH, THIS SHEET

KEY	QUANTITY	BOTANICAL NAME COMMON NAME	SIZE	CONDITION	REMARKS
GP	285	GLYCERIA PALLIDA FOWL MANNAGRASS	1 QUART	CONTAINER	SPACE 18" O.C.
HM	720	HIBISCUS MOSCHEUTOS SWAMP ROSE MALLOW	1 QUART	CONTAINER	SPACE 18" O.C.
IV	375	IRIS VERSICOLOR BLUE FLAG	1 QUART	CONTAINER	SPACE 18" O.C.
JE	525	JUNCUS EFFUSUS SOFT RUSH	1 QUART	CONTAINER	SPACE 18" O.C.
LO	320	LEERSIA ORYZOIDES RICE CUTGRASS	1 QUART	CONTAINER	SPACE 18" O.C.
LC	285	LOBELIA CARDINALIS CARDINAL FLOWER	1 QUART	CONTAINER	SPACE 18" O.C.
PV	845	PELTANDRA VIRGINICA ARROW ARUM	1 QUART	CONTAINER	SPACE 18" O.C.
PC	755	PONTEDERIA CORDATA PICKEREL WEED	1 QUART	CONTAINER	SPACE 18" O.C.
SV	345	SCRIPUS VALIDUS SOFTSTEM BULRUSH	1 QUART	CONTAINER	SPACE 18" O.C.
SP	860	SCRIPUS PUNGENS COMMON THREE SQUARE	1 QUART	CONTAINER	SPACE 18" O.C.
———	625 LF	LIVE FASCINE	LF		SEE SPECIAL PROVISIONS

SEEDING NOTES:

1. SEEDING RATE FOR WET MIX WITH TYPE 'A' MATTING SHALL BE 15.0 POUNDS PER ACRE (2.0) POUNDS FOR 0.13 ACRE SHORELINE FRINGE/HIGH MARSH AREAS THIS PLAN SHEET. SEE SPECIAL PROVISIONS
2. SEEDING RATE FOR MODIFIED COVER COMPANION SEED MIX 'd' SHALL BE 100.0 POUNDS PER ACRE. (60.0) POUNDS FOR 0.60 ACRE UPLAND AREAS THIS PLAN SHEET. SEE SPECIAL PROVISIONS

PLANT LIST - TREES & SHRUBS, THIS SHEET

KEY	QUANTITY	BOTANICAL NAME COMMON NAME	SIZE	CONDITION	REMARKS
(symbol)	10	ACER RUBRUM RED MAPLE	21/2" CAL.	B & B	AS SHOWN
(symbol)	10	BETULA NIGRA RIVER BIRCH	8-10' HT.	B & B	AS SHOWN MULTI-STEMMED
(symbol)	3	QUERCUS PALUSTRIS PIN OAK	21/2" CAL.	B & B	AS SHOWN
(symbol)	10	LIQUIDAMBAR STYRACIFLUA SWEETGUM	21/2" CAL.	B & B	AS SHOWN
(symbol)	8	TAXODIUM DISTICHUM BALD CYPRESS	1 3/4" CAL.	B & B	AS SHOWN
(symbol)	7	AMELANCHIER CANADENSIS SERVICEBERRY	6' HT.	B & B	AS SHOWN
(symbol)	5	MAGNOLIA VIRGINIANA SWEETBAY MAGNOLIA	6' HT.	B & B	AS SHOWN
IVA	4	ILEX VERTICELLATA 'APOLLO' 'APOLLO' WINTERBERRY HOLLY	3' HT.	CONTAINER	SPACE 4' O.C.
IVW	28	ILEX VERTICELLATA 'WINTER RED' 'WINTER RED' WINTERBERRY HOLLY	3' HT.	CONTAINER	SPACE 4' O.C.
MP	27	MYRICA PENSYLVANICA NORTHERN BAYBERRY	3' HT.	CONTAINER	SPACE 4' O.C.
IVS	29	ITEA VIRGINICA SWEETSPIRE	3' HT.	CONTAINER	SPACE 4' O.C.
VD	24	VIBURNUM DENTATUM ARROWWOOD	3' HT.	CONTAINER	SPACE 4' O.C.
PVS	48	PANICUM VIRGATUM SWITCH GRASS		CONTAINER	SPACE 3' O.C.

GENERAL NOTES:

1. PLANS ARE FOR LANDSCAPE PURPOSES ONLY. AS BUILT ROADWAY CONDITIONS MAY VARY. CONTRACTOR SHALL VERIFY CONDITIONS AND UTILITY LOCATIONS AND INFORM THE ENGINEER OF ANY DISCREPANCIES OR POTENTIAL PROBLEMS PRIOR TO PERFORMING THE WORK.
2. CONTRACTOR SHALL VERIFY LOCATIONS OF EXISTING UTILITIES PRIOR TO PLANT INSTALLATION. CONTRACTOR SHALL NOTIFY MISS UTILITY A MINIMUM OF 72 HOURS PRIOR TO DIGGING.
3. THE ADMINISTRATION IS TO BE NOTIFIED 48 HOURS BEFORE PLANTING BEGINS. THE LOCATION OF ALL PLANT MATERIAL IS TO BE APPROVED IN THE FIELD BY SHA LANDSCAPE OPERATIONS. CALL LANDSCAPE OPERATIONS AT 410-545-8590.
4. TREES SHALL NOT BE PLANTED WITHIN 7'-0" OF THE CENTERLINE OF SWALES, NOR WITHIN 7'-0" OF THE BACK OF TRAFFIC BARRIERS, NOR WITHIN 5'-0" OF THE CENTERLINE OF UNDERGROUND UTILITY LINES.
5. NO TREE OR SHRUB PLANTING PITS ARE TO BE LEFT OPEN OR UNATTENDED.
6. ALL AREAS THAT ARE DISTURBED DURING CONSTRUCTION AND ARE NOT SCHEDULED TO BE PAVED OR PLANTED SHALL BE SEEDED IN ACCORDANCE WITH MDSHA STANDARD SPECIFICATIONS.
7. QUANTITIES SHOWN ARE FOR THE CONTRACTOR'S CONVENIENCE. THE PLAN SHALL GOVERN.
8. LIVE FASCINES OR ANY WOODY VEGATATION IS NOT TO BE LOCATED WITHIN 25' OF THE PRINCIPAL SPILLWAY STRUCTURE OR PERFORATED UNDERDRAIN PIPE AND OR 15' FROM THE TOE OF ANY EMBANKMENT.

HUMAN & ROHDE, INC.
LANDSCAPE ARCHITECTS
512 VIRGINIA AVENUE
TOWSON, MARYLAND 21286
410 825 3885

BY: SALLY

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION
HIGHWAY HYDRAULICS DIVISION

REVISIONS

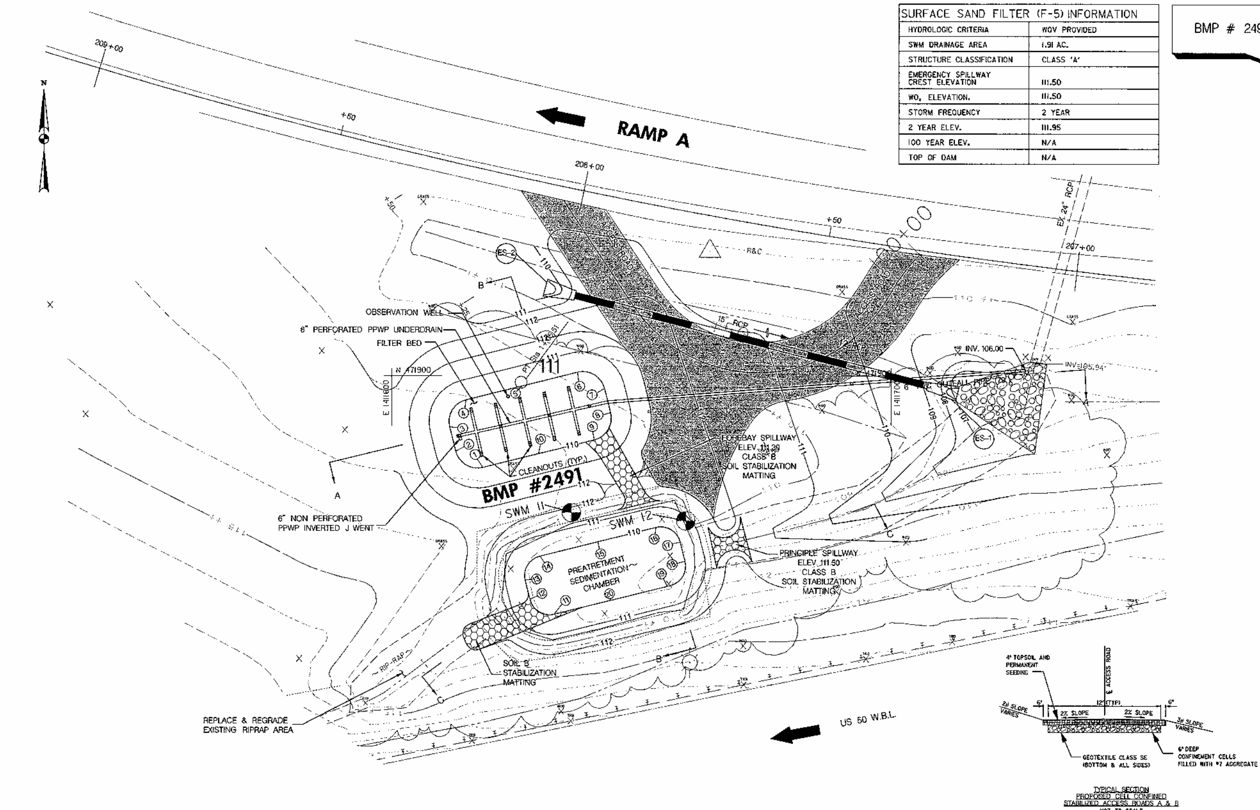
BMP # 2488 - LANDSCAPE PLAN - WETLAND SYSTEM (W-3)

SCALE 1" = 20' DATE 8-10-06 CONTRACT NO.

DESIGNED BY / COUNTY
DRAWN BY / LOGMILE
CHECKED BY / HORIZONTAL SCALE
F.A.P. NO. / VERTICAL SCALE

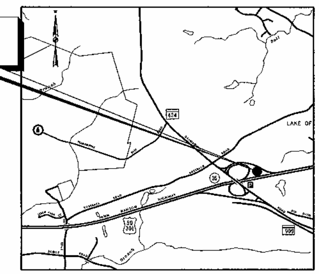
DRAWING NO. LS - 01 OF 01 SHEET NO. 18 OF 32

PLOTTED: MONDAY, AUGUST 14, 2006 AT 11:24 AM
FILE: D:\PROJECTS-NEW\SHA PROJECTS\RT. 50 SWM\LANDSCAPE- BMP2488\2488-LANDSCAPE.DGN



SURFACE SAND FILTER (F-5) INFORMATION	
HYDROLOGIC CRITERIA	WQV PROVIDED
SWM DRAINAGE AREA	1.91 AC.
STRUCTURE CLASSIFICATION	CLASS 'A'
EMERGENCY SPILLWAY CREST ELEVATION	111.50
WQv ELEVATION.	111.50
STORM FREQUENCY	2 YEAR
2 YEAR ELEV.	111.95
100 YEAR ELEV.	N/A
TOP OF DAM	N/A

BMP # 2491



VICINITY MAP (N.T.S.)

COORDINATES FOR BMP # 2273		
POINT #	STATION	OFFSET FROM ℄
1	STA. 208+08.62	58.41' LT
2	STA. 208+14.62	56.35' LT
3	STA. 208+51.87	51.87' LT
4	STA. 208+14.67	45.84' LT
5	STA. 208+04.30	40.79' LT
6	STA. 207+96.86	35.82' LT
7	STA. 207+91.06	37.98' LT
8	STA. 207+89.28	42.51' LT
9	STA. 207+91.89	48.49' LT
10	STA. 208+01.74	53.41' LT
11	STA. 207+95.71	64.32' LT
12	STA. 208+05.93	82.32' LT
13	STA. 208+04.21	78.71' LT
14	STA. 207+99.92	73.44' LT
15	STA. 207+88.75	68.33' LT
16	STA. 207+77.51	63.37' LT
17	STA. 207+72.36	65.39' LT
18	STA. 207+70.95	69.05' LT
19	STA. 207+73.91	74.59' LT
20	STA. 207+84.80	79.37' LT

STRUCTURE SCHEDULE

STRUCTURE NO.	STATION	OFFSET FROM ℄	TYPE	ELEVATION			STANDARD NO.	REMARKS
				TOP	INV. IN	INV. OUT		
ES-1	208+00	20.50' LT	END SECTION	-	109.85		-	
ES-2	207+20	26.50 LT	END SECTION	-		107.00	-	

PIPE SCHEDULE

PIPE	LENGTH	INV. IN	INV. OUT	PIPE SIZE
ES-1 to ES-2	73	109.65	107.20	15" RCP CLASS IV

NOTES:

1. MAINTENANCE OF TRAFFIC SHALL CONFORM TO STD. No. 104.05-01 FOR SHOULDER WORK, EXP.- FREEWAY GREATER THAN 40 MPH.

Dewberry
Dewberry & Davis LLC

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION
HIGHWAY HYDRAULICS DIVISION

FUNCTIONAL ENHANCEMENT OF SWM FACILITIES ALONG US-50 ANNE ARUNDEL COUNTY

CROSS REFERENCE		R/W PLAT NUMBER	REVISIONS
ITEM	SHEET NOs.		
TYPICAL SHEETS			
SUPERELEVATION SHEETS			
PIPE & DRAINAGE SCHEDULE			
GEOMETRIC LAYOUT SHEETS			
ROADWAY PLAN SHEETS			
ROADWAY PROFILE SHEETS			
TRAFFIC CONTROL SHEETS			
EROSION & SEDIMENT CONTROL			
SIGNING & MARKING PLANS			
LANDSCAPE PLAN SHEETS			
UTILITIES			

BMP #2491 STORMWATER MANAGEMENT PLAN (POCKET SAND FILTER F-5)

SCALE 1" = 10' DATE 08/14/2006 CONTRACT NO. AA4195174

DESIGNED BY D. MOBLEY COUNTY ANNE ARUNDEL
DRAWN BY D. MOBLEY LOGMILE <MILE1> <MILE2>
CHECKED BY <CHECKED BY>
F.A.P. NO.

DRAWING NO. SW-01 OF 01 SHEET NO. 20 OF 32

PLOTTED: SATURDAY, AUGUST 12, 2006 AT 02:03 PM
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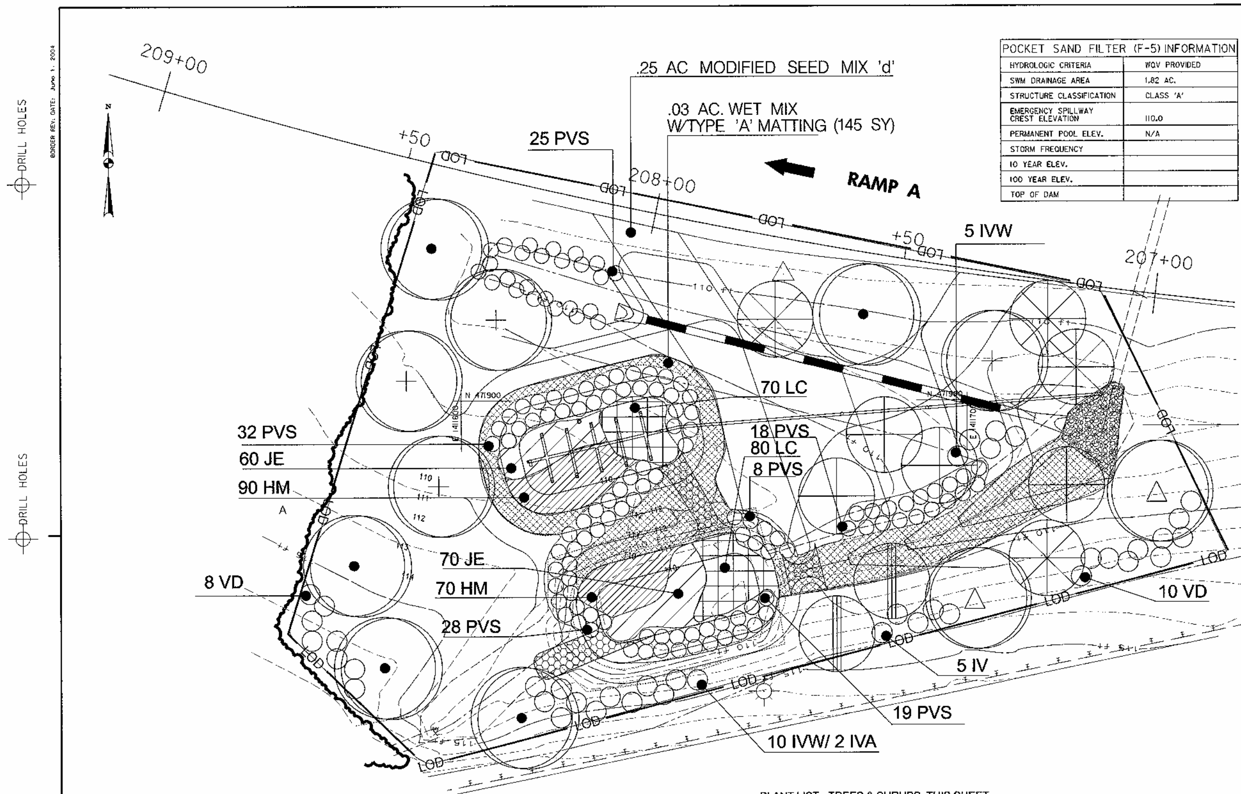
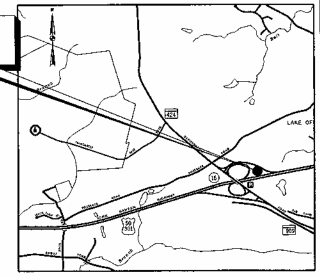


POCKET SAND FILTER (F-5) INFORMATION	
HYDROLOGIC CRITERIA	WQV PROVIDED
SWM DRAINAGE AREA	1.82 AC.
STRUCTURE CLASSIFICATION	CLASS 'A'
EMERGENCY SPILLWAY CREST ELEVATION	110.0
PERMANENT POOL ELEV.	N/A
STORM FREQUENCY	
10 YEAR ELEV.	
100 YEAR ELEV.	
TOP OF DAM	

BMP # 2491



VICINITY MAP (N.T.S.)

GENERAL NOTES:

1. PLANS ARE FOR LANDSCAPE PURPOSES ONLY. AS BUILT ROADWAY CONDITIONS MAY VARY. CONTRACTOR SHALL VERIFY CONDITIONS AND UTILITY LOCATIONS AND INFORM THE ENGINEER OF ANY DISCREPANCIES OR POTENTIAL PROBLEMS PRIOR TO PERFORMING THE WORK.
2. CONTRACTOR SHALL VERIFY LOCATIONS OF EXISTING UTILITIES PRIOR TO PLANT INSTALLATION. CONTRACTOR SHALL NOTIFY MISS UTILITY A MINIMUM OF 72 HOURS PRIOR TO DIGGING.
3. THE ADMINISTRATION IS TO BE NOTIFIED 48 HOURS BEFORE PLANTING BEGINS. THE LOCATION OF ALL PLANT MATERIAL IS TO BE APPROVED IN THE FIELD BY SHA LANDSCAPE OPERATIONS. CALL LANDSCAPE OPERATIONS AT 410-545-8590.
4. TREES SHALL NOT BE PLANTED WITHIN 7'-0" OF THE CENTERLINE OF SWALES, NOR WITHIN 7'-0" OF THE BACK OF TRAFFIC BARRIERS, NOR WITHIN 5'-0" OF THE CENTERLINE OF UNDERGROUND UTILITY LINES.
5. NO TREE OR SHRUB PLANTING PITS ARE TO BE LEFT OPEN OR UNATTENDED.
6. ALL AREAS THAT ARE DISTURBED DURING CONSTRUCTION AND ARE NOT SCHEDULED TO BE PAVED OR PLANTED SHALL BE SEEDED IN ACCORDANCE WITH MDSHA STANDARD SPECIFICATIONS.
7. QUANTITIES SHOWN ARE FOR THE CONTRACTOR'S CONVENIENCE. THE PLAN SHALL GOVERN.
8. LIVE FASCINES OR ANY WOODY VEGATATION IS NOT TO BE LOCATED WITHIN 25' OF THE PRINCIPAL SPILLWAY STRUCTURE OR PERFORATED UNDERDRAIN PIPE AND OR 15' FROM THE TOE OF ANY EMBANKMENT.

PLANT LIST FOR AQUATIC BENCH, THIS SHEET

KEY	QUANTITY	BOTANICAL NAME / COMMON NAME	SIZE	CONDITION	REMARKS
HM	160	HIBISCUS MOSCHEUTOS / SWAMP ROSE MALLOW	1 QUART	CONTAINER	SPACE 18" O.C.
JE	130	JUNCUS EFFUSUS / SOFT RUSH	1 QUART	CONTAINER	SPACE 18" O.C.
LC	150	LOBELIA CARDINALIS / CARDINAL FLOWER	1 QUART	CONTAINER	SPACE 18" O.C.

SEEDING NOTES:

1. SEEDING RATE FOR WET MIX WITH TYPE 'A' MATTING SHALL BE 15.0 POUNDS PER ACRE. (0.5) POUNDS FOR 0.03 ACRE SHORELINE FRINGE/HIGH MARSH AREA THIS PLAN SHEET. SEE SPECIAL PROVISIONS
2. SEEDING RATE FOR MODIFIED COVER COMPANION SEED MIX 'd' SHALL BE 100.0 POUNDS PER ACRE. (25.0) POUNDS FOR 0.25 ACRE UPLAND AREAS THIS PLAN SHEET. SEE SPECIAL PROVISIONS

PLANT LIST - TREES & SHRUBS, THIS SHEET

KEY	QUANTITY	BOTANICAL NAME / COMMON NAME	SIZE	CONDITION	REMARKS
	4	ACER RUBRUM / RED MAPLE	21/2" CAL.	B & B	AS SHOWN
	2	LIQUIDAMBAR STYRACIFLUA / SWEETGUM	21/2" CAL.	B & B	AS SHOWN
	4	BETULA NIGRA / RIVER BIRCH	8-10' HT.	B & B	AS SHOWN MULTI-STEMMED
	5	QUERCUS PALUSTRIS / PIN OAK	21/2" CAL.	B & B	AS SHOWN
	4	AMELANCHIER CANADENSIS / SERVICEBERRY	6' HT.	B & B	AS SHOWN
	2	MAGNOLIA VIRGINIANA / SWEETBAY MAGNOLIA	6' HT.	B & B	
IVA	2	ILEX VERTICELLATA 'APOLLO' / 'APOLLO' WINTERBERRY HOLLY	3' HT.	CONTAINER	SPACE 4' O.C.
IVW	15	ILEX VERTICELLATA 'WINTER RED' / 'WINTER RED' WINTERBERRY HOLLY	3' HT.	CONTAINER	SPACE 4' O.C.
IVS	5	ITEA VIRGINICA / SWEETSPIRE	3' HT.	CONTAINER	SPACE 4' O.C.
VD	18	VIBURNUM DENTATUM / ARROWWOOD	3' HT.	CONTAINER	SPACE 4' O.C.
PVS	105	PANICUM VIRGATUM / SWITCH GRASS	GAL.	CONTAINER	SPACE 3' O.C.

HUMAN & ROHDE, INC.
LANDSCAPE ARCHITECTS
512 VIRGINIA AVENUE
TOWSON, MARYLAND 21286
410 825 3885

SHA
STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION
HIGHWAY HYDRAULICS DIVISION

REVISIONS

BMP #2491 LANDSCAPE PLAN (POCKET SAND FILTER F-5)

SCALE 10' DATE 8-10-06 CONTRACT NO.

DESIGNED BY D. MOBLEY COUNTY
DRAWN BY D. MOBLEY LOGMILE <MILE1> <MILE2>
CHECKED BY <CHECKED BY>
F.A.P. NO.

DRAWING NO. LS -01 OF 01 SHEET NO. 23 OF 32

APPENDIX A:

Source ID Examples

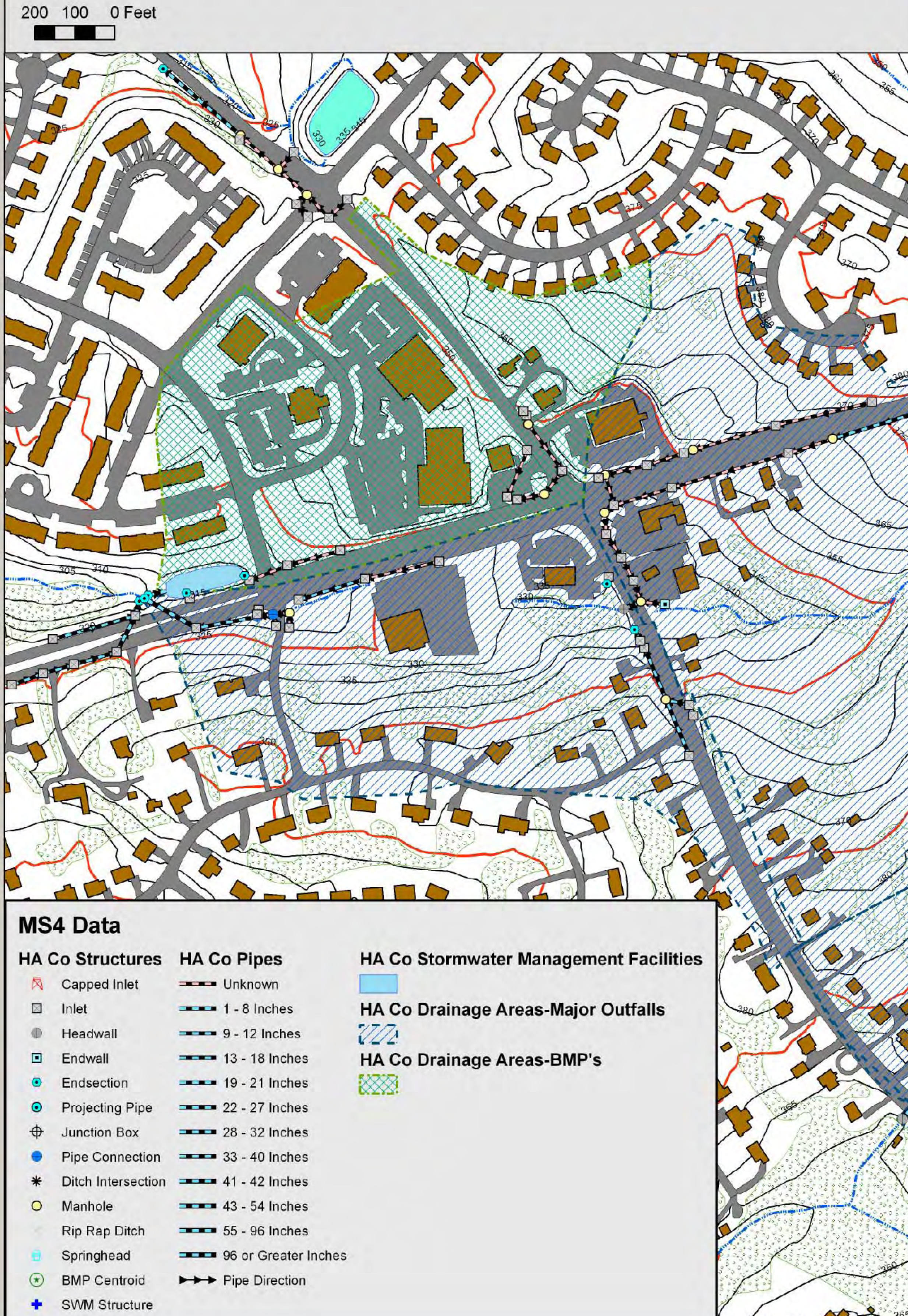
Harford County

Frederick County

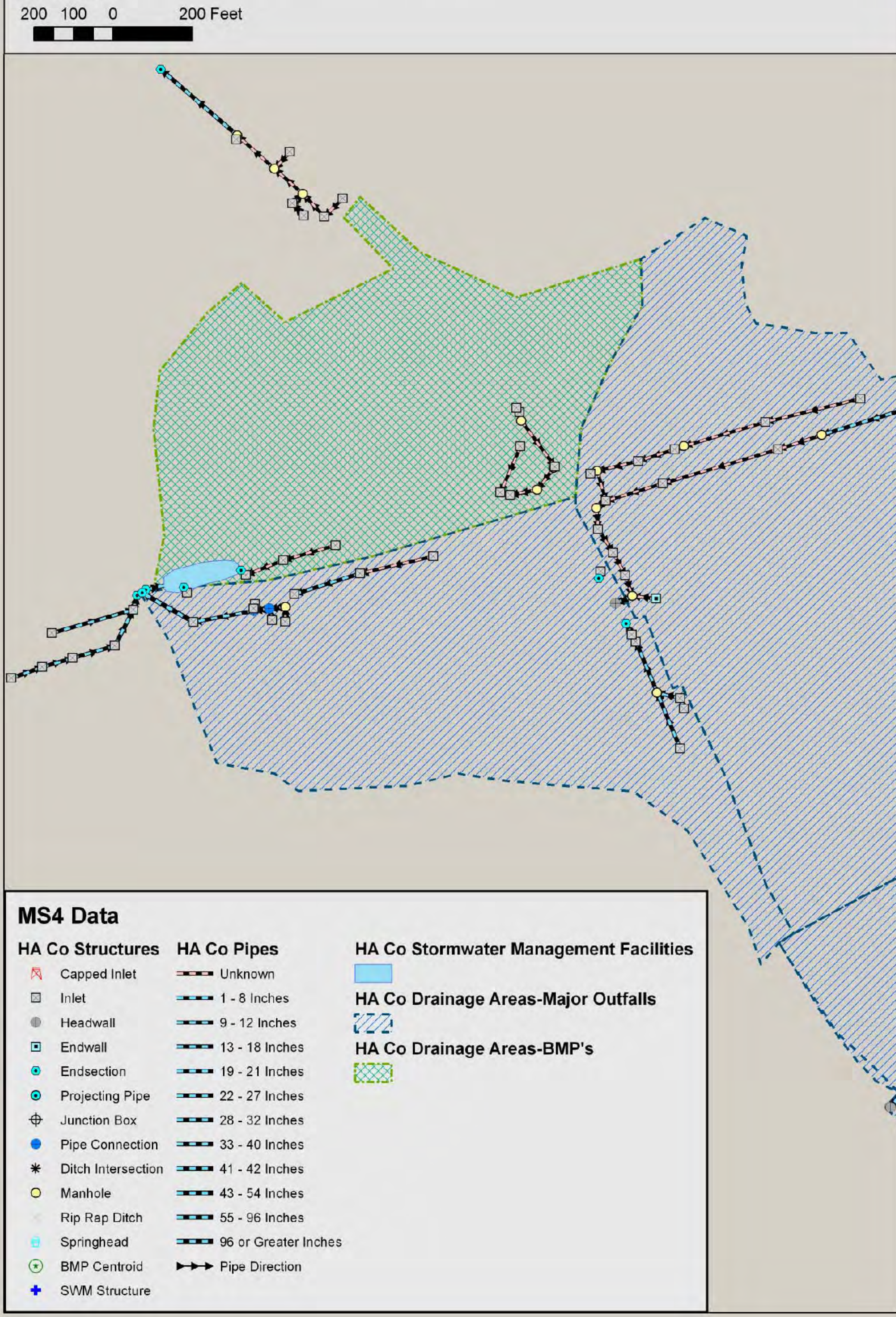
Howard County

Montgomery County

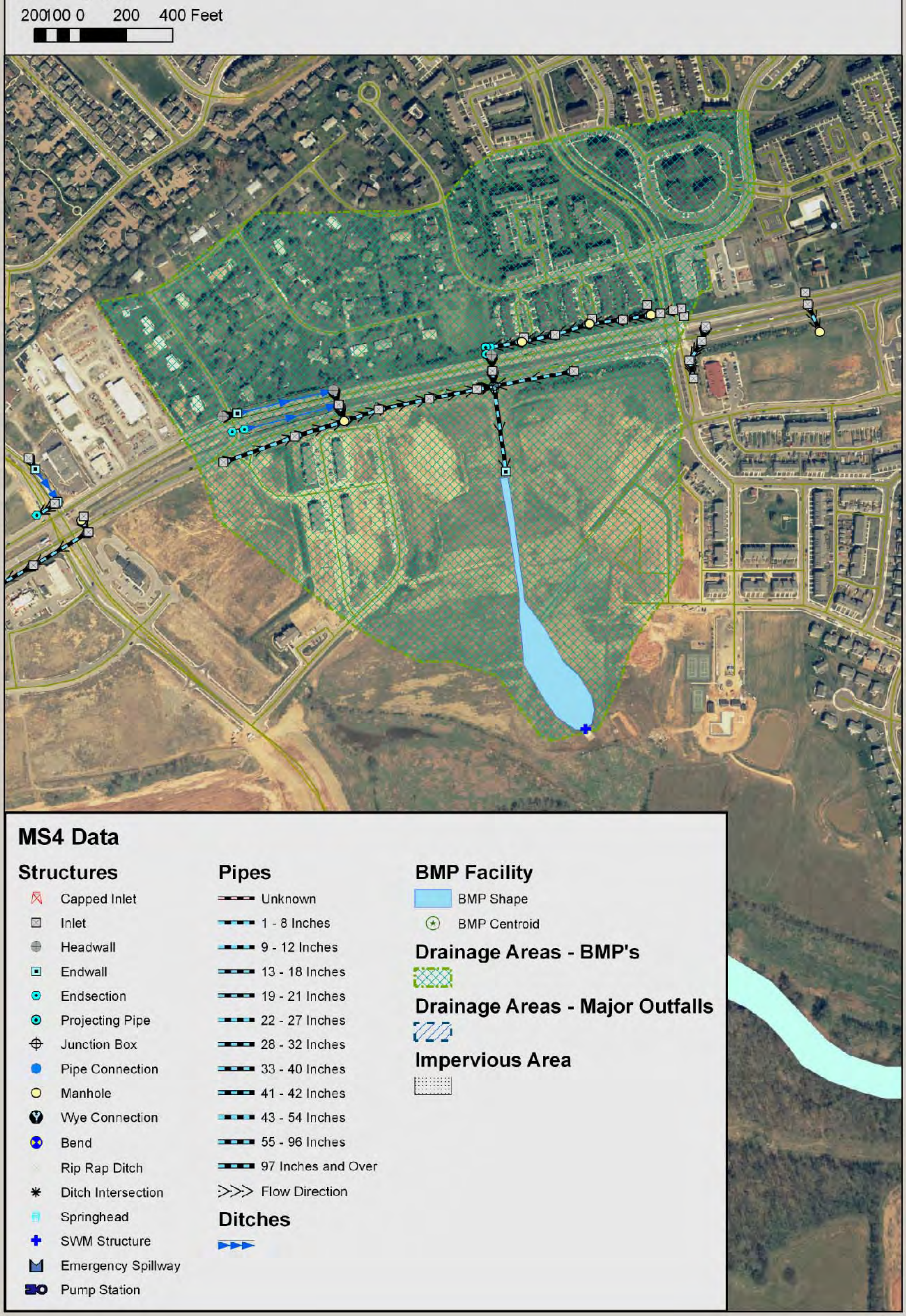
MD SHA Harford County MS4
Data Sampling October 2006
MD 22



MD SHA Harford County MS4
Data Sampling October 2006
MD 22



MD SHA Frederick County MS4
Data Sampling October 2006
MD 355



MS4 Data

Structures
- Capped Inlet
- Inlet
- Headwall
- Endwall
- Endsection
- Projecting Pipe
- Junction Box
- Pipe Connection
- Manhole
- Wye Connection
- Bend
- Rip Rap Ditch
- Ditch Intersection
- Springhead
- SWM Structure
- Emergency Spillway
- Pump Station

Pipes
- Unknown
- 1 - 8 Inches
- 9 - 12 Inches
- 13 - 18 Inches
- 19 - 21 Inches
- 22 - 27 Inches
- 28 - 32 Inches
- 33 - 40 Inches
- 41 - 42 Inches
- 43 - 54 Inches
- 55 - 96 Inches
- 97 Inches and Over
- >>> Flow Direction

Ditches

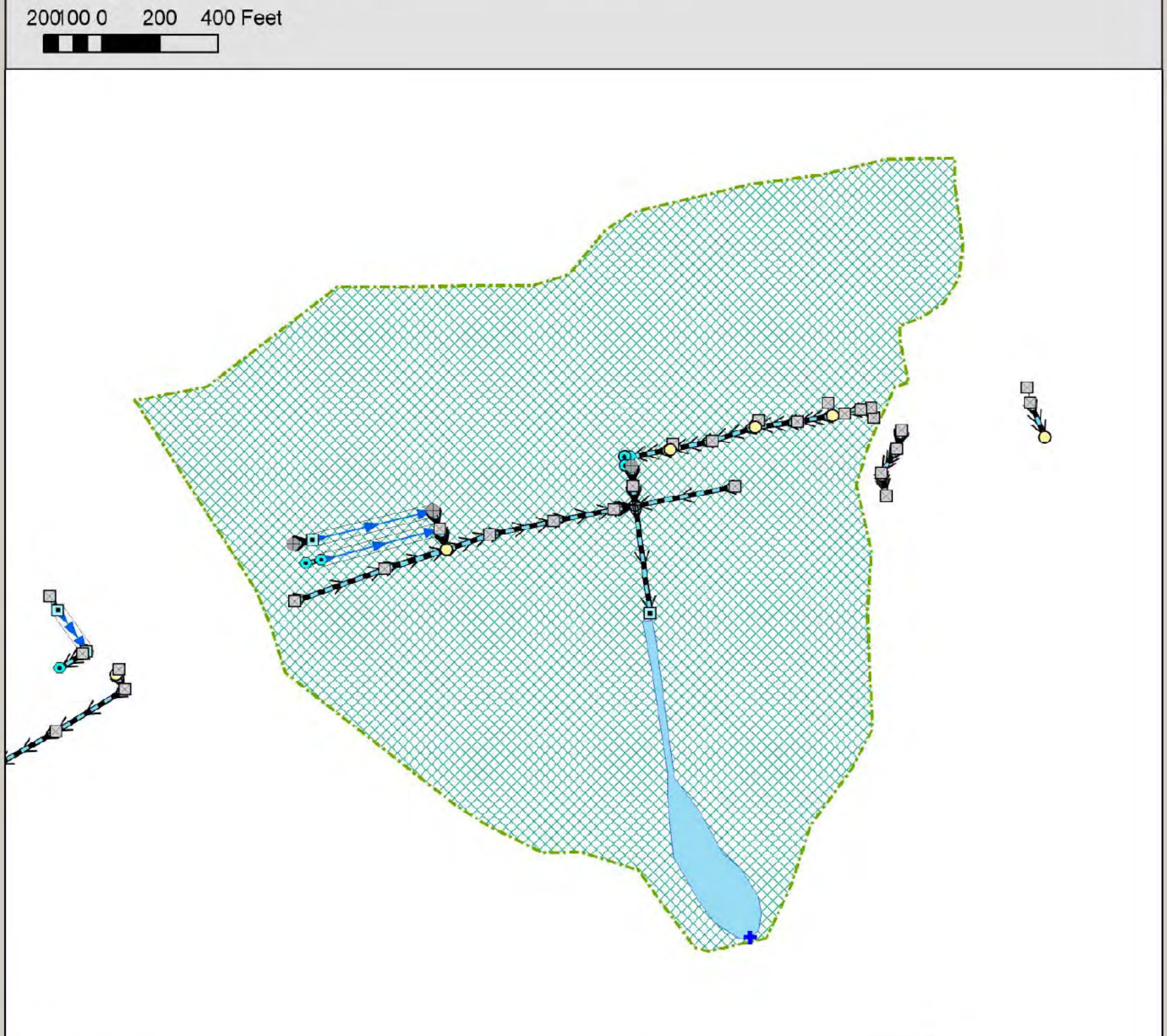
BMP Facility
- BMP Shape
- BMP Centroid

Drainage Areas - BMP's

Drainage Areas - Major Outfalls

Impervious Area

MD SHA Frederick County MS4
Data Sampling October 2006
MD 355



MS4 Data

Structures
- Capped Inlet
- Inlet
- Headwall
- Endwall
- Endsection
- Projecting Pipe
- Junction Box
- Pipe Connection
- Manhole
- Wye Connection
- Bend
- Rip Rap Ditch
- Ditch Intersection
- Springhead
- SWM Structure
- Emergency Spillway
- Pump Station

Pipes
- Unknown
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- 19 - 21 Inches
- 22 - 27 Inches
- 28 - 32 Inches
- 33 - 40 Inches
- 41 - 42 Inches
- 43 - 54 Inches
- 55 - 96 Inches
- 97 Inches and Over
- Flow Direction

Ditches

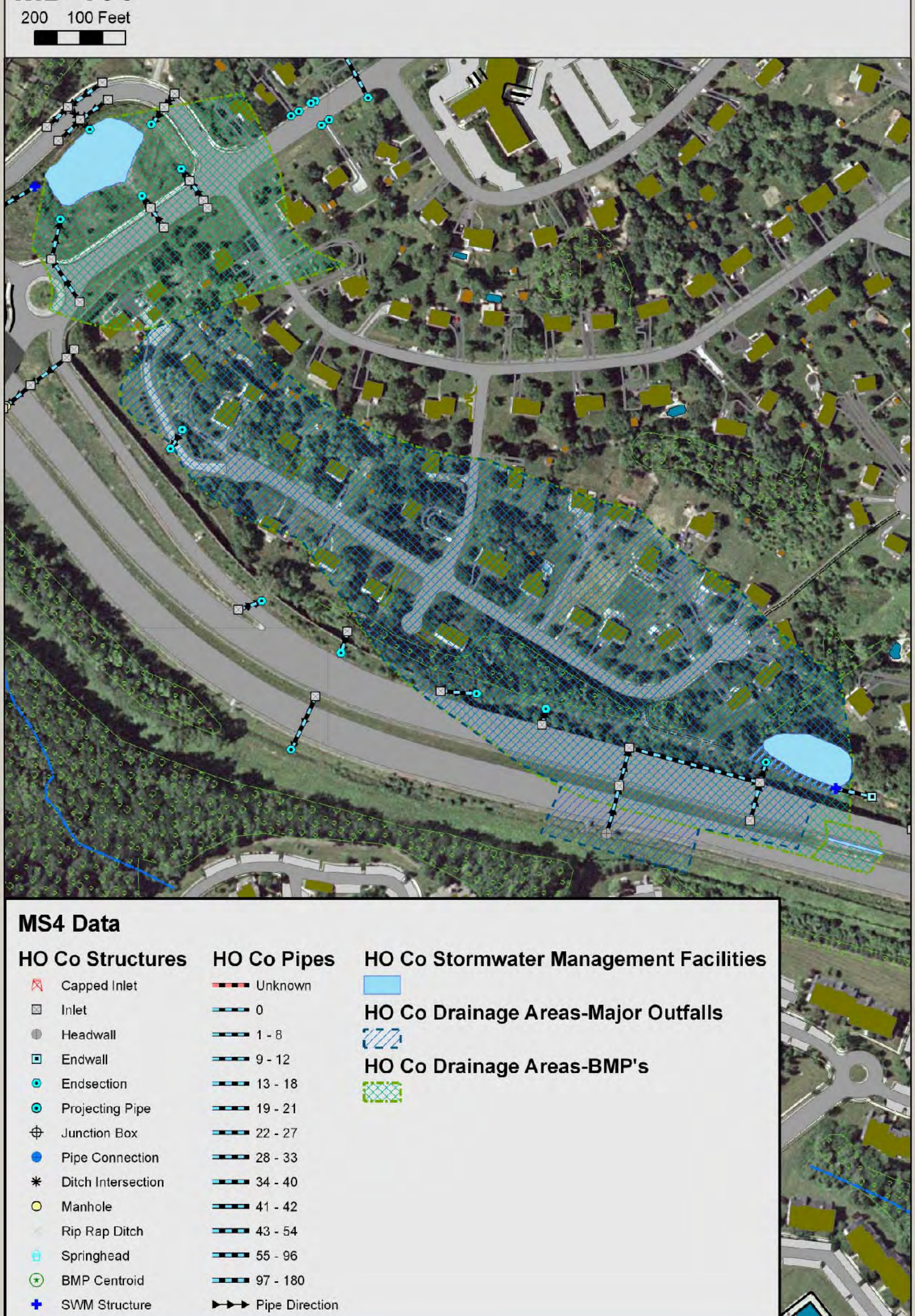
BMP Facility
- BMP Shape
- BMP Centroid

Drainage Areas - BMP's

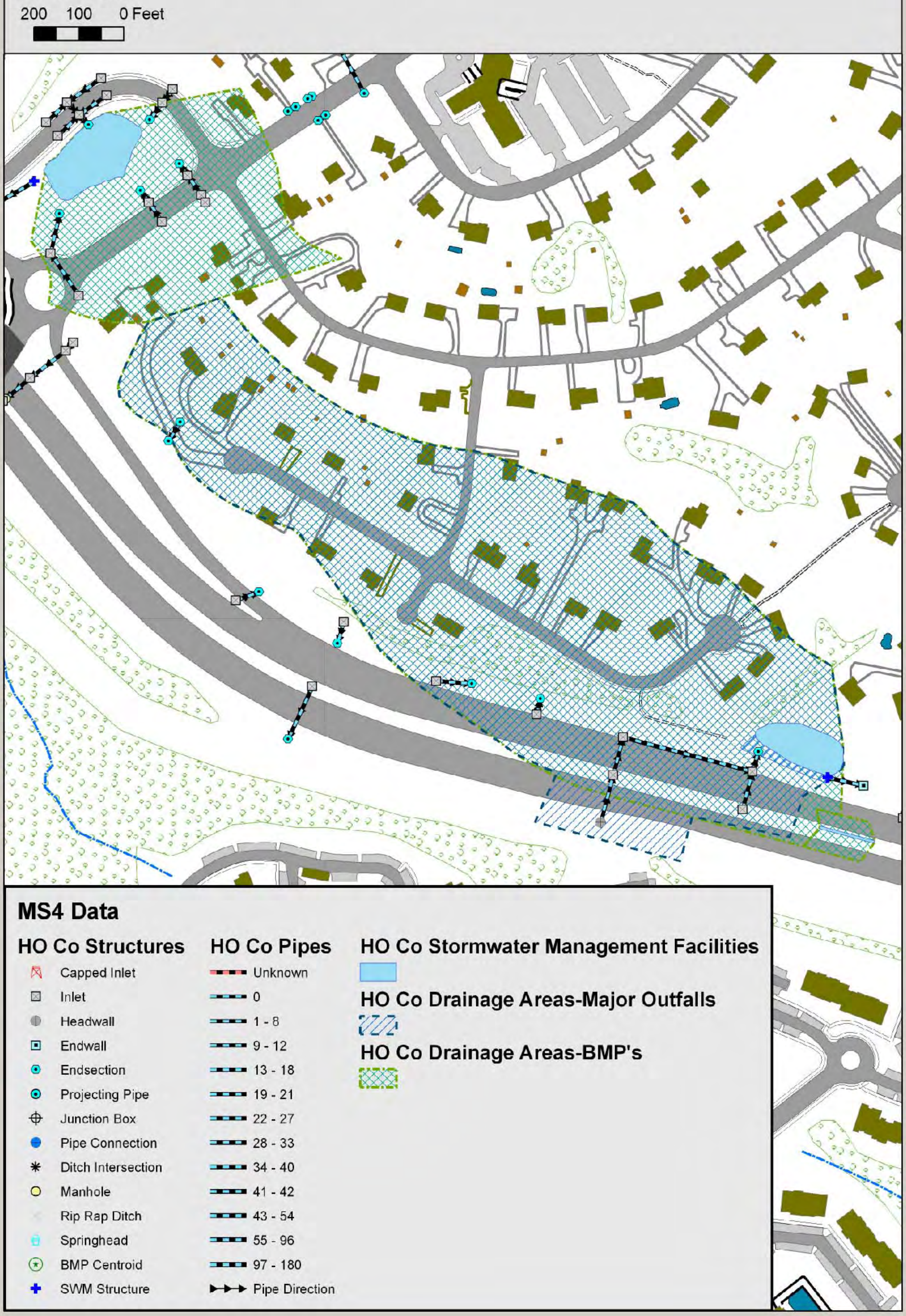
Drainage Areas - Major Outfalls

Impervious Area

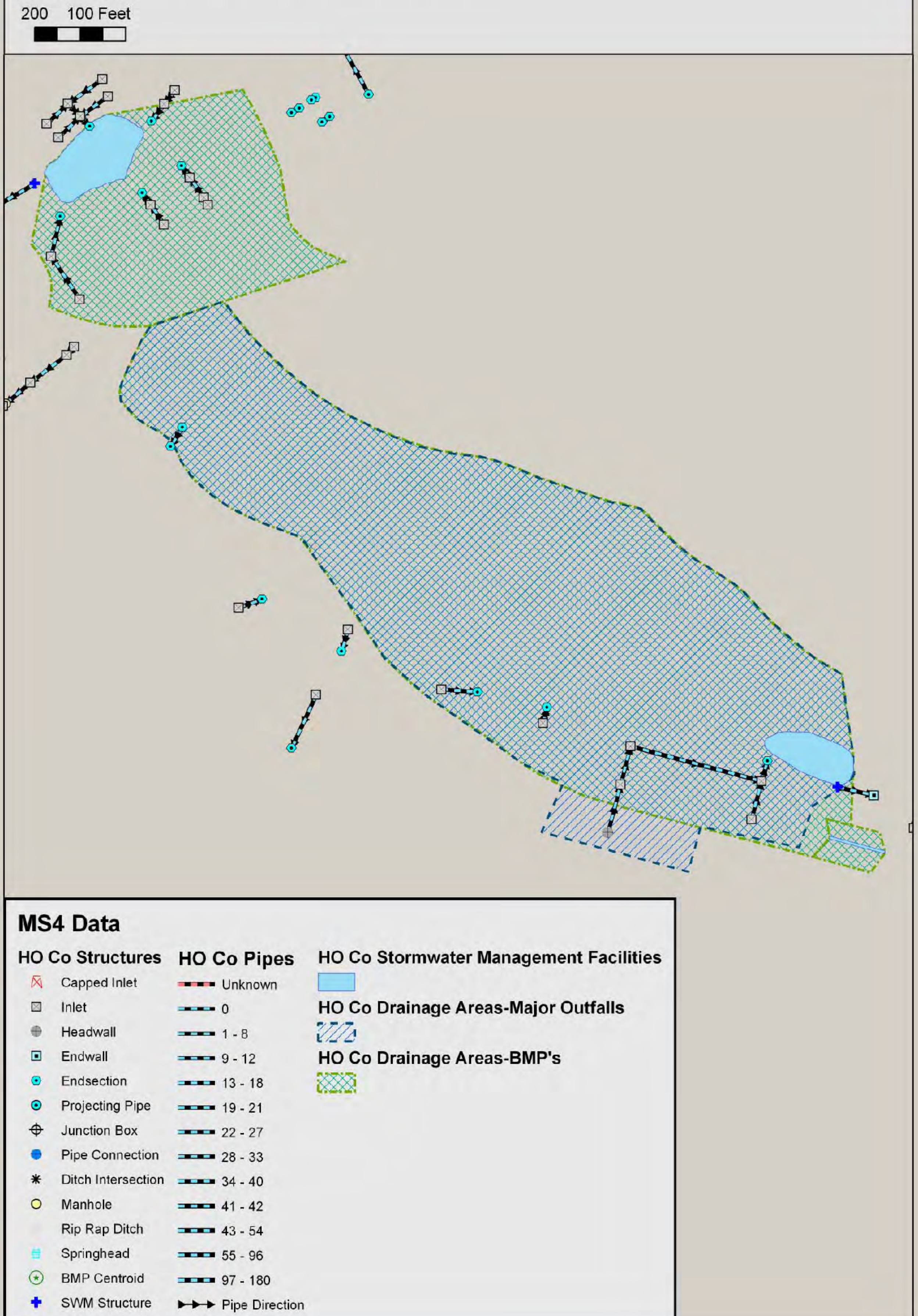
MD SHA Howard County MS4
Data Sampling October 2006
MD 100



MD SHA Howard County MS4
Data Sampling October 2006
MD 100

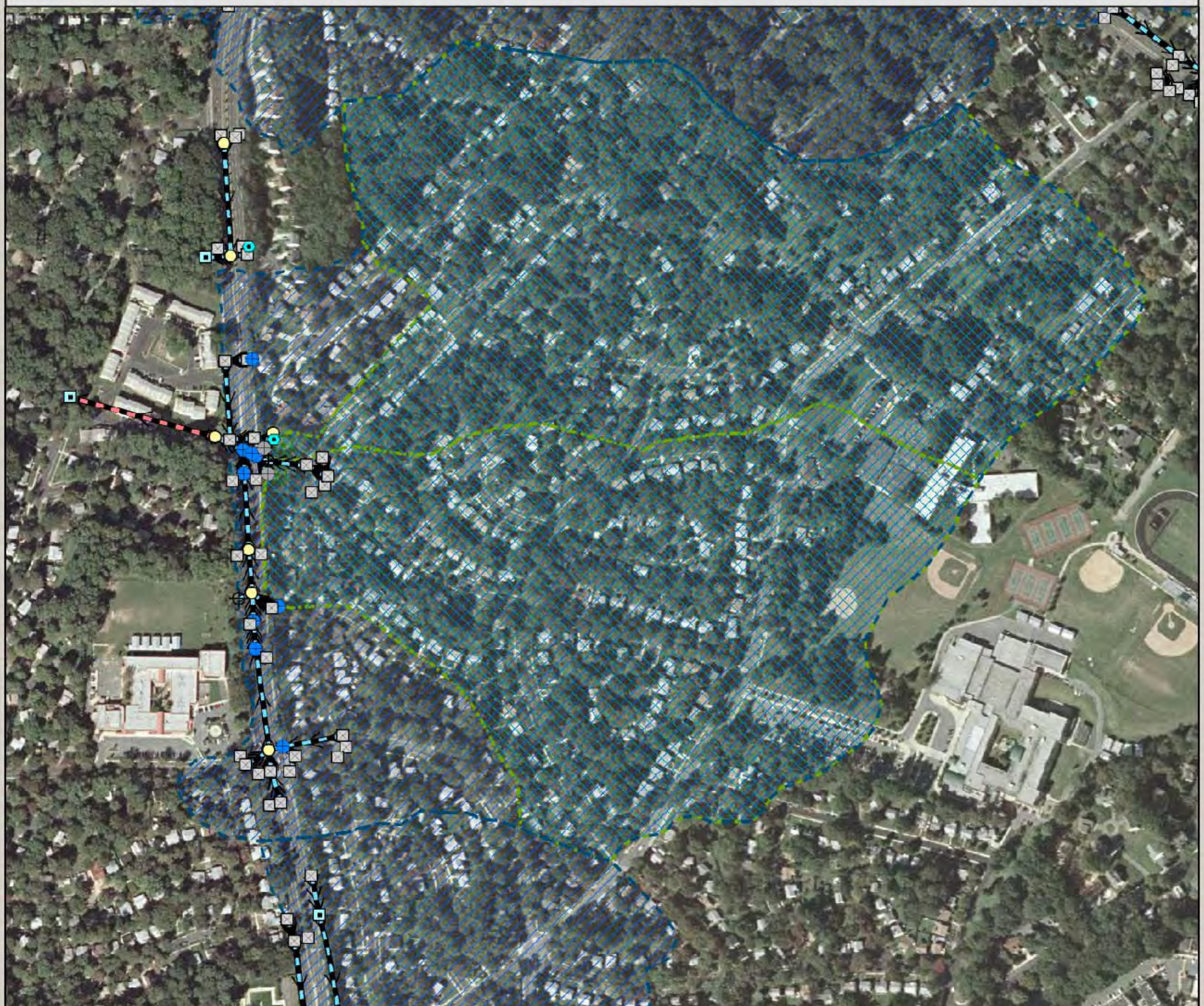


MD SHA Howard County MS4
Data Sampling October 2006
MD 100



MD SHA Montgomery County MS4
Data Sampling October 2006
MD 185

200 100 0 Feet



MS4 Data

Structures

- Capped Inlet
- Inlet
- Headwall
- Endwall
- Endsection
- Projecting Pipe
- Junction Box
- Pipe Connection
- Manhole
- Wye Connection
- Bend
- Rip Rap Ditch
- Ditch Intersection
- Springhead
- SWM Structure
- Emergency Spillway
- Pump Station

Pipes

- Unknown
- 0 - 8 Inches
- 9 - 12 Inches
- 13 - 18 Inches
- 19 - 21 Inches
- 22 - 27 Inches
- 28 - 32 Inches
- 33 - 40 Inches
- 41 - 42 Inches
- 43 - 54 Inches
- 55 - 96 Inches
- 97 and Over
- Flow Direction

Ditches

BMP Facility

- BMP Shape
- BMP Centroid

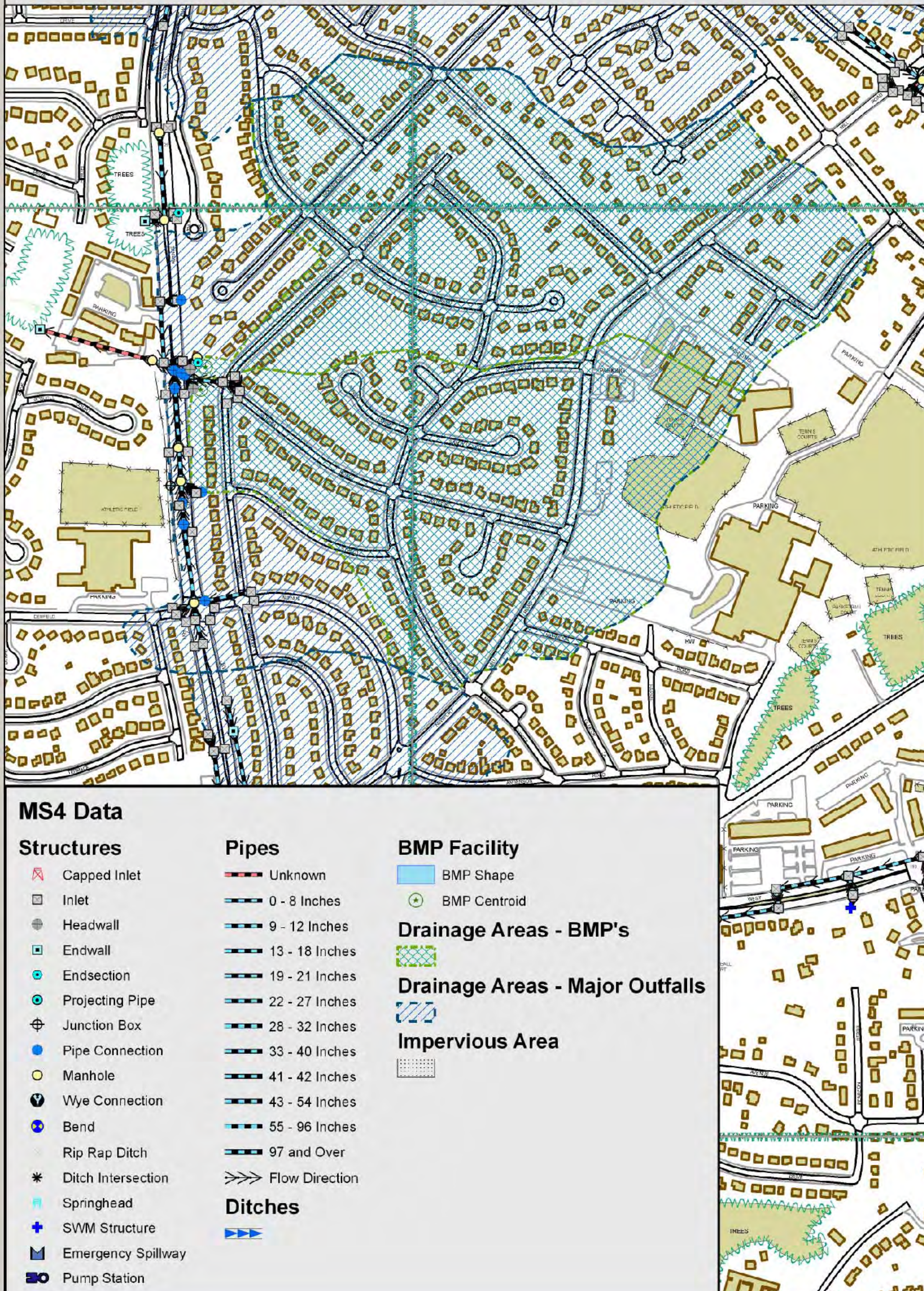
Drainage Areas - BMP's

Drainage Areas - Major Outfalls

Impervious Area

MD SHA Montgomery County MS4
Data Sampling October 2006
MD 185

200100 0 Feet



MS4 Data

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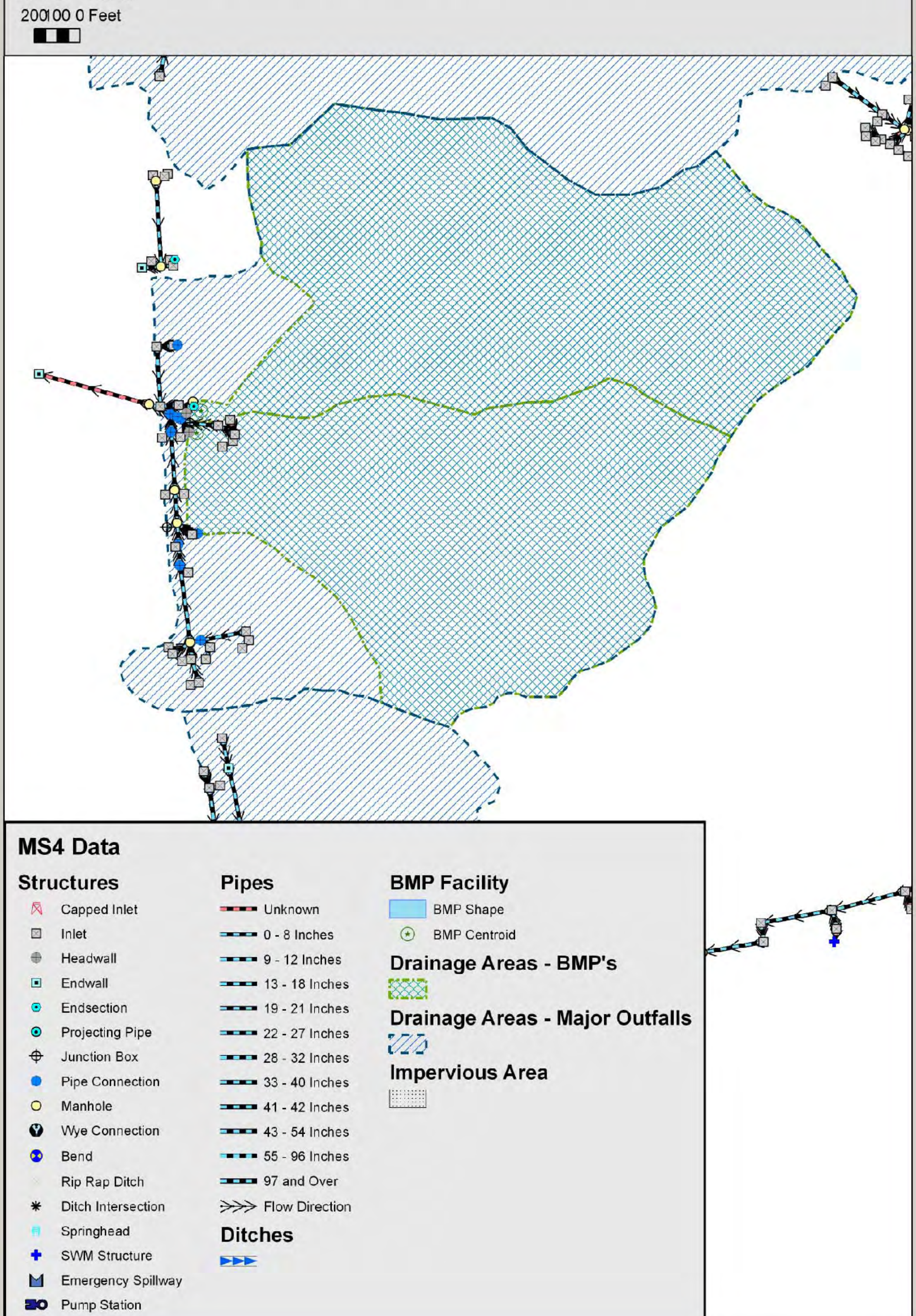
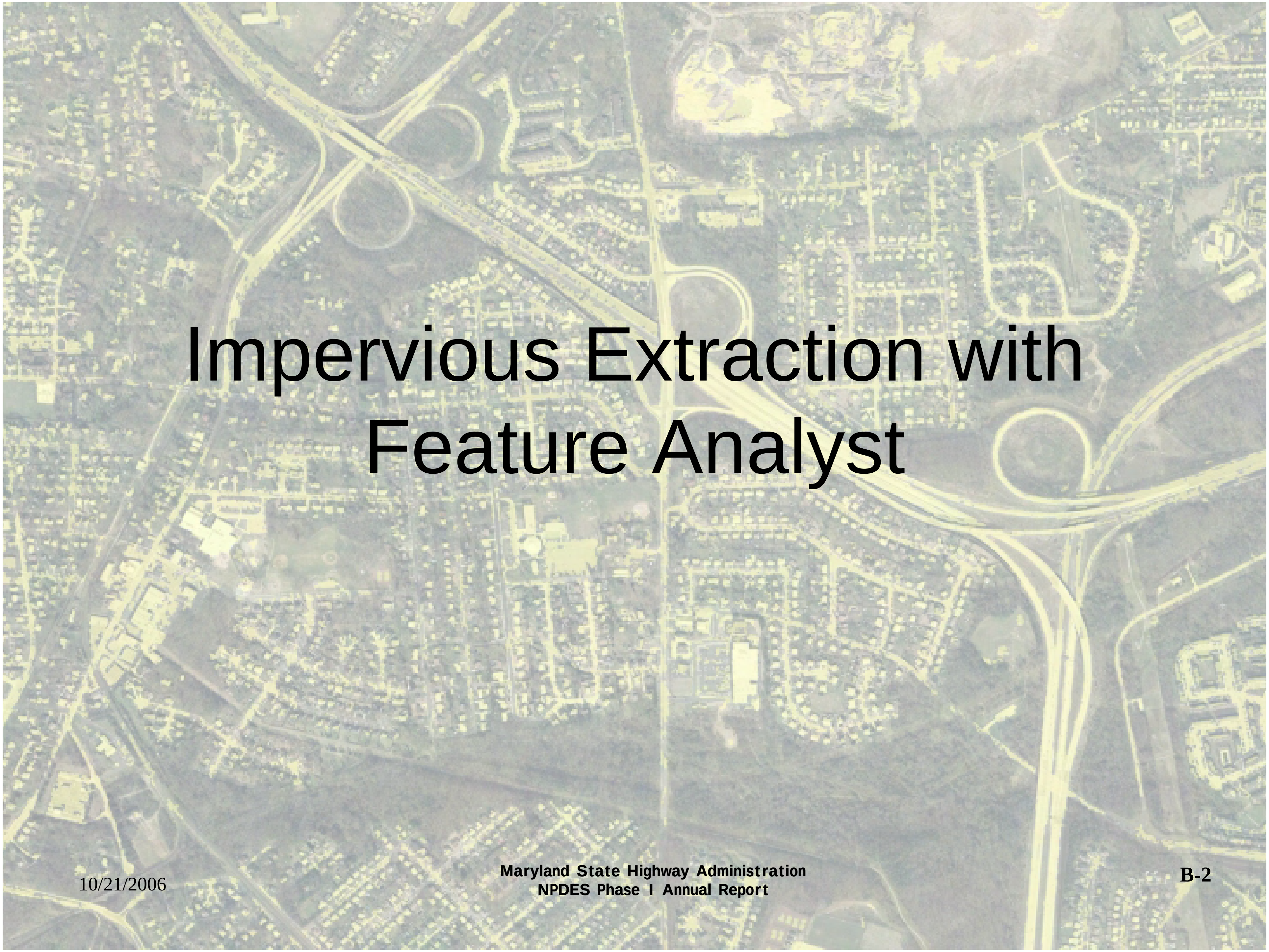


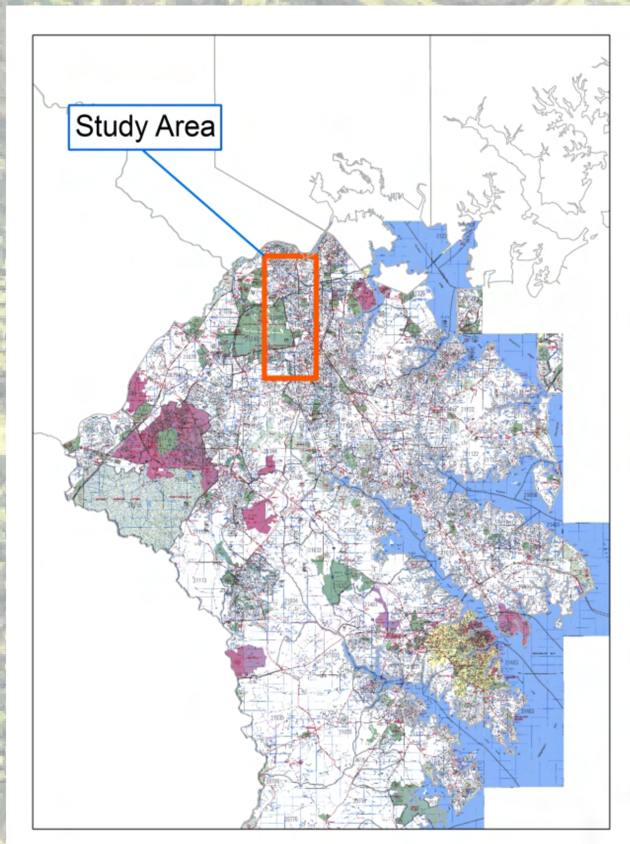
APPENDIX B:

Impervious Extraction with Feature Analyst

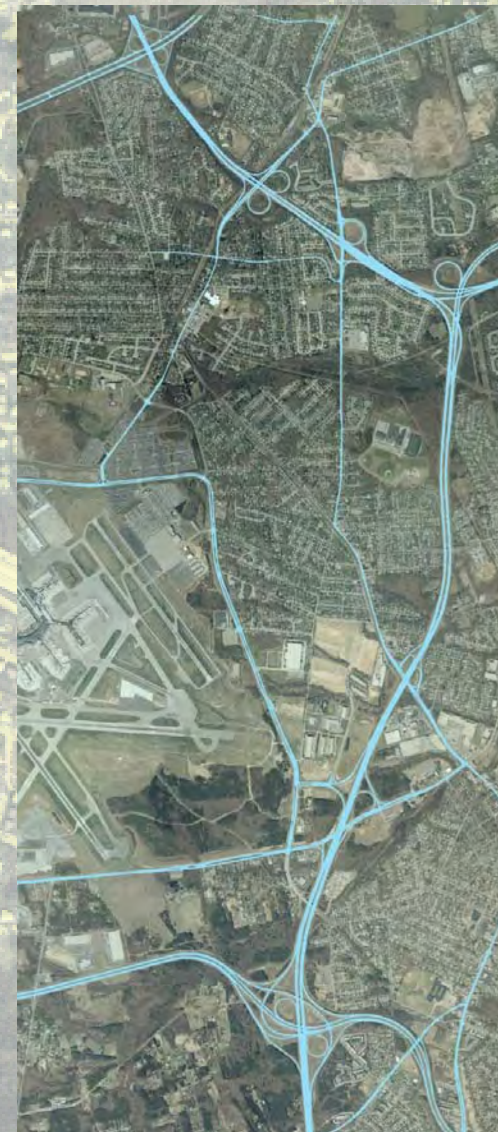


Impervious Extraction with Feature Analyst

Study Area



Utilize Heads Up Digitizing Pilot Study as Baseline



Approximately 3% of Anne Arundel County

Available Input Image Data

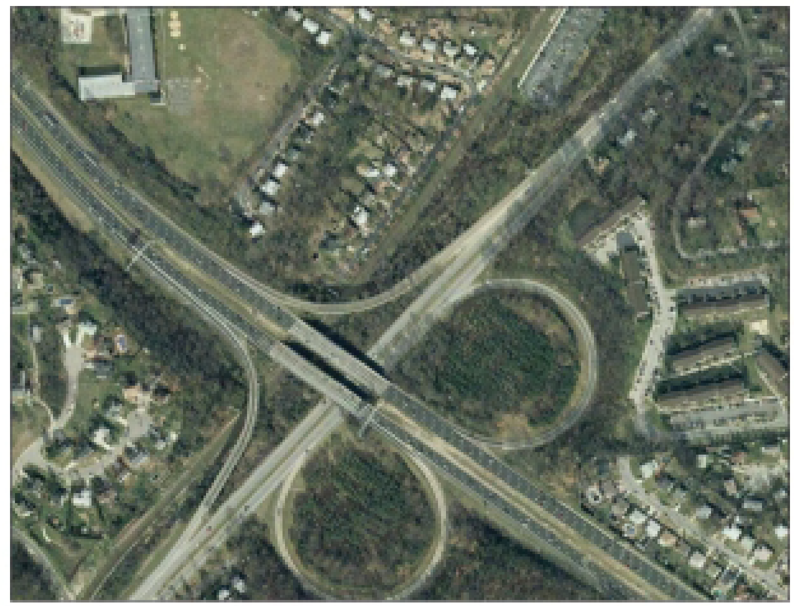
- 2000 VARGIS @ 1 ft. pixel
- 2003 Aerial Express @ 2.46 ft. pixel

Resolution Merge

2000 Color
1 foot resolution

2003 Color
2.46 foot resolution

Resolution Merge



Band Averaged Color Ortho 1 ft pixel

This technique can be used to create 1 new image from 2 or more images. This is useful in situation where heavy vegetation covers impervious features.

Select training areas

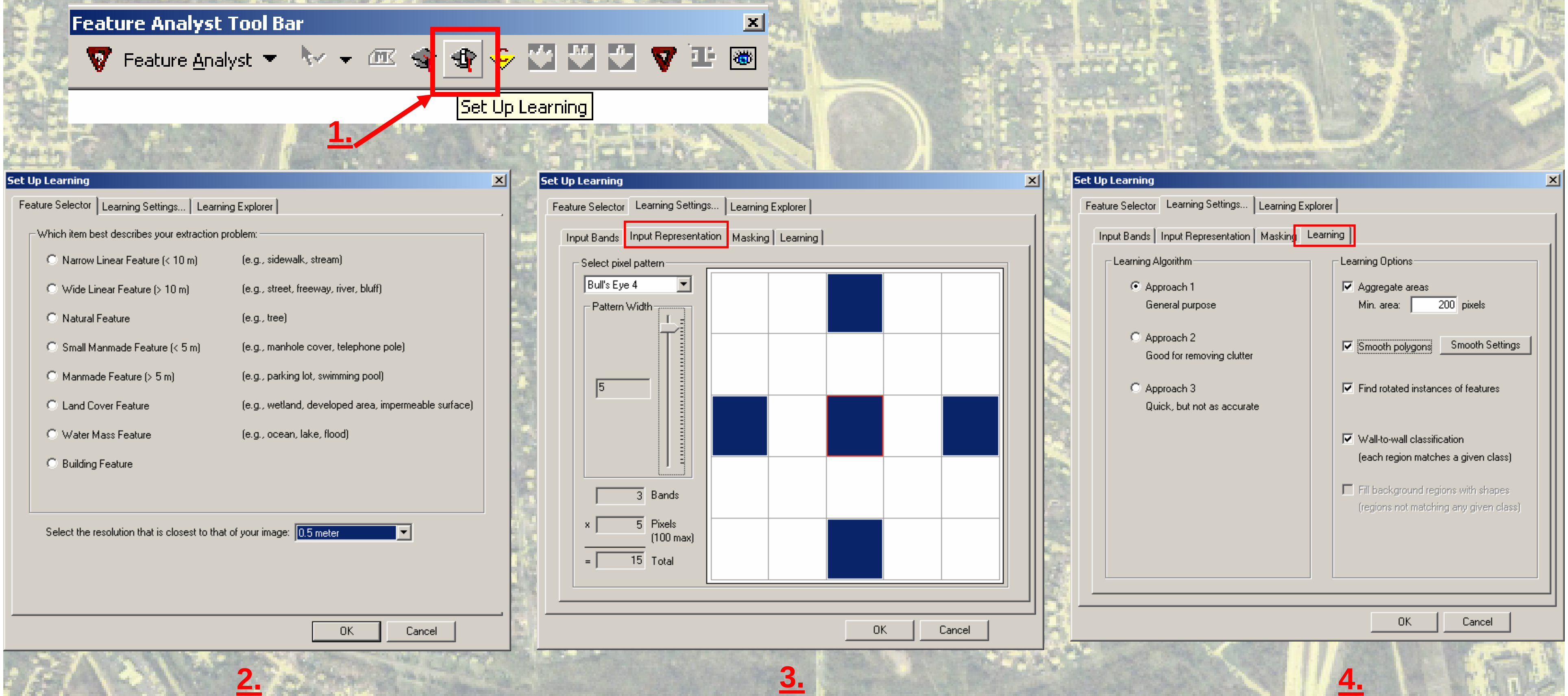
- Once the imagery is loaded into the software, training areas must be created to “teach” the software the spectral characteristics of impervious surfaces.

- Generally, to obtain quality results:
  - Training areas should representatively sample type and distribution of visible features
    - Natural, residential, commercial
  - Image must have consistent spectral characteristics
  - Image size must be manageable, larger image creates longer processing times

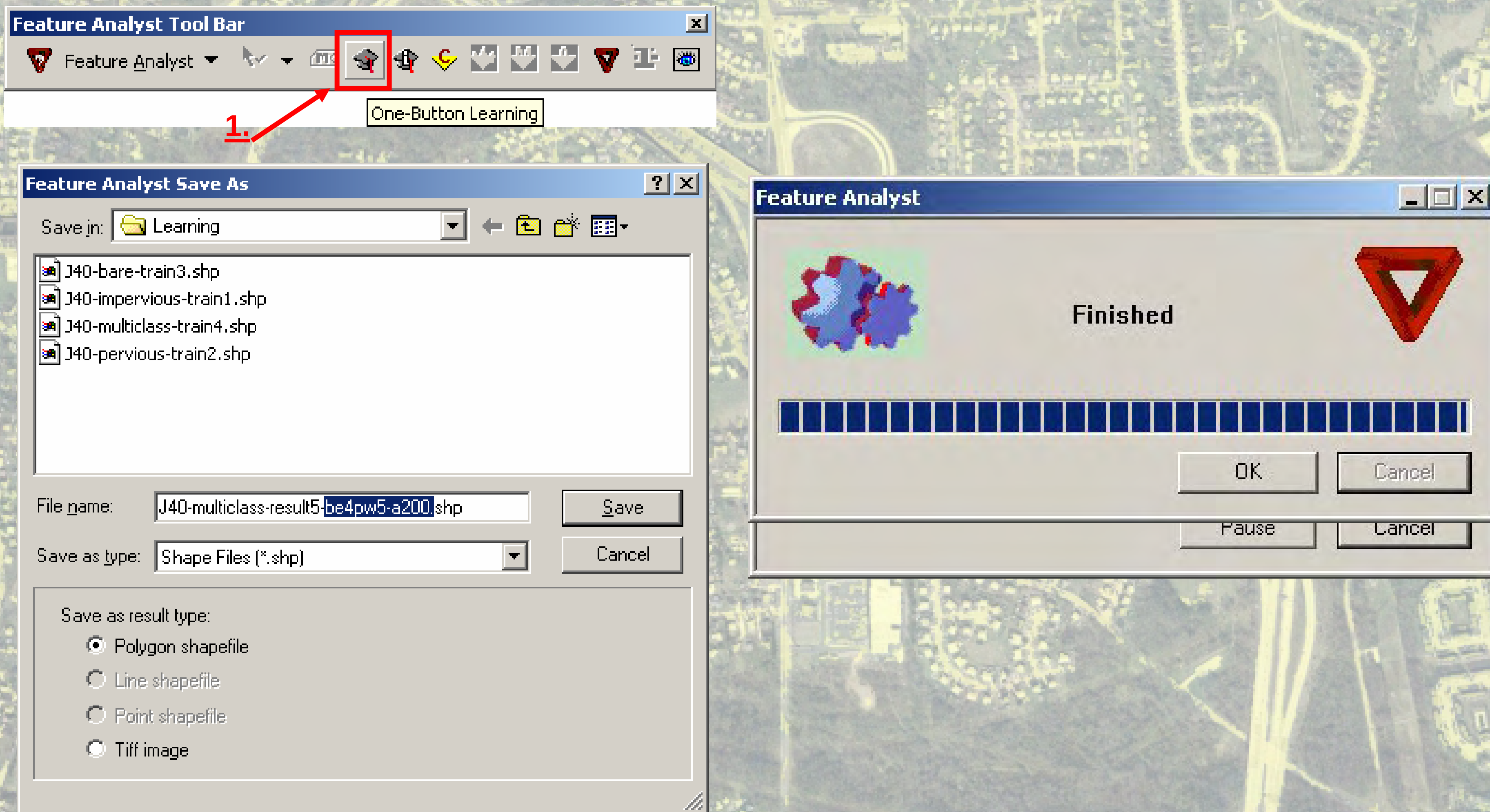
Creating Training Data

- The process of "training" the software utilizes a LEARNER file which remembers the teaching process.
  - All steps get recorded in the learner file (.lrn)
  - Start by collecting examples of training areas across the image.

Set up Learning in the Software



Learning


Feature Analyst Tool Bar
Feature Analyst
One-Button Learning
1.
Feature Analyst Save As
Save in: Learning
J40-bare-train3.shp
J40-impervious-train1.shp
J40-multiclass-train4.shp
J40-pervious-train2.shp
File name: J40-multiclass-result5-be4pw5-a200.shp
Save
Save as type: Shape Files (*.shp)
Cancel
Save as result type:
Polygon shapefile
Line shapefile
Point shapefile
Tiff image
Feature Analyst
Finished
OK
Cancel
Pause
Cancel

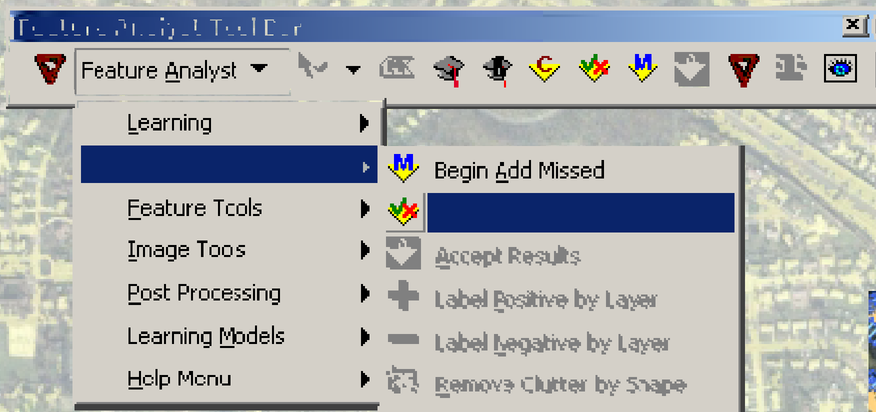
Training-Learning Result

“First Run” Output

In the software, the learning process is iterative. This represents the output after the initial set of learning parameters were defined. The process can now be further refined utilizing additional capabilities of the software.

Clutter Removal / Add Missed

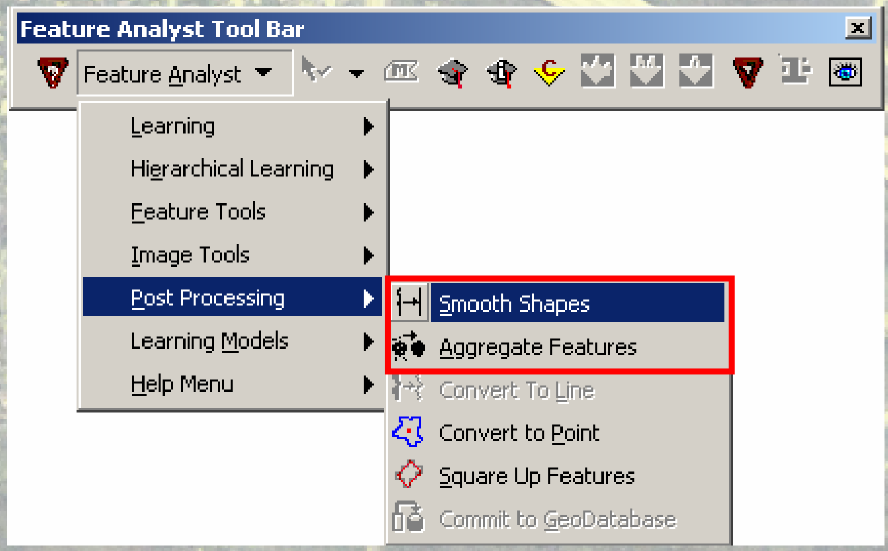
Hierarchical Learning



After the initial processing, this step teaches the software what impervious area it correctly identified and what impervious area it incorrectly identified.

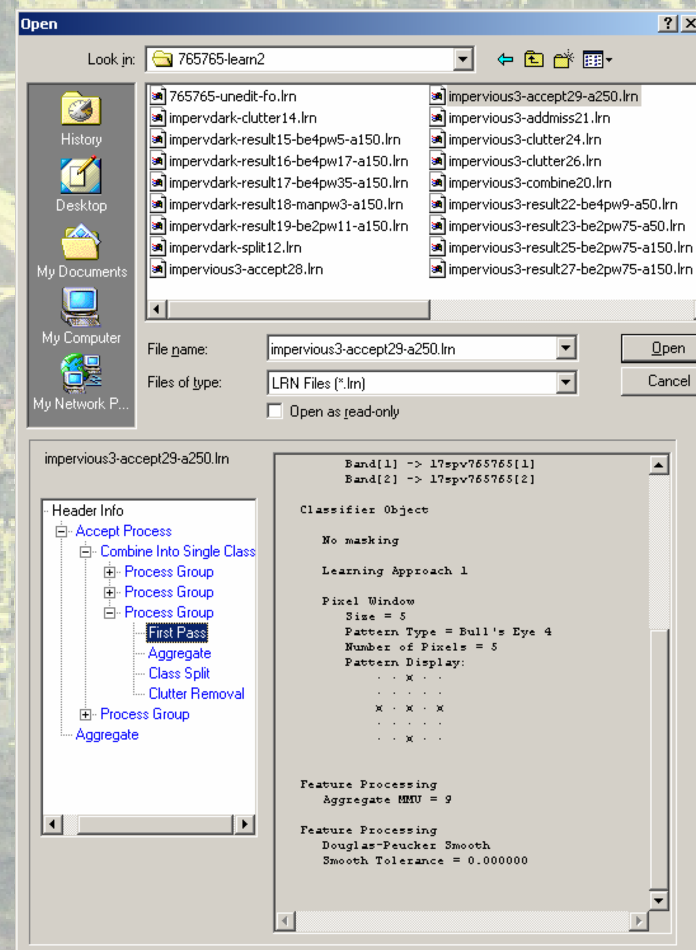
Aggregate & Smoothing
Post Processing

- Additional post processing functions can be utilized to refine data.
  - Aggregate can be used to remove smaller polygons that are unwanted.
    - i.e. trees misclassified as impervious.
  - Smoothing is used to reduce the number of vertices and thus the file size as well.



Learner File

- The parameters set up in the Learning process are saved to a Learner File (.lrn).
- This includes the following:
  - Training data
  - Input image & selected bands
  - Pattern type, size, and display
  - Aggregate size
  - Smoothing size
- The Learner File can be applied to multiple images in a batch classify process.



Results

Feature Analyst Impervious Surfaces Output

These images show the results of the impervious surface extraction process prior to running the post processing cleanup utilities.

Both images are the same.
First with no background ortho.
Second with ortho background.

Results

FA Impervious Surfaces Output Post “Cleanup”

Heads Up Digitized Impervious

Feature Analyst Impervious

ISSUES

- Output from FA tends to over estimate impervious surface
- Output from FA is not easily separated into subgroups (sidewalks, median, bridge, etc)
- Output from FA must be “cleaned” to remove non-SHA owned roadway
  - Vector parcel layer with ROW may reduce the amount of effort required to separate non-SHA areas
- FA has a hard time isolating impervious surface obscured by vegetation
  - Can mitigate this some with resolution merged images

BENEFITS

- Significant time savings.
- Feature Analyst analysis performed in $1/10^{th}$ the time required for heads up digitization.
- Feature Analyst tends to over estimate impervious area for more conservative results.
- Results are very similar to heads up digitizing.
- Standard methodology that is replicable, does not suffer from operator error.
- Relies on only aerial photography, not dependant on other data sets.

APPENDIX C:

Low Impact Development Implementation Studies at Mt. Rainier, MD

By *University of Maryland*

Low Impact Development Implementation Studies at Mt. Rainier, MD

Allen P. Davis, Ameya Pradhan and Kelly R. Flint
Department of Civil and Environmental Engineering
University of Maryland
College Park, MD 20742

October 20, 2006

Abstract

The impact of two management practices, gutter filters and bioinlets, on stormwater highway runoff quality at an ultra urban area in Mt. Rainier, MD, was evaluated. The analyses were divided into 3 phases: before construction (Phase 1, 32 events), gutter filters only (Phase 2, 17 events), and gutter filters and bioinlets (Phase 3, 14 events). Comparisons between Phases 1 and 3 resulted in Total Suspended Solids (83%), cadmium (86-89%) and lead (84%) demonstrating statistically significant reductions using the student's t test and the Mann-Whitney U test on the mean event mean concentration (EMC). Total Kjeldahl Nitrogen (12%), nitrite (42%) and copper (29%) demonstrated statistically significant reduction, while Total Phosphorus (20-40%) indicated an increase in EMC by the Mann-Whitney U test after Phase 3, but these values were insignificant based on the student's t test. Results support the application of these stormwater management practices in urban areas.

Introduction and Background

As part of a commitment to environmental protection, the Maryland State Highway Administration (SHA) is exploring the use of Low Impact Development (LID) technologies in roadway and transportation projects. LID technologies emphasize reducing rainfall runoff generation and management of runoff through filtration and infiltration practices. Performance information on LID practices in roadway application is necessary so that these practices can be integrated into SHA planning, design development, construction processes, and existing project retrofits, and maintenance objectives.

A project was begun in late 2000 to evaluate an urban highway area in Maryland for retrofitting Low Impact Development (LID) practices. An area of U.S. Route 1 in Mt. Rainier was selected for this study at the intersection of Rt. 1 and 33rd Street (Figure 1). A stormwater monitoring study has been initiated employing automated sampling instrumentation and flow measuring devices in the storm sewer, as well as a remote automated rain gauge. The background data collection was completed as samples have been collected and analyzed for 32 precipitation events from June 2002 to September 2003. Construction was begun and completed in Fall 2003 on a gutter filter to treat part of the runoff flow. Seventeen storm events were monitored after this modification. In late October 2004, three bioinlets were added to the area to complete the LID upgrade. Site monitoring continued for 14 events since these installations to quantify and document water quality improvements due to the LID implementation.

Project Objectives

The primary task for this project was to monitor stormwater flows and quality, monitor rainfall, and analyze pollutant concentrations and loadings. As part of this project, concentrations and mass loadings of pollutants were determined before, during construction, and after LID practice implementation. By monitoring in the storm sewer, a system-wide approach was employed. With these long-term data, improvements in stormwater quality gained through the use of LID practices are appropriately documented and statistically defendable.

Monitoring Equipment and Protocol

Based on design by the Low Impact Development Center (Beltsville, MD), a Tracom 24-inch Palmer-Bowlus flume was installed below grade, just north of the inlet at the corner of Rt. 1 and 33rd St at Mt. Rainier (Figure 2). An ISCO Model 6712 Portable Sampler with a polypropylene strainer was installed adjacent to the flume. The sampler had a bubble flow meter calibrated with the flume to monitor flow rates through the flume. The sampler contained twenty-four 350-mL glass bottles. The sampling program was set to collect 12 samples per event (filling 2 bottles per sample to ensure adequate volume for all the water quality testing). The sample timing is presented in Table 1. Glass bottles were cleaned and acid washed before placement in the sampler.

A sampling event was triggered when the water level in the flume reached 0.05 ft, which corresponds to a flow of about 0.02 cfs. This flow rate corresponds to a rainfall intensity of 0.016 in/hr, based on a drainage area of 60,000 ft^2 (1.38 acres) and a rational method c of 0.9. Samples were collected within 24 hours and transported to the Environmental Engineering Laboratory, College Park, MD. At the lab, samples were immediately preserved and analyzed for total phosphorous, nitrate, and nitrite. After initial analyses, remaining samples were preserved and refrigerated. One bottle (approximately 100 mL) for each sample was preserved for metal analyses using six drops of concentrated HNO_3 (trace metal grade). The second bottle for each sample was preserved by adding 2 mL of concentrated H_2SO_4 to 200 mL of sample. TKN analysis and metal digestion were completed within two weeks. Metal analyses were carried out within 6 months.

In June 2002, a Wireless Vantage Pro weather station with remote data collection was installed on the roof of the Mt. Rainier Public Works building approximately 1500 ft from the sampling site. This tipping bucket sampler logged rainfall depth in 2-minute increments. Data were stored via a PC inside the Public Works building.

Table 1. Sampling Times for Automated Collection during Storm Events at Mt. Rainier.

Sample Number	Time	Sample Number	Time
1	0 minutes	7	2 hours
2	20 minutes	8	2 hr, 20 min
3	40 minutes	9	2 hr, 40 min
4	1 hour	10	3 hr, 40 min
5	1 hr, 20 min	11	4 hr, 40 min
6	1 hr, 40 min	12	5 hr, 40 min

Table 2. Analytical Methods for Determination of Pollutant Concentrations in Mt. Rainier Storm Events.

Pollutant	Standard Method (APHA *et al*. 1995)	Detection Limit (mg/L)
Total Suspended Solids, TSS	2540D	1
Total Phosphorus	4500-P	0.24
Total Kjeldahl Nitrogen, TKN	4500-N_{org}	0.14
Copper	3030 E	0.002
Lead	3030 E	0.002
Zinc	3030 E	0.025
Nitrite	4500-NO_3^- B	0.01 as N
Nitrate	Dionex DX-100 ion chromatograph or	0.1 as N
	4500-NO_3^- B	0.5 as N

Analytical methodologies for pollutant measurements have been described in detail in previous documents to SHA and are summarized in Table 2. In samples in which the concentration was found to be below the detection limit, two values are calculated; the first assumes that the sample concentration is zero and the second uses the detection limit.

The monitoring work began in early June 2002, with the first phase of the project completed in September 2003 to characterize runoff water quality for the Mt. Rainier area without any treatment. Sampling began again in November 2003 after the construction of the gutter filters on the east side of Rt. 1 and continued throughout implementation of the bioretention inlets, which were completed in October 2004. The entire project was competed at the end of 2005, allowing collection of one full year’s data for the bioretention inlets.

Data Analyses and Statistical Procedures

For each pollutant, the total mass (*M*) present in each storm event was calculated as:

$$M = \int_0^T CQdt \qquad (1)$$

where *Q* is the measured stormwater flowrate and *C* is the pollutant concentration for each sample during the event. *T* is the event duration. The interval between samples is *dt*.

Additionally, the event mean concentration (EMC) was calculated similarly as:

$$EMC = \frac{\int_0^T CQdt}{\int_0^T Qdt} \qquad (2)$$

The EMC represents the concentration that would result if the entire storm event discharge was collected in a single container. EMC weights discrete concentrations with flow volumes; therefore, it is generally used to compare pollutant concentrations among different events.

The "simple method" was employed to estimate an annual pollutant mass loading (*L*), i.e., kg/ha/yr or lb/ac/yr. This is given by:

$$L = fR_v PC \qquad (3)$$

Here, *f* is the fraction of total rainfall events that produce runoff, R_v is the runoff coefficient, *P* is the average total depth of annual rainfall, and *C* is the flow-weighted average pollutant concentration. A units conversion factor, dependent on the units employed, must also be included in Eqn. 3.

The total project analysis has been divided into three components. The first is baseline monitoring of the site without LID controls (Phase 1). The second evaluation period occurred after installation of the gutter filter system (Phase 2). The final study period includes the completion of the LID retrofit with installation of the bioretention inlets (Phase 3).

Probability plots allow an easy method for evaluating the fit of data to a particular cumulative distribution and drawing comparisons between these distributions. Probability plots are used in this study to compare the distributions of the water quality data for each project phase. Runoff concentrations are generally assumed to follow a lognormal distribution, however some constituents do follow a normal distribution (Van Buren 1997).

The cumulative probability is assigned by ordering the points from smallest to largest and assigning a probability based on a plotting position function. For this study, therefore, the plotting position function below is used to plot data on probability plots with the least bias (Cunnane 1978, Looney and Gelledge 1985).

$$plotting\ \ position = \frac{i - .375}{N + 0.25} \qquad (4)$$

Comparisons of the probability plot along any horizontal line show the percentage of storms for each treatment phase that will exceed a given concentration. Likewise, a comparison along a vertical line shows the concentration that will be exceeded for a given percentage of storms.

Statistical analyses in the form of the student's t test and the Mann-Whitney U test allowed establishing with a 95% confidence level whether any reduction in the concentration of the pollutants could be attributed to the treatment measures.

Rosner's outlier test was used for determining outliers (if any) for all pollutant EMC data sets (sample size > 25) except Cd in Phase 1. The Dixon Thompson test was adopted to identify outliers for pollutant data sets in Phases 2 and 3 and Cd from Phase 1 (sample size < 25). The student's t test and the Mann-Whitney U test were employed on the data sets after ignoring the outliers and results were obtained.

Results and Discussion

Before Construction of the LID Practices-Phase 1

From June 2002 to September 2003, 32 storm events were sampled and monitored, representing 16 months of intensive monitoring. Nearly 240 runoff samples were collected and more than 1700 pollutant concentrations were measured. Rainfall and runoff flow data were also collected. As expected, a wide range of concentrations was found. The concentration range measured for all pollutants spans at least an order of magnitude and, for most, is more than 2 orders of magnitude. The pollutants generally demonstrate the maximum concentration in the initial sample, decreasing with time. In quite a few storm events, however, the concentration in later samples is more than the initial.

The range for the EMCs for the 32 events, with the exception of cadmium (which was only monitored for ten events), covers at least an order of magnitude. EMC data are summarized in Table 3 and all EMC water quality data are plotted in the probability plots of Figures 3-11. Comparisons for the water quality data from this study can be made to EMC ranges from studies of a bridge and a highway in North Carolina (Table 3). It is observed from Table 3 that the Mt. Rainier values for nitrate+nitrite, TKN, phosphorus, and TSS appear similar to those for North Carolina. However, for the three metals, EMCs found in the Mt. Rainier study appear greater than those found in North Carolina. This is especially the case for lead, in which values are about an order of magnitude higher, and cadmium, which appears two orders of magnitude higher. The greater concentrations at Mt. Rainier possibly reflect the ultra-urban characteristics of this area.

Table 3. Summary Information for Pollutant Concentrations Found From June 2002 to September 2003 (32 events) in Mt. Rainier, MD (Phase 1, No LID), Compared to Data on Bridge and Highway Runoff in North Carolina.

Water Quality Parameter	Sample Range	EMC Range	Mean EMC	EMC Range from Wu et al. (1998)	
				3-Lane Bridge	4-Lane Hwy
Nitrate + Nitrite (mg-N/L)	0.02-4.6	0.024-4.3	0.86- 0.87	0.08-13.4	0.06-0.56
TKN (mg-N/L)	0.28-29	0.81-10	3.4	0.68-2.45	0.67-2.0
TP (mg-P/L)	<0.24-3.6	<0.24-1.9	0.52-0.57	0.04-1.54	0.07-1.27
TSS (mg/L)	32-10,000	41-1600	420	32-771	9-221
Zn (mg/L)	0.080-30	0.18-6.0	1.2	--	--
Cd** (µg/L)	<2.0-130	13-93	35	<0.5	<0.5
Cu (µg/L)	14-740	24-290	110	<0.5-52	<0.5-21
Pb (µg/L)	6.4-2300	15-1200	220	<0.5-56	<0.5-35

*** = only ten events monitored*

Using the Simple Method of Eq. 3, the yearly specific pollutant loading for the urban Mt. Rainer site is calculated. For this area, a runoff coefficient, R_v equal to 0.95 was determined. Also, the average yearly rainfall for the Washington DC area is assumed as 44 in./yr. The results are presented in Table 4. Note that, in agreement with the EMC comparisons in Table 3, the predicted loadings are all much larger than comparable literature values. The ratio between the Mt. Rainier loading and that for the commercial land use from Wong *et al.* (1997) ranges from a low value of 2.3 for nitrate + nitrite to a maximum of 6.2 for TSS. Again, the ultra-urban characteristics of the Mt. Rainier drainage area may be contributing to the higher annual loading. The Mt. Rainier study site is a small, almost entirely impervious area.

Another interesting aspect that has been noted is that, even though rainfall was greater than average over the 16-month timeframe of the study, pollutant concentrations do not appear smaller because of excess rainfall. Current temporal models for stormwater runoff suggest that a fixed mass of pollutants is deposited in a drainage area over a fixed amount of time. This assumption requires, therefore, that times of minimal rainfall will produce highly concentrated runoff, while excess rain will produce more dilute runoff. No indication of this phenomenon was found throughout the 32 storm events monitored.

Detailed analysis of the water quality and hydrologic data for the 32 background storm events have been presented in Flint (2004).

Table 4. Loading Information for Pollutants Found From June 2002 to September 2003 (32 events) in Mt. Rainier, MD (Phase 1, No LID), using the Simple Method.

Water Quality Parameter	Mt. Rainier Annual Loading		Estimated Annual Loading for Urban Land Uses (Wong 1997) (kg/ha-year)	
	(kg/ha-year)	(lb/ac-year)	Commercial	Other Urban
Nitrate + Nitrite (as N)	9.3	8.3	4	3
TKN	25	22	6	6
TP (as P)	4.6	4.1	1	2
TSS	3100	2800	500	600
Zn	8.5	7.6	2	1
Cd	0.24	0.22	--	--
Cu	0.84	0.74	0.2	0.3
Pb	1.72	1.53	0.7	1

After Construction of the Gutter Filters-Phase 2

Gutter Filters were installed on the east side of U.S. Rt. 1 in fall 2003 (Figure 12). From December 2003 to September 2004, 17 storm events were sampled and monitored. Rainfall and runoff flow data were also collected. Wide ranges of concentrations have been measured. Table 5 compares the mean EMCs of the selected pollutants at the Mt. Rainier site before and after construction of the gutter filters. These results suggest that the gutter filters are successful in improving the quality of the stormwater runoff. The mean EMC of all the pollutants except for phosphorus and nitrate decreased. The mean EMC values for TSS, TKN, Pb, and Zn have reduced by at least one half of those found before the construction of the filters. The EMCs of the other pollutants, Cu and Cd also decreased. In case of TSS, one very high concentration in the storm event of 11/12/2003 (4600 mg/L) skews the result; a significant reduction in the TSS concentrations is found in the other storm events. This high concentration may be related to the gutter filter inlet construction. Another interesting point is the increase of the EMC values for TP.

Based on the results of the student's t test, it was concluded with a 95% confidence level that the gutter filter treatment method was effective in the case of TKN, Cu and Zn while it could not be established at 95% confidence that the gutter filters significantly changed levels of nitrite, nitrate, TP, Cd and Pb. The student's t test was not applicable to TSS due to the high variance. However, when outlying mean EMCs for TSS and Pb data sets were excluded, the student's t test established that the gutter filters resulted in a statistically significant removal of these pollutants. The Mann-Whitney U test concluded that the gutter filters were working in reducing the concentrations of TSS, TKN, Zn, Cd, Cu and Pb. Nitrite, nitrate and TP did not show a statistically significant difference in the mean EMC.

Table 5. Summary Information for Comparison of Pollutant Concentrations at Mt. Rainier, MD, Before (Phase 1) and After (Phase 2) Gutter Filter construction.

Pollutant	Phase 1	Phase 2	Reduction	Statistical Significance at 95%	
				t test	U test
TKN (mg-N/L)	3.4	1.7	50%	Yes	Yes
Nitrate (mg-N/L)	0.85	1.2	(-41%)	No	No
Nitrite (mg-N/L)	0.24	0.21	13%	No	No
TP (mg-P/L)	0.52-0.57	0.67-0.72	~(-28%)	No	No
TSS (mg/L)*	350	90	74%	Yes	Yes
Zn (mg/L)	1.2	0.35	71%	Yes	Yes
Cu (µg/L)	110	66	40%	Yes	Yes
Pb (µg/L)**	190	58	69%	Yes	Yes
Cd (µg/L)	35	20	43%	No	Yes

*Ignoring the TSS outlier concentration from storm events on 07/26/02 and 03/06/03.
**Ignoring the Pb outlier concentration from storm events on 02/03/03 and 11/12/03.

After Construction of Bioretention Inlets-Phase 3
Construction of the bioretention inlets was completed in September 2004 (Figure 13). Fourteen storm events were monitored. Tables of EMC values, with comparisons to the other data sets, are given in Tables 6 and 7.

For the comparison between Phase 1 and Phase 3 of the project (Table 6), the student's t test concluded at a 95% confidence level that the treatment was working in reducing the concentrations only for TSS, Cd, Pb and *Zn (with one point sequestered). The Mann –Whitney U test established at 95% confidence level that the means were different and the concentrations for TSS, TKN, nitrite, Cd, Cu and Pb decreased due to the gutter filters and bioinlets. With the Mann-Whitney U test, at a 95% confidence level it can be said that the means were different and the concentrations of nitrate and TP *increased* due to the gutter filters and bioinlets.

The mean EMCs for the pollutants in Phases 2 and 3 were less than those when the stormwater received no treatment (Phase 1) but there were some exceptions. The mean EMC for TP in Phase 1 was less than the mean EMC in Phase 2, which, was less than in Phase 3. Similarly, the mean EMC for nitrate in Phase 1 was less than in Phase 2, which was less than Phase 3. In cases of TKN and Cu, Phase 1 was the highest, followed by Phase 3 and Phase 2 was the lowest. Disregarding the Zn outlier in Phase 3, it was observed that the mean EMC in Phase 1 was the highest followed by Phase 3, with Phase 2 slightly less.

In several instances, the results of the student's t test and the Mann-Whitney U test do not match. This results mainly because the t test uses raw data, while the U test uses ranked measures. The U test is appropriate for analyzing data with a large variance as it eliminates the effects of the outliers. The t test has to be run on the same sample sets regardless of the outliers. Discrepancy was observed in the results from the t test and the U test when the raw data was scattered. The student's t test is appropriate for a data set if the underlying distribution is normal. These characteristics of the t test lead to inconsistency in the results from the student's t test and Mann-Whitney U test. Greater emphasis was placed on the results from the Mann-Whitney U test as the assumption of normally distributed data for applying student's t test was typically violated.

Table 6. Summary Information for Comparison of Pollutant Concentrations at Mt. Rainier, MD, Before (Phase 1) and After Gutter Filter+Biofilter installation (Phase 3).

Pollutant	Phase 1	Phase 3	Reduction	Statistical Significance at 95%	
				t test	U test
TKN (mg-N/L)	3.4	3.0	12%	No	Yes
Nitrate (mg-N/L)	0.85	21	(-2370%)	No	Yes
Nitrite (mg-N/L)	0.24	0.14	42%	No	Yes
TP (mg-P/L)	0.52-0.57	0.71	(-25-37%)	No	Yes
TSS (mg/L)	420	70	83%	Yes	Yes
Zn (mg/L)*	1.2	0.50	58%	Yes	Yes
Cu (µg/L)	110	78	29%	No	Yes
Pb (µg/L)	220	36	84%	Yes	Yes
Cd (µg/L)	35	4-5	86-89%	Yes	Yes

*Ignoring the Zn outlier concentration from storm event on 01/13/05.

Table 7. Summary Information for Comparison of Pollutant Concentrations at Mt. Rainier, MD, After Gutter Filters only (Phase 2) and After Gutter Filter+Biofilter construction (Phase 3).

Pollutant	Phase 2	Phase 3	Reduction	Statistical Significance at 95%	
				t test	U test
TKN (mg-N/L)	1.7	3.0	(-76%)	No	Yes
Nitrate (mg-N/L)	1.2	21	(-1650%)	No	Yes
Nitrite (mg-N/L)	0.21	0.14	33%	No	Yes
TP (mg-P/L)	0.67-0.72	0.71	(-6%)-1%	No	No
TSS (mg/L)	350	70	80%	No	Yes
Zn (mg/L)	0.35	18	(-5000%)	No	Yes
Cu (µg/L)	66	78	(-18%)	No	Yes
Pb (µg/L)	110	36	67%	No	Yes
Cd (µg/L)	20	1.1	95%	Yes	Yes

The data suggest that the gutter filters lowered the concentrations for all the pollutants except nitrate and TP. The statistically significant removal percentages as a function of the influent concentrations in stormwater analyzed after treatment from gutter filters only were 75% (*TSS), 50% (TKN), 71% (Zn), 40% (Cu) and 69% (**Pb). Giving priority to the Mann-Whitney U test, the concentration of Cd decreased by 43%. The water quality from the gutter filters with respect to nitrite, nitrate and TP was statistically identical to before implementation. The comparison between Phase 1 and Phase 3 indicated reductions of TSS (83%), Cd (86-89%), Pb (84%) and *Zn (58%). The student's t test failed, but the Mann-Whitney U test established with 95% confidence that there was a statistically significant reduction of TKN (12%), nitrite (42%) and Cu (29%). The Mann-Whitney U test established at a 95% significance level that the water quality deteriorated for nitrate and TP, with significant increases in concentration.

The comparison of EMC pollutant data between Phases 2 and 3 did not give statistically significant differences in any of the pollutants by the student's t test. The only exception to this was Cd on ignoring an outlier concentration (**Cd - 95% removal) from the storm on 10/19/04. The Mann-Whitney U test established at 95% significance that the water quality improved after the addition of bioinlets (Table 7) with TSS (80%), nitrite (33%), Cd (75-80%) and Pb (67%). The Mann-Whitney U test established at a 95% significance level that the water quality deteriorated for TKN, nitrate, Cu and Zn. When the outlier concentrations for nitrate (storm event on 04/13/04) and Zn (01/13/05) were ignored, it was concluded by the Mann-Whitney U test at a 95% significance level that the water quality deteriorated. Neither test could establish any statistical difference in the mean EMC of TP between Phases 2 and 3 (Table 7).

A summary of mean EMC values for all three project phases in presented in Table 8.

Table 8. Summary Information for Comparison of Pollutant Concentrations at Mt. Rainier, MD, Before Construction, after Gutter Filter Construction, and after Completion of Bioretention Inlets.

Water Quality Parameter	Phase 1	Phase 2	Phase 3
	Before Construction (Mean EMC)	After Gutter Filter Construction (Mean EMC)	After Bioretention Inlet Construction (Mean EMC)
TKN (mg-N/L)	3.4	1.7	3.0
Nitrate (mg-N/L)	0.85	1.2	21
Nitrite (mg-N/L)	0.24	0.21	0.14
TP (mg-P/L)	0.52-0.57	0.67-0.72	0.71
TSS (mg/L)	350*	90*	70
Zn (mg/L)	1.2	0.35	0.50***
Cu (µg/L)	110	66	78
Pb (µg/L)	190**	58	36
Cd (µg/L)	35	20	4-5

*Ignoring the TSS outlier concentration from storm events on 07/26/02 and 03/06/03.
**Ignoring the Pb outlier concentration from storm events on 02/03/03 and 11/12/03.
***Ignoring the Zn outlier concentration from storm event on 01/13/05.

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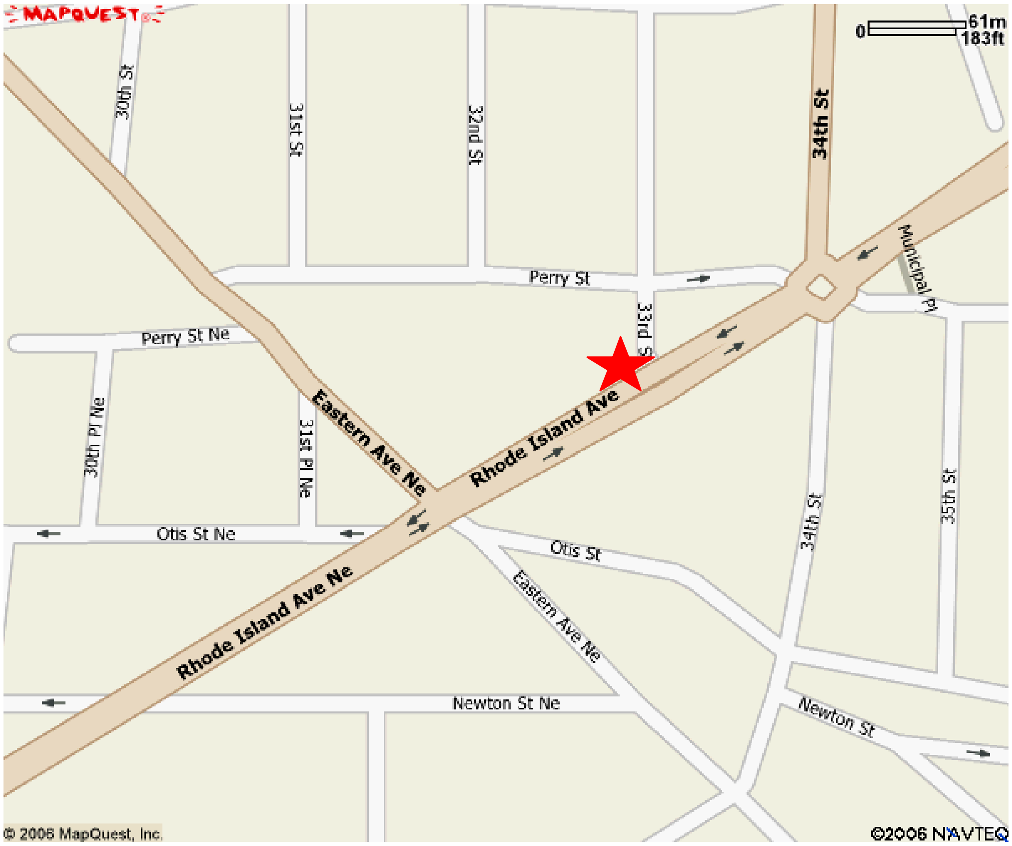

Figure 1. Mt. Rainier LID monitoring site

Figure 2. Stormwater monitoring site at Mt. Rainier with samplers below grade.

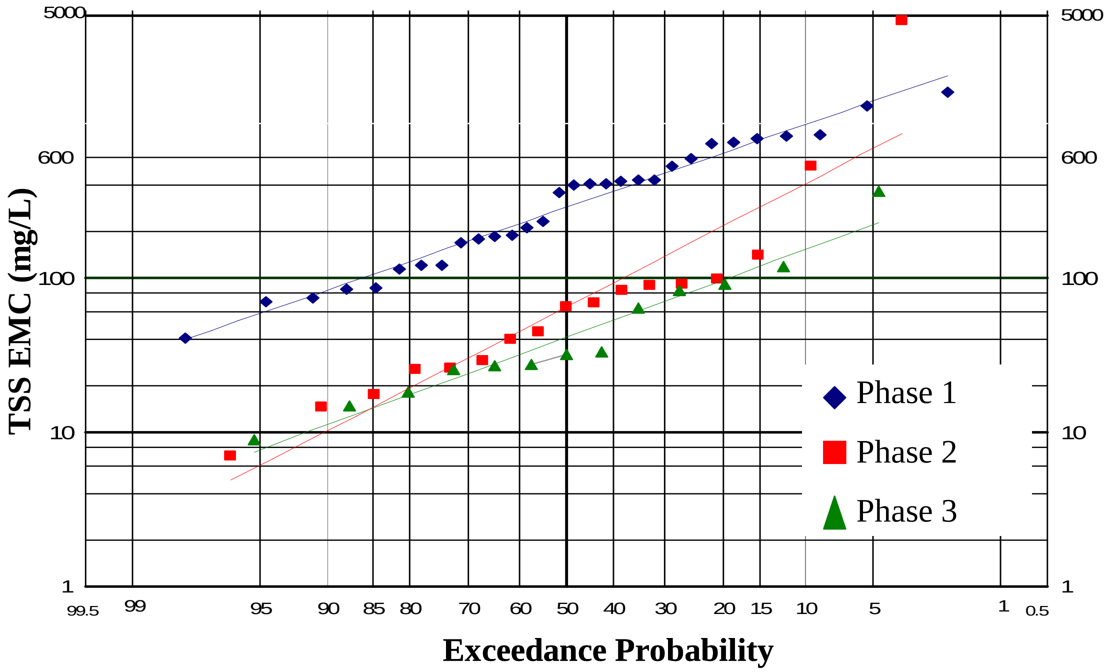

Figure 3. TSS EMC probability plot for storm events before LID implementation (Phase 1), after gutter filter installation (Phase 2), and after gutter filter and bioinlet installation (Phase 3) at Rt. 1 Mt. Rainier, MD.

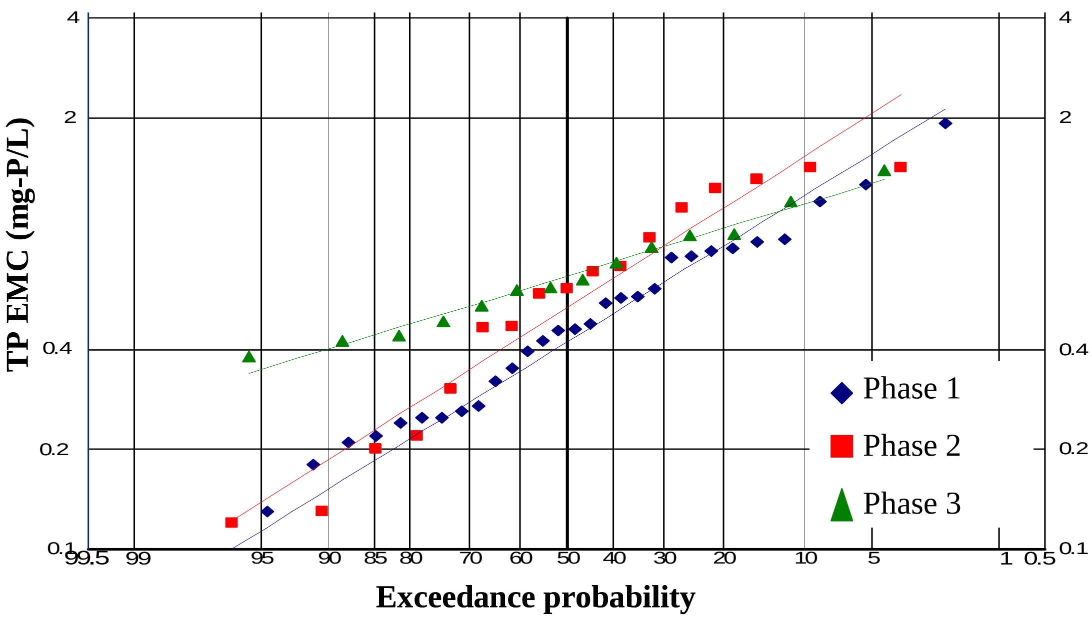

Figure 4. Total phosphorus EMC probability plot for storm events before LID implementation (Phase 1), after gutter filter installation (Phase 2), and after gutter filter and bioinlet installation (Phase 3) at Rt. 1 Mt. Rainier, MD.

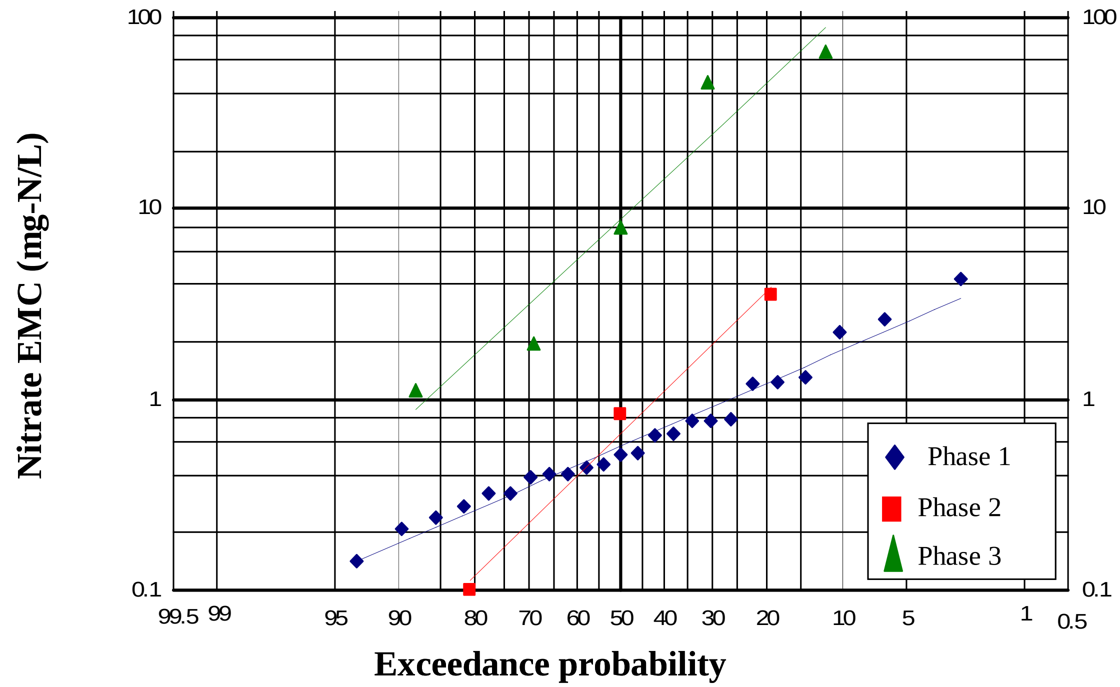

Figure 5. Nitrate EMC probability plot for storm events before LID implementation (Phase 1), after gutter filter installation (Phase 2), and after gutter filter and bioinlet installation (Phase 3) at Rt. 1 Mt. Rainier, MD.

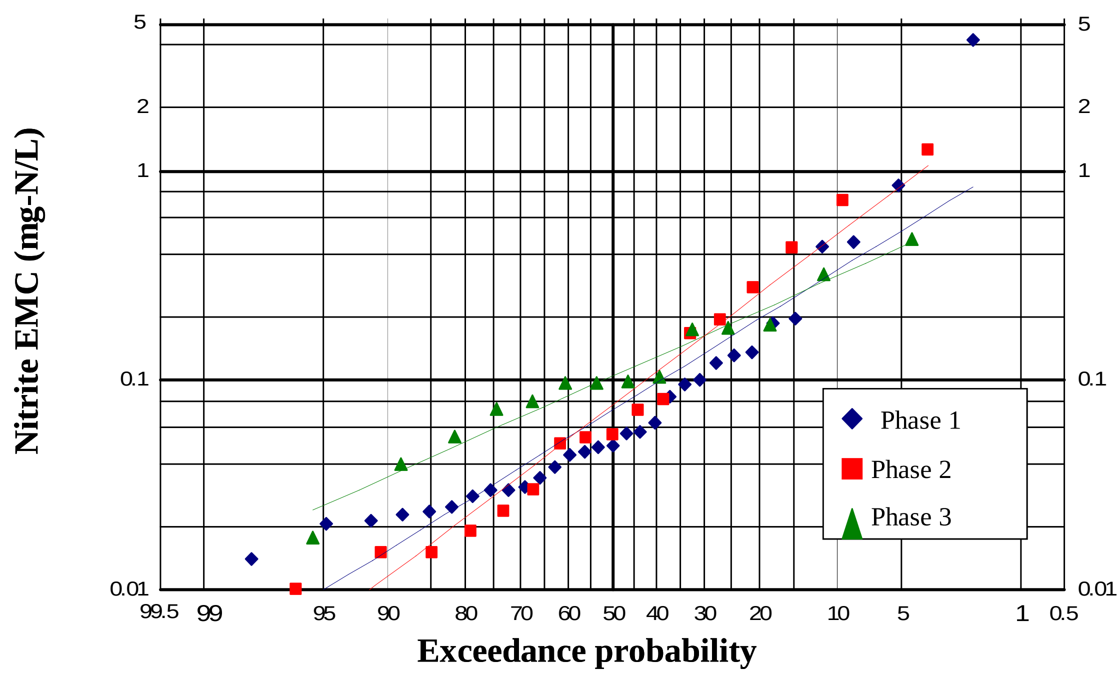

Figure 6. Nitrite EMC probability plot for storm events before LID implementation (Phase 1), after gutter filter installation (Phase 2), and after gutter filter and bioinlet installation (Phase 3) at Rt. 1 Mt. Rainier, MD.

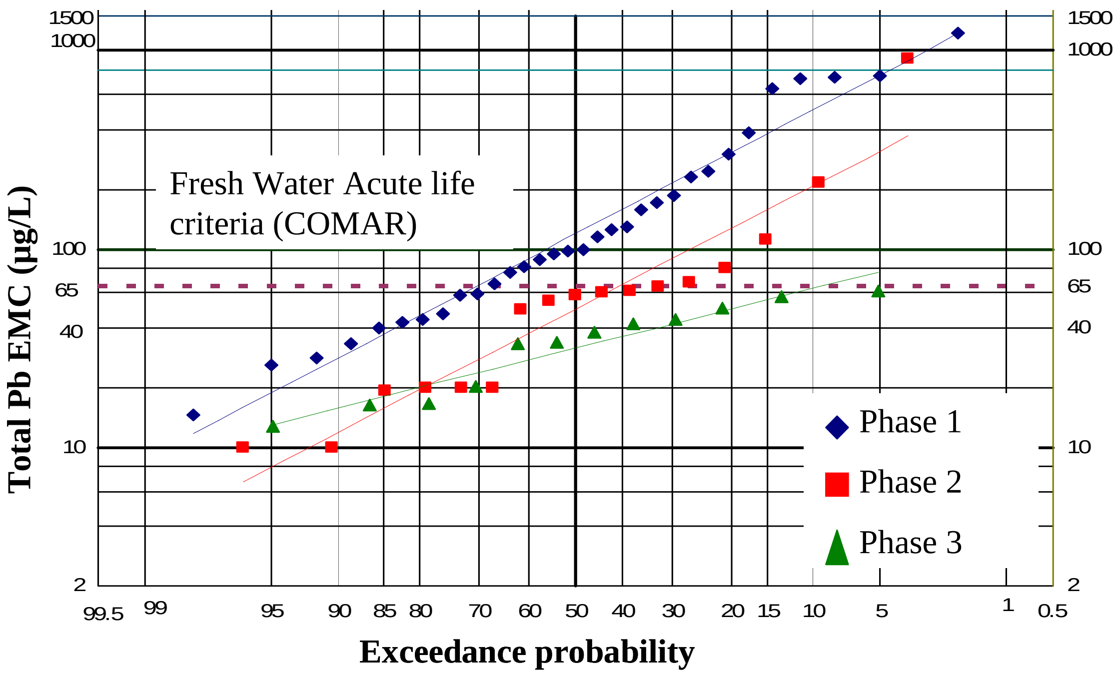

Figure 7. Total lead EMC probability plot for storm events before LID implementation (Phase 1), after gutter filter installation (Phase 2), and after gutter filter and bioinlet installation (Phase 3) at Rt. 1 Mt. Rainier, MD.

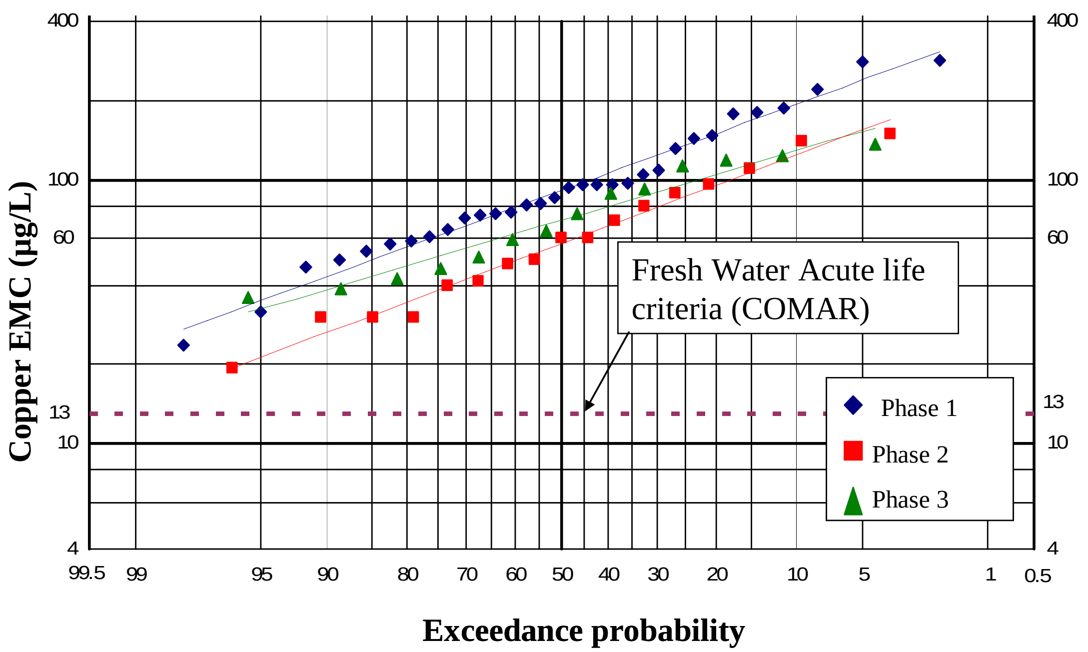

Figure 8. Total copper EMC probability plot for storm events before LID implementation (Phase 1), after gutter filter installation (Phase 2), and after gutter filter and bioinlet installation (Phase 3) at Rt. 1 Mt. Rainier, MD.

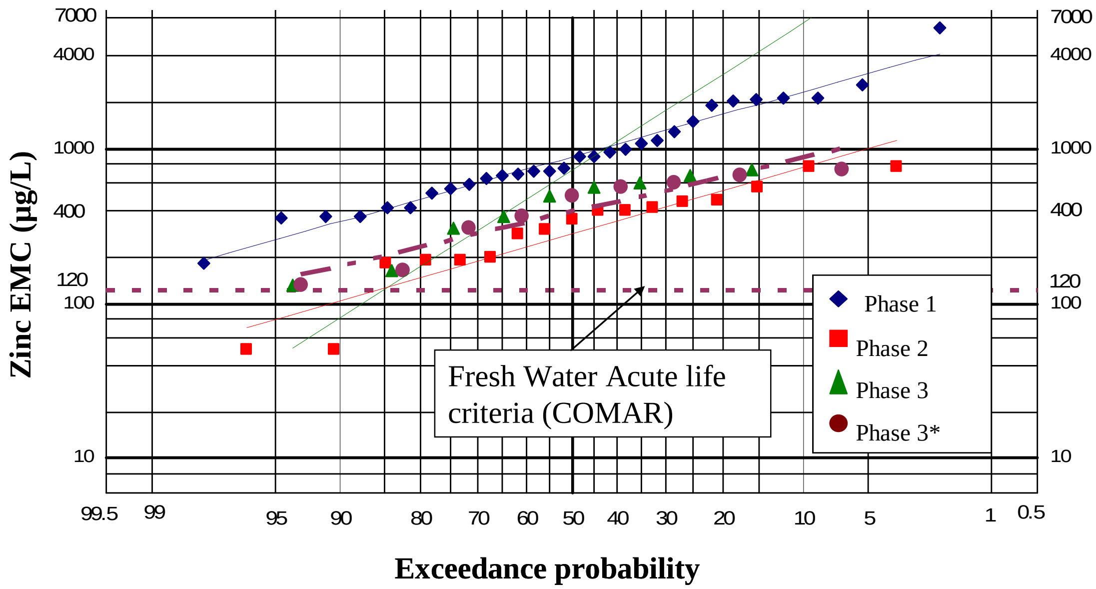

Figure 9. Total zinc EMC probability plot for storm events before LID implementation (Phase 1), after gutter filter installation (Phase 2), and after gutter filter and bioinlet installation (Phase 3) at Rt. 1 Mt. Rainier, MD. (Phase 3* data exclude one outlier point.)

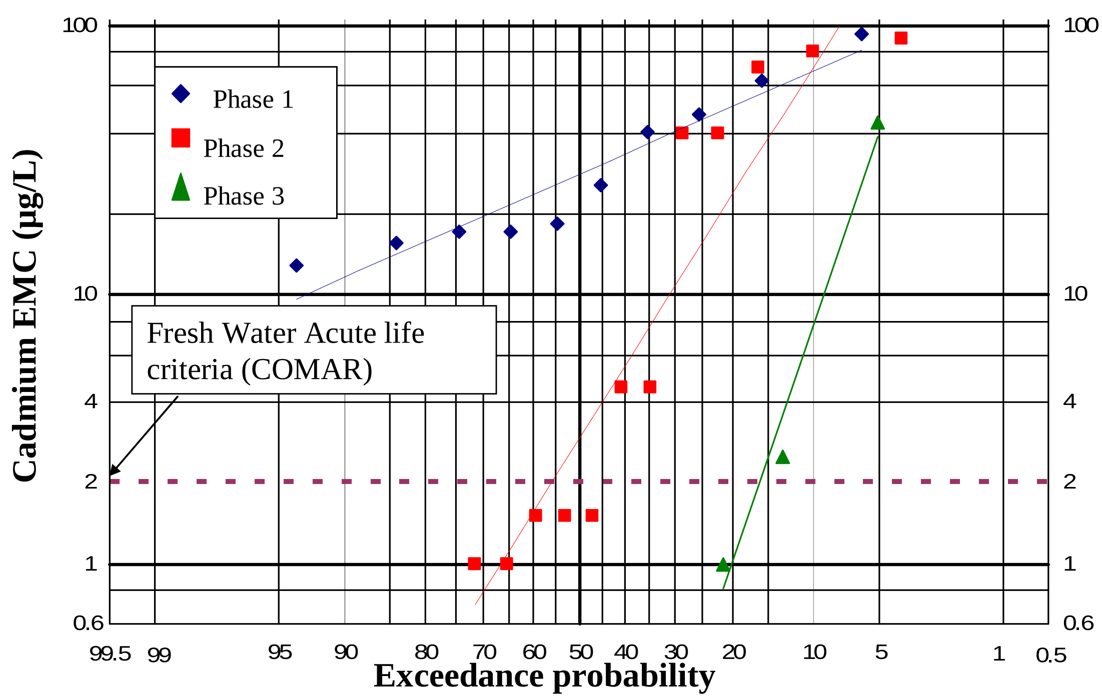

Figure 10. Total cadmium EMC probability plot for storm events before LID implementation (Phase 1), after gutter filter installation (Phase 2), and after gutter filter and bioinlet installation (Phase 3) at Rt. 1 Mt. Rainier, MD.

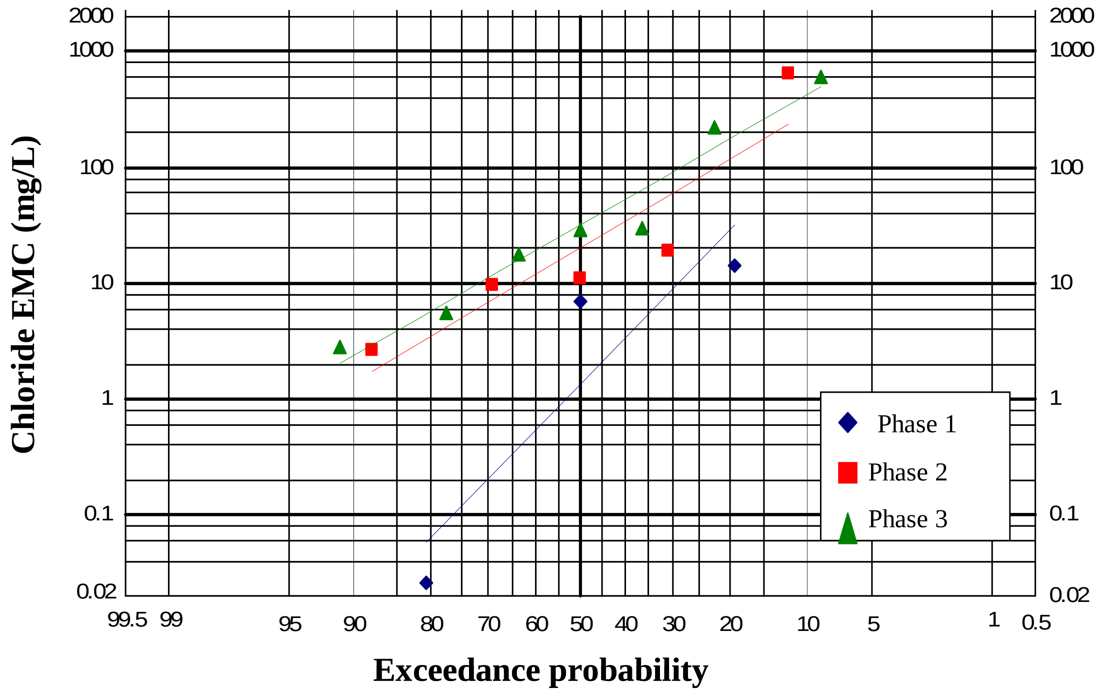

Figure 11. Chloride EMC probability plot for storm events before LID implementation (Phase 1), after gutter filter installation (Phase 2), and after gutter filter and bioinlet installation (Phase 3) at Rt. 1 Mt. Rainier, MD.

Figure 12. Completed gutter filter, fall 2003.

Figure 13. Completed bioretention inlets, fall 2004.

APPENDIX D:

Grassed Swale Pollutant Removal Efficiency Studies

By University of Maryland

Grassed Swale Pollutant Removal Efficiency Studies

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Abstract

Due to growing awareness of non-point source pollution treatment, 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. Results of this comparison for 22 rainfall events over 1.5 years show significant peak reduction (50-53%), delay of the peak flow (33-34 min) and reduction of total volume (46-54%). 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.

Introduction and Background

As part of a commitment to environmental protection, the Maryland State Highway Administration (SHA) is exploring the use of Low Impact Development (LID) technologies in roadway and transportation projects. LID technologies emphasize reducing rainfall runoff generation and management of runoff through filtration and infiltration practices. Performance information on LID practices in roadway application is necessary so that these practices can be integrated into SHA planning, design development, construction processes, and existing project retrofits, and maintenance objectives.

One such LID technology that has been employed for the conveyance of stormwater runoff in SHA designs for many years is grassed swales. Water quality enhancements can be realized in these swales through sedimentation (due to the low velocity induced by the vegetation), filtering by the grass blades, infiltration, and likely some biological processes. Swales are commonly used on highway projects because they represent an aesthetically pleasing method for conveying runoff. While recent studies have revealed them as an effective LID technology, good performance data and mechanistic understanding of swale design parameters are not available.

The most comprehensive research on the effectiveness of grassed swales for pollutant removal was performed and published by Yu *et al*. (2001). This research compiled previous experimental findings with original grassed swale pollutant removal tests to examine the effects of length, longitudinal slope, and check dams placed along the length of the swale. Results showed that the removal of suspended solids and nutrients, to a lesser extent, was mostly influenced by the hydraulic retention time. This retention time could be increased through the use of long swales with gradual slopes and check dams, thereby increasing pollutant removal. For long duration, low-intensity storms, swales were shown to be highly effective for pollutant removal due to enhanced infiltration. These conclusions were drawn on a very sparse data set and therefore the authors recommend further research into the factors affecting pollutant removal to determine grassed swale design parameters.

As part of the Maryland SHA commitment to exploring the usefulness of LID and the great amount of uncertainty regarding the performance and pollutant removal mechanisms of grassed swales, a pilot project has been constructed on Maryland Route 32 near Savage, Maryland. This swale system consists of two individual swales with different designs. The study system has been constructed to concurrently monitor representative inflow and outflow from the grassed swales, allowing the determination of pollutant removal efficiency. Performance information for grassed swales is critical to managing SHA roadway environmental impacts. Swale design flexibility will allow their use in a wider array of applications, allowing water quality benefits to be extended to a greater number of projects.

Project Goals and Objectives

The goals for this project were to systematically quantify the effects of some operational parameters for water quality improvement using grassed swales. The first will evaluate the hydrologic and water quality benefits of employing grass swales for highway runoff management. The second is to examine the effect of the shallow sloped grass pre-treatment area adjacent to the grassed swale. Water quality parameters examined in the swale studies were those considered as being most problematic from roadway runoff. Flow rates were recorded to determine the effect of swales on stormwater quantity and so that total pollutant mass reduction could be calculated. The work was completed using two grassed swales with different designs and one concrete channel receiving runoff directly from the roadway, which was assumed to be equivalent in quantity and water quality to the inputs for the two swales.

Pollutants Selected

Target pollutants for monitoring include total suspended solids (TSS), nitrate-N, nitrite-N, total Kjeldahl nitrogen (TKN), total phosphorus, chloride, cadmium, copper, lead and zinc. These pollutants are of the greatest concern in roadway runoff because of their toxicity, water quality concern, and/or concern for anticipated total maximum daily loads (TMDL) limits.

Total Suspended Solids (TSS)
Particulates in highway runoff are mainly from pavement wear, vehicles, atmospheric deposition, maintenance activities, and washoff from local soils. They can cause impacts that include increased color and turbidity, decreased light penetration, clogging, and direct toxicity to aquatic organisms. Many pollutants are associated with the fine-size particles that do not settle easily. As a result, TSS themselves cause water quality problems, as do the many pollutant constituents that adsorb to TSS.

Nutrients
As impervious area increases, nutrients build up on surfaces, leading to high pollution loads. Nutrients in urban runoff can accelerate eutrophication in receiving waters. Surface algal scums, water discoloration, taste and odors, depressed oxygen levels, and release of toxic compounds are possible impacts of high nutrient levels. The critical nutrients causing accelerated algal production are nitrogen compounds and phosphorus.

Nitrogen (Nitrate, Nitrite, TKN) - Nitrogen sources are derived from decomposing organic matter, animal and human wastes, fertilizers, and atmospheric deposition.

Phosphorus - Phosphorus is commonly bound to fine sediments. Phosphorus is derived from many of the same sources as nitrogen (Strecker, 1994); one source of phosphorus is tree leaves (Hodges, 1997).

Chloride
Chloride is found naturally, but is used in deicing agents on roadways.

Metals
Heavy metals in urban runoff have toxic effects on aquatic life and can contaminate drinking water supplies. Metals are present in the dissolved form and adsorbed to particulates. The bioavailability and mobility of dissolved metals are of the greater concern to aquatic life.

Copper - Sources of copper in roadway and urban runoff are brake pad materials, motor oil, and flashing used in buildings.

Lead - Tire wear, motor oil and batteries are common sources of lead in roadway runoff.

Zinc – Sources of zinc in roadway and urban runoff are tire wear, brake pads, motor oil and grease, and zinc-coated building materials.

Cadmium – Cadmium is generally found with zinc and the sources are the same as for zinc.

Monitoring Location

The monitoring location for this project is MD Route 32 near Savage, Maryland. This is a four-lane (two in each direction) limited access highway. The sampling areas are just south of the

Vollmerhausen Road overpass (Figure 1). The area adjacent to the sampling area is wooded with nearby residential; however, the roadway is raised so that runoff is only created by the roadway. Two swales were constructed in the highway median to receive runoff laterally from the southbound roadway lanes (Figure 2). The first is a swale constructed based on Maryland Department of the Environment (MDE) guidelines, with a sloped grass pretreatment area between the roadway and the swale channel (Figure 3). The second swale, to the north, was identically constructed, but without the pretreatment area (known as SHA swale, Figure 4). Both swales run 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, Figure 5), south of the swales. Sampling areas were designed so that all three drainage areas are similar and therefore comparable (Direct 60,800 ft^2, SHA swale 42,464 ft^2, and MDE swale 65,910 ft^2). Sampling will occur at a V-notch weir located at the end of each swale.

Sampling Goals and Purpose

The study system was designed for input/output analysis. The runoff flow and pollutant load determined in the flow directly off the highway is considered as equal to the total roadway input flow to each swale. This value is compared to flow and water quality measured at the outlet of each swale. Efficiencies were directly calculated for each storm event. Additionally, the efficiencies for each swale are directly compared. The sampling campaign for this project was designed to collect as many samples as possible for each storm event and a goal of sampling one storm event per month is established.

Monitoring Equipment and Protocol

Construction of the grassed swales adjacent to Route 32 was completed in late October, 2004. After allotting several weeks for the swales to stabilize, the sampling program was initiated.

In order to monitor flows and sample water quality, a 125-degree V-notch wooden weir was constructed at the end of each 500 ft swale. An ISCO Model 6712 Portable Sampler was installed in a secured vault adjacent to each swale. Each sampler has a bubble flow meter calibrated with the corresponding weir to monitor flow rates through the weir. The bubble tube was attached to the weir level with the V-notch. A stainless steel strainer was placed just upstream of the weir.

The sampler contains twenty-four 300-mL glass bottles that were cleaned and acid washed before placement in the sampler. The sampling program was set to collect 12 samples per event (filling 2 bottles per sample to ensure adequate volume for all the water quality testing). The sample timing is presented in Table 1, with an emphasis on obtaining more samples in the early part of the precipitation event. The sampler for direct stormwater runoff has an adjusted sampling schedule in order to cover the time period of the two swales. Preliminary sampling has shown that the grassed swales trigger a few hours later due to initial infiltration, so the direct stormwater sampling times were lengthened accordingly.

Table 1. Sampling Times for Automated Collection During Storm Events at Rt. 32

Direct Runoff		Two Swales	
Sample Number	Time	Sample Number	Time
1	0 minutes	1	0 minutes
2	20 minutes	2	20 minutes
3	40 minutes	3	40 minutes
4	1 hour	4	1 hour
5	1 hour, 20 min	5	1 hour, 20 min
6	2 hours	6	1 hour, 40 min
7	2 hr, 40 min	7	2 hours
8	3 hr, 20 min	8	2 hr, 20 min
9	4 hr, 20 min	9	2 hr, 40 min
10	5 hr, 20 min	10	3 hr, 40 min
11	6 hr, 20 min	11	4 hr, 40 min
12	8 hr	12	6 hr

A sampling event was triggered when the head behind the weir reached 0.1 ft, which corresponds to a flow of about 0.035 cfs. This flow rate corresponds to a rainfall intensity of 0.031 in/hr, based on a drainage area of 1.25 acres and a rational method c of 0.9. Collected samples were picked up within 24 hours and transported to the Environmental Engineering Laboratory, College Park, MD. At the lab, samples were immediately analyzed for total phosphorous, nitrate-N, nitrite-N, and TSS. After these initial analyses, remaining samples were preserved and refrigerated. One bottle for each sample containing approximately 100 mL of sample was preserved for metal analyses using six drops of concentrated trace level HNO_3. The second bottle for each sample was preserved by adding 2 mL of concentrated H_2SO_4 to 200 mL of sample for TKN analysis. TKN and metal digestion was completed within two weeks. Metal analyses were carried out within 6 months

One ISCO 674 Tipping Bucket Rain Gauge with 0.01 inch sensitivity was installed on top of a sampler vault and connected to one of the portable samplers. This tipping bucket logs rainfall depth in 2-minute increments.

Analytical Methodology

Analytical methodologies for pollutant measurements are described in detail below and are summarized in Table 2.

Table 2. Analytical Methods for Determination of Pollutant Concentrations in Grass Swale Storm Events.

Pollutant	Standard Method (APHA et al. 1995)	Detection Limit (mg/L)
Total Suspended Solids, TSS	2540D	1
Total Phosphorus	4500-P	0.24
Total Kjeldahl Nitrogen, TKN	4500-N_{org}	0.14
Copper	3030 E	0.002
Lead	3030 E	0.002
Zinc	3030 E	0.025
Cadmium	3030 E	0.002
Nitrite	4500-NO_2^- B	0.01 as N
Nitrate	Dionex DX-100 ion chromatograph 4500-NO_3^- B	0.1 as N 0.5 as N
Chloride	Dionex DX-100 ion chromatograph	2

TSS Analysis
This test follows Section 2540D of Standard Methods (APHA *et al*.1995). A well-mixed sample was filtered through a weighed standard glass-fiber filter and the residue retained on the filter is dried to a constant weight at 103 to 105°C for 1 hour. The detection limit is 1 mg/L.

Phosphorus Analysis
Total phosphorus analysis was divided into two general procedural steps: (a) conversion of the various phosphorus forms to dissolved orthophosphate by persulfate digestion, and (b) colorimetric determination of dissolved orthophosphate. As phosphorus may occur in combination with organic matter, a persulfate digestion method was used to oxidize organic matter to release phosphorus as orthophosphate.

This test follows Section 4500-P of Standard Methods (APHA *et al.* 1995). Fifty-mL samples were placed into Erlenmeyer flasks; 20 drops of H_2SO_4 solution were added, along with 0.5 g $K_2S_2O_8$ (J. T. Baker). The flasks were then boiled until about 10 mL of liquid remained. Later 20 mL of deionized water was added to each flask. The liquid in each flask was further diluted to 100 mL with deionized water. Four mL of ammonium molybdate reagent and 10 drops of stannous chloride reagent were added to each flask. The samples were allowed to sit for 10 minutes. Finally, the samples were placed into a spectrophotometer (Shimadzu model UV160U) to measure the color at 690 nm. A detection limit of 0.24 mg/L as P has been established.

Nitrate, Nitrite, and Chloride Analyses
Analyses of nitrate and chloride were routinely performed using a Dionex DX-100 ion chromatograph. The eluent was 1.3 mM sodium carbonate/1.5 mM sodium bicarbonate (J. T. Baker) solution. The flow rate was adjusted to 1.4 mL/min to clearly differentiate nitrate and

chloride. The concentration of nitrate in the samples was determined against standards of 0.14, 0.7, 1.4 and 3.08 mg/L as N prepared with sodium nitrate (Fisher Scientific) in deionized water. The concentration of chloride in the samples was determined against standards of 1, 3, 5 and 8 mg/L prepared using 1000 mg/L chloride stock solution (Fisher Scientific) in deionized water. Standard concentrations above the instrument detection limits were employed for nitrate and chloride due to the wide spread of sample concentrations found over the course of a storm event. The scale and standard concentrations were set to a range appropriate for the majority of samples in an event.

In samples where chloride levels were very high (winter), overlap between chloride and nitrate peaks prevented the use of this method. In these samples, spectrophotometric measurement of nitrate was carried out using a UV-visible recording spectrophotometer, Shimadzu model UV160U. Procedure details are as outlined in Standard Method 4500-NO_3^- B (APHA *et al.* 1995). Two spectrophotometric measurements are performed in order to measure nitrate and dissolved organic matter, which interferes. The nitrate concentrations were determined against standards of 1, 4, 7, and 10 mg/L as N, prepared by diluting 1000 mg/L stock solution to required calibration concentrations (Fisher Scientific).

Spectrophotometric measurement of nitrite was carried out similarly, using Standard Method 4500-NO_2^- B (APHA *et al.* 1995). Standards of 0.02, 0.08, 0.12, 0.24 mg/L as N were prepared by diluting 1000 mg/L stock solution (Fisher Scientific).

TKN Analysis

TKN was measured via Standard Method 4500-N_{org}, Macro-Kjeldahl Method (APHA *et al.*, 1995). TKN analysis was completed in three steps: (a) digestion of a 200-mL sample by evaporation after addition of 50 mL of digestion regent prepared as detailed in the Standard Method, (b) distillation of digested sample diluted to 300 mL and treatment with 50 mL of sodium hydroxide-sodium thiosulfate reagent, and (c) titration of distillate with standard 0.02 N sulfuric acid titrant. The detection limit is 0.14 mg/L for TKN.

Cadmium, Copper, Lead, and Zinc Analyses

Metal analyses were divided into two steps: (a) digestion of samples by evaporation of 75 to 100 mL of sample, after addition of 5 mL of concentrated trace metal-grade HNO_3 (Standard Method 3030 E), and (b) analysis of cadmium, copper and lead on the furnace module of a Perkin Elmer Model 5100ZC atomic absorption spectrophotometer, Standard Method 3110, and zinc on the flame module, Standard Method 3111 (APHA *et al.*, 1995). Standards for cadmium, copper, lead and zinc were prepared using 1000 mg/L Fisher Scientific stock solutions.

Data Evaluation and Loading Calculations

For each pollutant, the total mass (M) present in each storm event was calculated as:

$$M = \int_0^{T_d} QC\,dt \qquad (1)$$

where Q is the measured stormwater flow rate and C is the pollutant concentration for each sample during the event. T_d is the event duration. The interval between samples is dt.

Additionally, the event mean concentration (EMC) was calculated similarly as:

$$EMC = \frac{\int_0^{T_d} CQdt}{\int_0^{T_d} Qdt} \tag{2}$$

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.

The EMC is a valuable tool for comparing the concentration that would result from the effluent of a grass swale during a given storm event. However, because of the difference in total drainage area caused by the inclusion of swale area, there is a significant difference in rainfall flow. With the assumption stated above that no significant pollutant mass is present in the rainfall, the EMC, unlike total mass, is affected by dilution. While the EMC is important because it shows the actual field-based resulting concentration exported to receiving waters, another evaluation method is necessary to describe the true removal capability of the swale by eliminating the effects of dilution. The Normalized Event Mean Concentration (N-EMC) assumes that rain falls only on the roadway surface and thereby calculates the concentration that would occur if the grass swale surface was shielded from the rainfall and the resulting storm event discharge was collected in one container. The N-EMC for this hypothetical situation without dilution is based on the same principle as the EMC, with the total mass leaving the swale divided by the normalized total volume of flow leaving the swale without rainfall on the swale. This relationship is shown as

$$N-EMC = \frac{M_{swale}}{V'_{swale}} = \frac{Mass_{swale}}{Volume_{swale} - Volume_{\text{swale-rainfall}}} = \frac{\int_0^{Td} Q(t)C_{swale}(t)dt}{\int_0^{Td} Q(t)dt - A_S \int_0^{Td} i(t)\,dt} \tag{3}$$

where the $Mass_{swale}$ is the total constituent mass leaving the swale, $Volume_{swale}$ is the total volume of runoff leaving the swale, and $Volume_{\text{swale-rainfall}}$ is the total volume of rainfall landing on the swale area during the storm event.

Swale N-EMCs can then be compared to the EMC of the direct channel, because this concrete channel has no dilution effects. The direct channel EMC is therefore the influent mean concentration, the swale N-EMC is the effluent mean concentration and any difference between the two can be attributed to the sum effect of infiltration and treatment.

In cases where the concentration of a pollutant was below the detection limit, two calculations were made. One calculation used the concentration of the smallest standard in the case of nitrate and chloride, and the instrument detection limit for the remaining pollutants; the other EMC calculation used zero for the respective measurement. For statistical purposes, a mean of these values is employed.

Probability plots allow an easy method for evaluating the fit of data to a particular cumulative distribution and drawing comparisons between these distributions. Probability plots are used in this study to compare the distributions of the assumed inputs for the grass swales (direct channel) to the effluent from each swale. 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. Runoff concentrations are generally assumed to follow a lognormal distribution, however some constituents do follow a normal distribution (Van Buren 1997). Because both of these distributions are feasible, data is plotted on both lognormally distributed and normally distributed plotting scale, with more attention given to the lognormal distribution.

The cumulative probability is assigned by ordering the points from smallest to largest and assigning a probability based on a plotting position function. For this study, therefore, the plotting position function below is used to plot data on probability plots with the least bias (Cunnane 1978, Looney and Gelledge 1985).

$$plotting\ \ position = \frac{i - .375}{N + 0.25} \qquad (4)$$

In the case of the storms with complete flow capture, points are plotted along the horizontal axis, but are not considered when drawing this line of best fit. Comparisons of the probability plot along any horizontal line show the percentage of storms for input and output that will exceed a given concentration. Likewise, a comparison along a vertical line show the concentration that will be exceeded for a given percentage of storms.

Results and Discussion

In total, 22 storm events were sampled, with 4 of those events containing only flow data. Of the 18 events in which water quality was evaluated, 9 events showed measurable flow through the swales. In the other 9 events, all flow was captured by the swales.

Hydrology

When hydrologic parameters are considered, it appears that the grass swales are effective at creating a more natural flow delivery with less shock to the receiving water bodies. Both swales significantly reduce the peak flow when compared to the direct runoff by an average of 50-53% (Figure 6). This peak flow reduction is important in reducing the threat of channel scour and likely is responsible for some of the water quality improvement through mechanisms related to lower flow velocities, such as sedimentation.

The swales are also capable of increasing the amount of time before the runoff peak is discharged when compared to the direct highway runoff. The mean delay to peak flow is 33 to 34 minutes for both swales. Longer travel times in the grass swales are likely caused by the added flow path length and also the flow retardation caused by the grass surface. These results are reasonable when compared to theoretical flow delays calculated using Manning's equation. This significant delay and reduction of peak flows, combined with qualitative trends gathered from the flows with respect to time, suggest that the grass swales are effective at infiltrating initial flows and spreading the subsequent flows. This smoothing and spreading of peak flows means that receiving water bodies downstream of the swales receive a more manageable and constant flow, which reduces channel scour and other problems associated with large flow peaks.

Besides the hydrologic improvements achieved by the grass swales through changing the distribution of effluent flows, the swales also have an important effect on total runoff volume. This volume reduction, normalized to remove the extra flow caused by differences in swale drainage areas, is significant in terms of percent reduction for both swales. The effect of the grass swales on total volume reduction is not constant, however, and shows three distinct treatment modes. In the lowest intensity storm events, the grass swales completely capture runoff, such that no measurable flow occurs at the swale outfall. A regression line describing the maximum rainfall depth and duration that can be completely captured by the swales was determined as:

$$R = (0.07 cm / h)\, D + 0.35 cm \quad (5)$$

where R represents total rainfall depth (cm) and D represents storm duration (hours). Using this relationship and data on storm events in the state of Maryland (Kreeb 2003), it was determined that grass swales using these design parameters should completely capture 67% of storm events in Maryland. For storm events with slightly higher rainfall intensities, the grass swales are effective at reducing the total runoff volume through infiltration, however, begin to lose effectiveness above a threshold limit of 80,000 l which corresponds to a rainfall depth of about 3.3 cm. These very large storm events, which only occur in 14% of storm events in Maryland, are not significantly affected by the grass swales in terms of volume reduction. Therefore, the swales theoretically completely capture the smallest 67% of storm events, successfully reduce the total volume in 19% of storm events, and show no effect on the largest 14% of storm events in Maryland. The cumulative effect of these three treatment conditions is that swales successfully reduce the total runoff volume by an average of 46-54%.

Water Quality

The grass swales exhibit generally positive reduction of pollutant mass and mean concentrations for many of the water quality constituents considered in this study. Total suspended solids, nitrite, and the metals zinc, copper, lead and cadmium show statistically significant reductions in total mass and, in most cases, N-EMCs. Reduction of N-EMCs was more difficult to prove because this comparison only included those storms with measurable flow. Mass reduction, however, included all complete-capture storm events and compared the swale effect using a more long-range and cumulative approach. The grass swales successfully removed TSS at a mean rate of 73-84% by mass and 41-52% by N-EMC (reduction of 52-61 mg/l TSS), suggesting that the swales are very capable of reducing suspended solids (Figure 7). Summary data are presented in Table 3.

Table 3. Median pollutant N-EMCs and mean pollutant mass removals for swales and direct runoff from Rt. 32 study. Results are compiled from 18 storm events.

Pollutant	Median N-EMC			Mean Mass Removal	
	Input	SHA	MDE	SHA	MDE
TSS (mg/L)	93	4	7	84%	73%
Nitrate (mg-N/L)	2.1	No Flow	0.3	11%	-1%
Nitrite (mg-N/L)	0.21	0.03	0.01	69%	55%
TP (mg-P/L)	0.29	0.07	0.2	60%	39%
TKN (mg/L)	2.5	0.9	1.3	26%	-4.9%
Cl^- (mg/L)	10	31	125	-605%	-2680%
Zn (µg/L)	350	11	87	85%	75%
Cu (µg/L)	42	4.8	8.6	70%	46%
Pb (µg/L)	24	2.9	4.8	73%	59%

Metals were all significantly removed by the swales in terms of mass, with zinc showing the highest removal (75-85% mean), followed by copper (47-70%) and lead (59-73%) which both had similar removal. Cadmium concentrations were almost entirely below detection limits, which made calculation of a removal percentage impossible, however, the swales do appear to be successfully removing this metal. Probability plots for metals are shown in Figures 8 to 10.

For nutrients, nitrite was successfully removed by the swale in terms of mass (55-69%) and N-EMC (56-66%, 0.33 mg/l) likely by oxidation to nitrate in the swale (Figure 11). Other nutrient removals by the grass swales are much more variable and thereby less significant. The grass swales showed no significant mass removal for any of the remaining measured nutrients (nitrate, TKN and total phosphorus), while the N-EMC data showed a statistically significant increase in TKN and total phosphorus (Figures 11-14). The high variability in nutrient removal and these statistical findings suggest that the grass swales are greatly affected by factors beyond the control of this study, such as seasonal differences, mowing, or other releases of organic matter. Overall, these differences tend to cancel in terms of mass loading over a long period, however. Because the mass loading is variable and the runoff volume is reduced, the mean concentrations of these nutrients are slightly elevated.

Chloride represents the one pollutant that shows very different results than all other measured constituents. The grass swales appear to be exporting chloride mass and increasing the resulting chloride N-EMC throughout the duration of this study (Figure 15). This increase in chloride is large (mean increase of 216-499 mg/l) and is statistically significant. These results suggest that a large reservoir of chloride accumulates in the roadside grass and soil during winter salting operations and slowly releases chloride during storm events throughout the year. Roadway salting operations appear to the be the only reasonable source for these highly elevated chloride concentrations, and therefore, there must be storm events during the winter or snow melt-off events that cause very high chloride mass delivery to the swale inflow. These storm events were not measured in this study because of the difficulties in sampling near-freezing temperatures.

Overall, the swale data do not appear to show any significant improvement by including a grass pretreatment area adjacent to the swale in terms of both hydrologic improvement and pollutant removal. Actually, for many of the measured parameters, the SHA swale without the pretreatment filter strip shows a statistically significant improvement over the MDE swale. No consistent significant difference exists between the SHA swale and the MDE swale in terms of peak flow reduction, delay to peak flow, or total runoff volume reduction. The pollutant data suggest that the SHA swale is more effective at removing total mass than the MDE swale for suspended solids, TKN, chloride, zinc, and lead. This difference in pollutant removal suggests that the grass swale itself is the most important pollutant removal mechanism and that the grass pretreatment area is of much less importance.

The relative unimportance of the pretreatment area can be explained by defining the treatment mechanisms for different pollutants. Pollutants that are particulate-bound or particulate-related are treated through initial runoff infiltration and then by reducing subsequent concentrations by sedimentation and filtration. This treatment method appears to be very effective, as pollutants like TSS and lead are readily removed by the grass swales. The other metals are likely governed in part by these processes, as their speciation can become predominantly particulate bound during intense rainfall (Dean *et al.* 2005). Despite the inclusion of a pretreatment area in the MDE swale, the SHA swale has a longer maximum travel distance (SHA 198m, MDE 152 m), allowing for more sedimentation and filtration and thereby better particulate-bound pollutant removal.

Dissolved constituents are governed by a different set of treatment mechanisms. Initially, these pollutants are removed by infiltration in a similar manner to particulate-bound pollutants; however, once the soil pore spaces are saturated, the swales remove dissolved pollutants through adsorption and some chemical and biological methods. Nitrite reduction is likely governed by chemical or biological oxidation, while the dissolved metals are most likely removed through adsorption, until their distribution becomes more particulate-bound. As shown by highly variable results in nutrient removal, the treatment methods for dissolved pollutants in grass swales are dependent on many chemical and physical factors and differ for each pollutant.

Summary and Conclusions

The results of this study suggest that grass swales are an inexpensive, effective, natural method of controlling the hydrologic effects of highway runoff and reducing pollutant loads and concentrations for suspended solids and metals. The design of grass swales for pollutant removal should focus on increasing infiltration through soil characteristics and increasing sedimentation and filtration through increasing hydraulic retention times. Because of this, additional swale length, thickness of grass, and swale slope are important design factors. The inclusion of a grass pretreatment area adjacent to the grass swale does not make any significant difference in hydrologic or water quality improvement in swales of this size (200 m length).

The conclusions suggested by this research, as applied in a highway design environment, suggest that the greatest runoff hydrology and water quality benefits will occur when the grass swales are as long as possible. The importance of increased retention times suggests that swales should be designed with long swale length, shallow channel slopes, thick vegetation, and soils that promote infiltration. When possible, it is best to allow grass in the swales to grow naturally to fill the channel depth. Inclusion of a pretreatment area may add some improvements; however, if the swales are designed correctly with a long length, the improvement is negligible. Care should be taken in design to ensure that no washout occurs by ensuring that the slopes are shallow and that the soil is firm enough to prevent channel scour. Finally, this research suggests that grass swales generally improve runoff characteristics and should be employed, where physical limitations allow, instead of concrete channels even in those sites that cannot provide the necessary width for a pretreatment area.

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Figure 1. Rt. 32 swale monitoring site

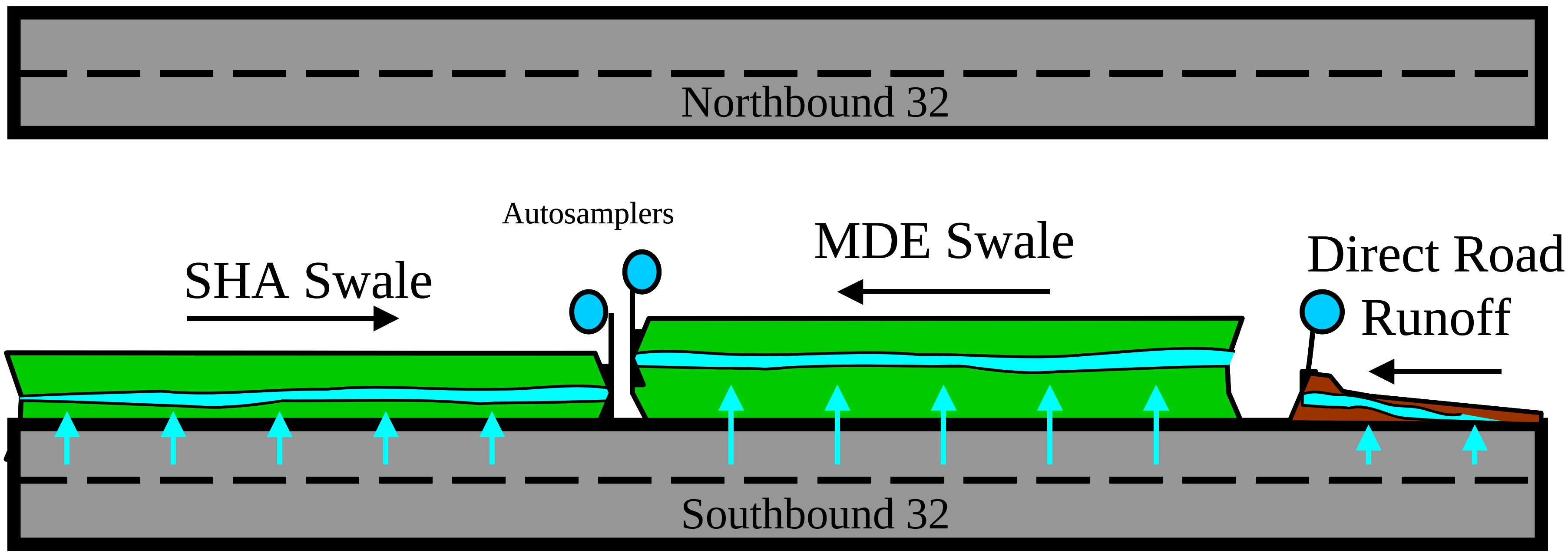

Figure 2. Diagram of swale study area.

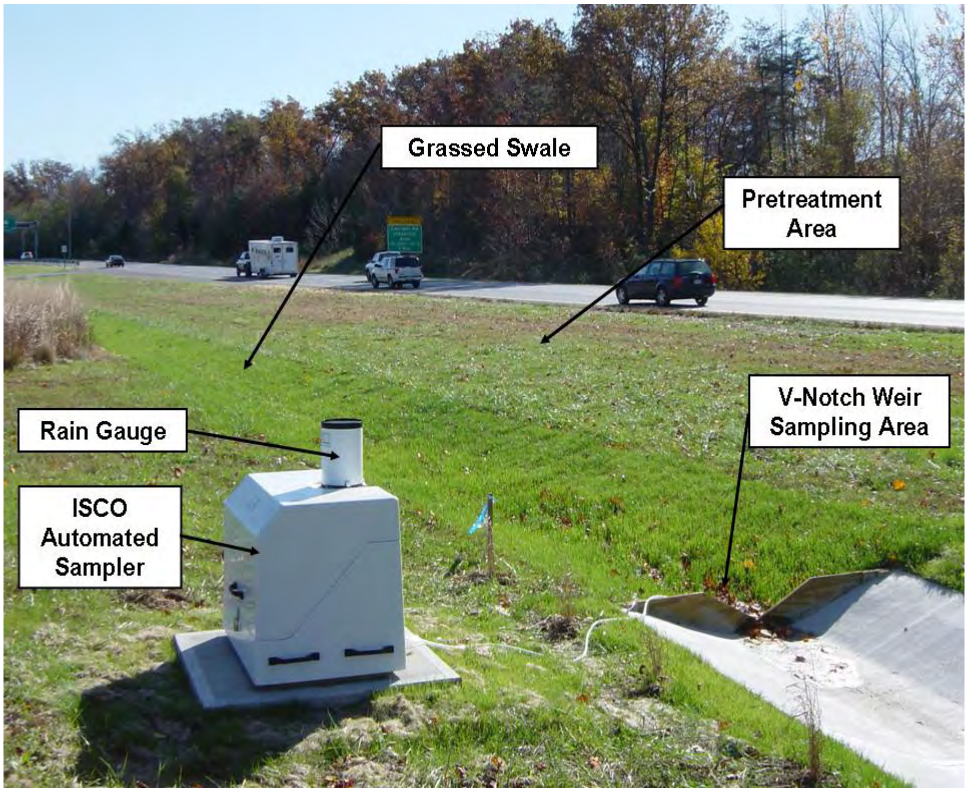

Figure 3. MDE swale at Rt. 32.

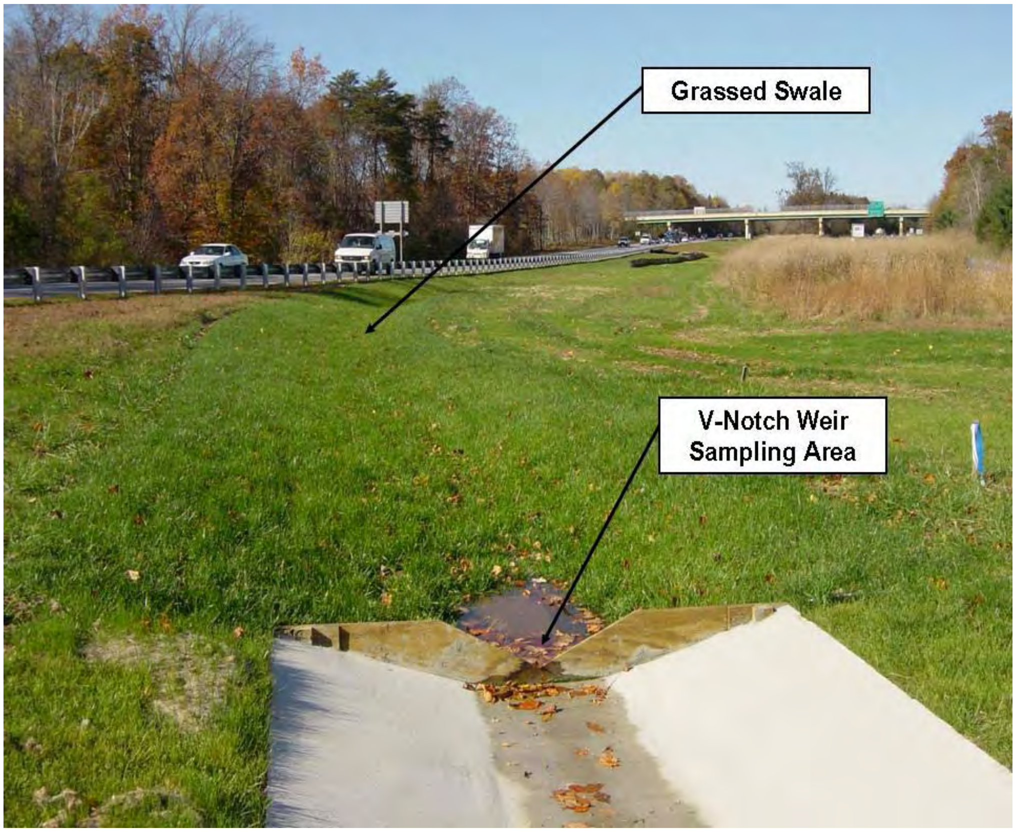

Figure 4. SHA Swale at Rt. 32.

Figure 5. Direct roadway runoff monitoring at Rt. 32.

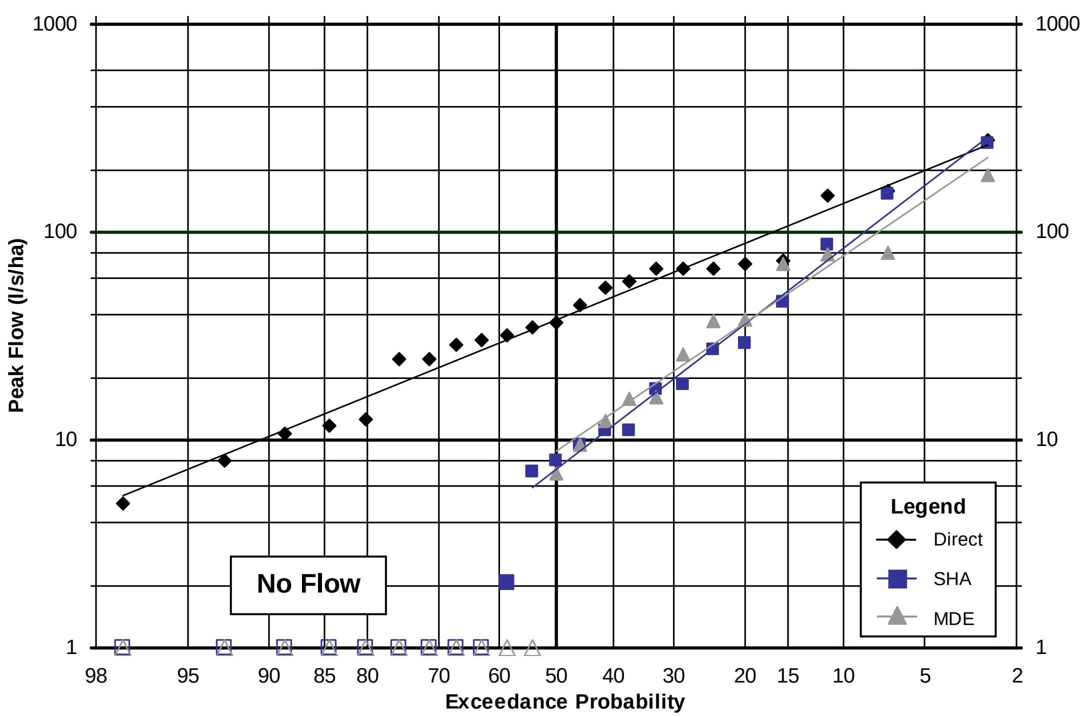

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Figure 6. Peak flow probability plot showing all storm events for influent (Direct) and swale effluent (SHA and MDE) at Rt. 32 Swales.

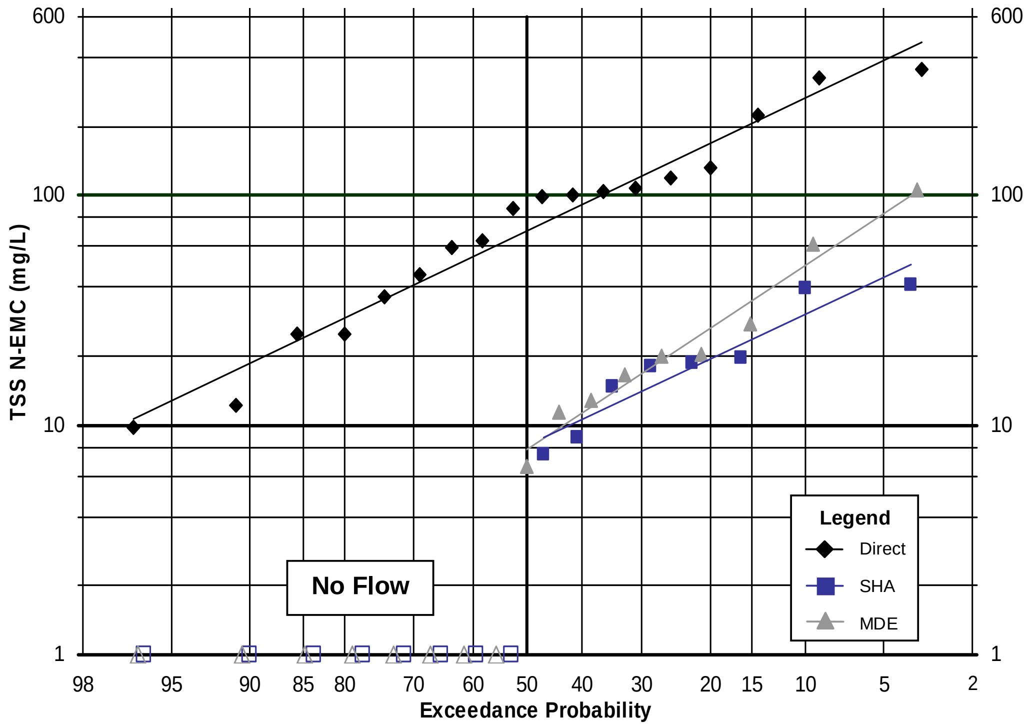

Figure 7. Total Suspended Solids N-EMC probability plot showing all storm events for influent (Direct) and swale effluent (SHA and MDE) at Rt. 32 Swales.

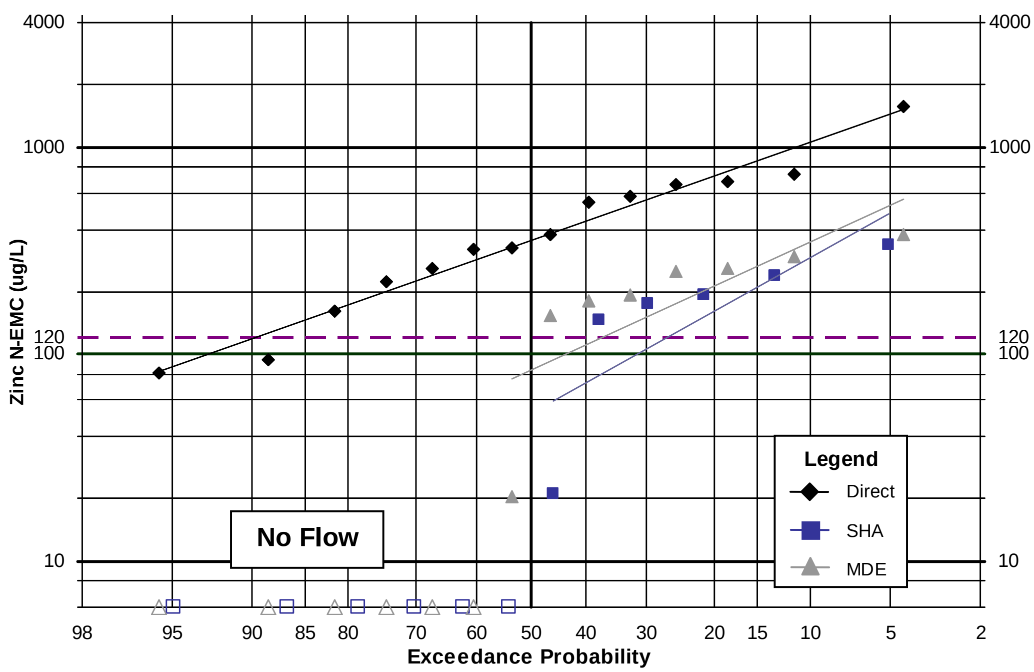

Figure 8. Total zinc N-EMC probability plot showing all storm events for influent (Direct) and swale effluent (SHA and MDE) at Rt. 32 Swales. Dashed line at 120 µg/L is Maryland aquatic toxicity criterion.

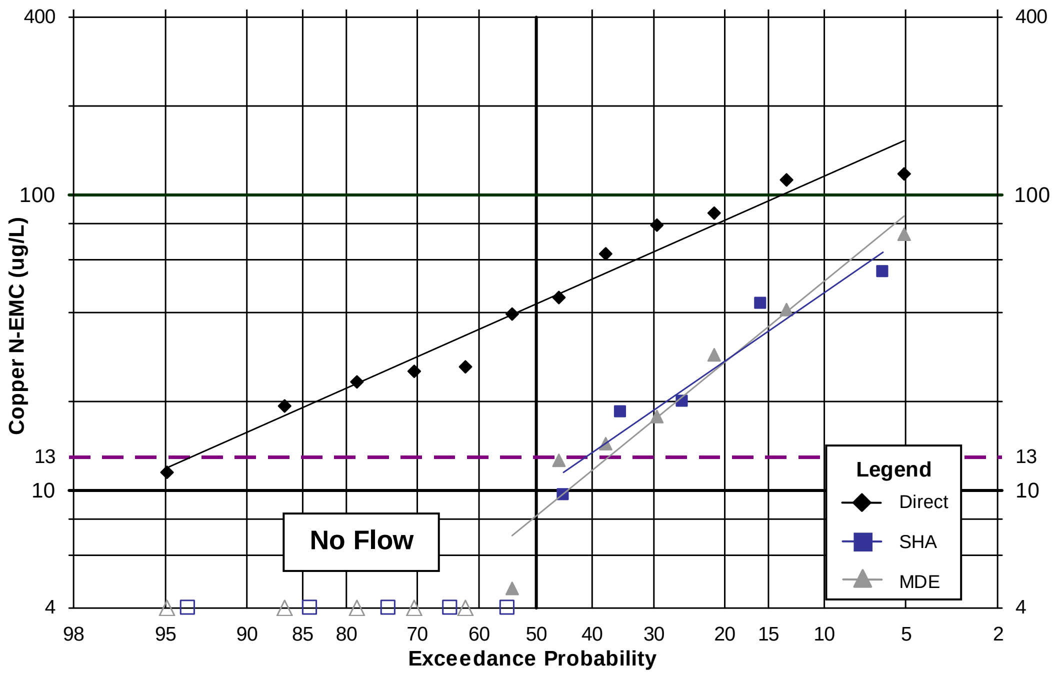

Figure 9. Total copper N-EMC probability plot showing all storm events for influent (Direct) and swale effluent (SHA and MDE) at Rt. 32 Swales. Dashed line at 13 µg/L is Maryland acute aquatic toxicity criterion.

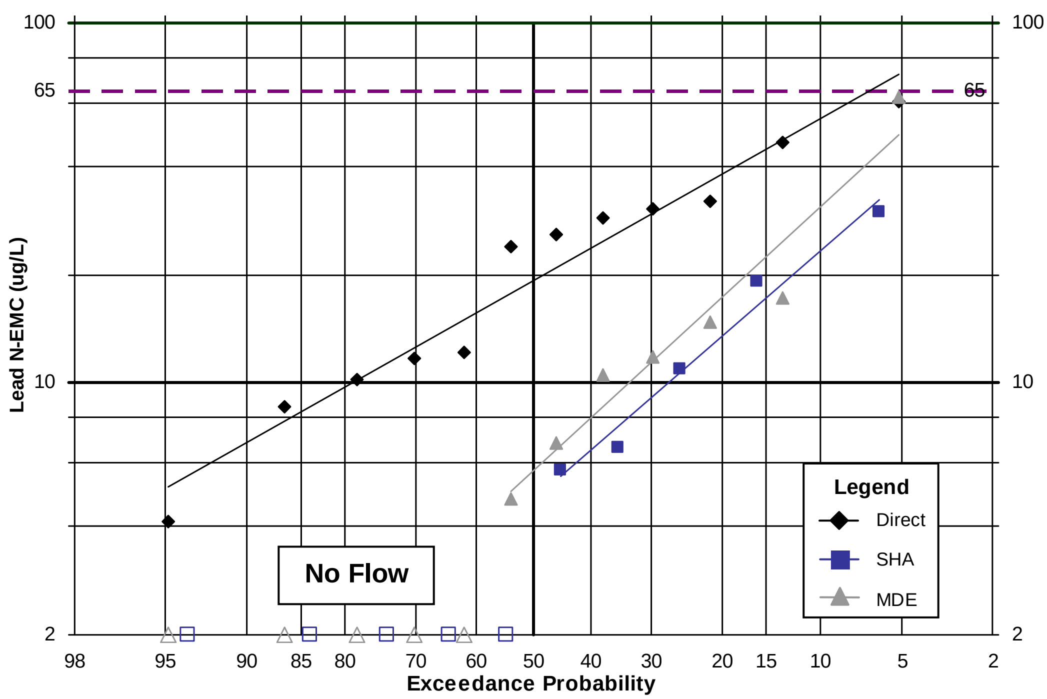

Figure 10. Total lead N-EMC probability plot showing all storm events for influent (Direct) and swale effluent (SHA and MDE) at Rt. 32 Swales. Dashed line at 65 µg/L is Maryland acute aquatic toxicity criterion.

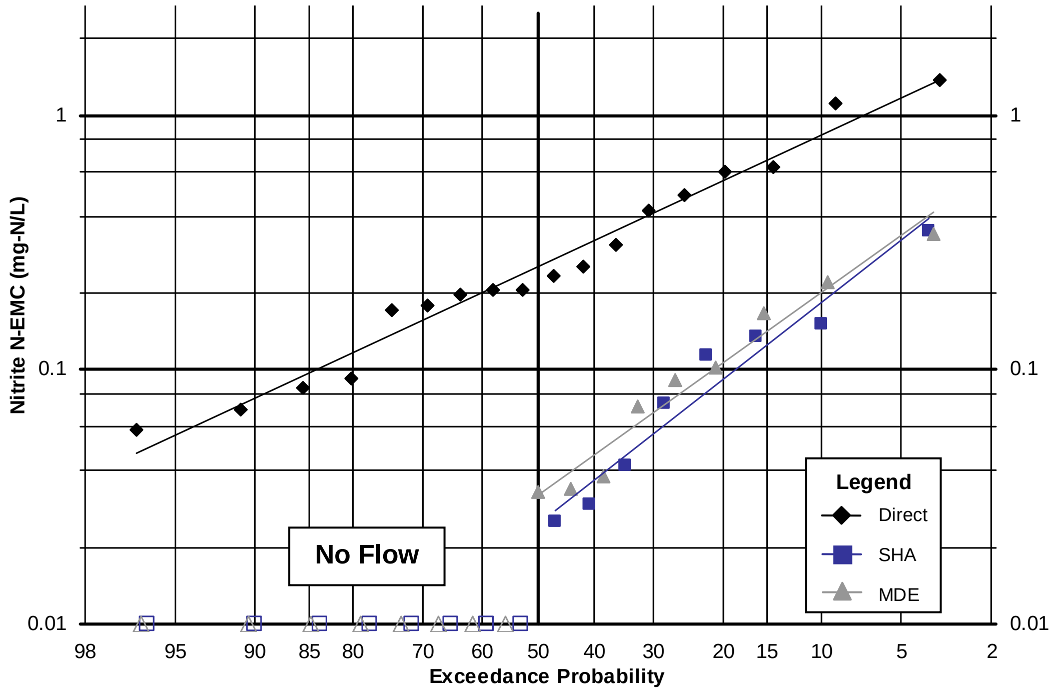

Figure 11. Nitrite N-EMC probability plot showing all storm events for influent (Direct) and swale effluent (SHA and MDE) at Rt. 32 Swales.

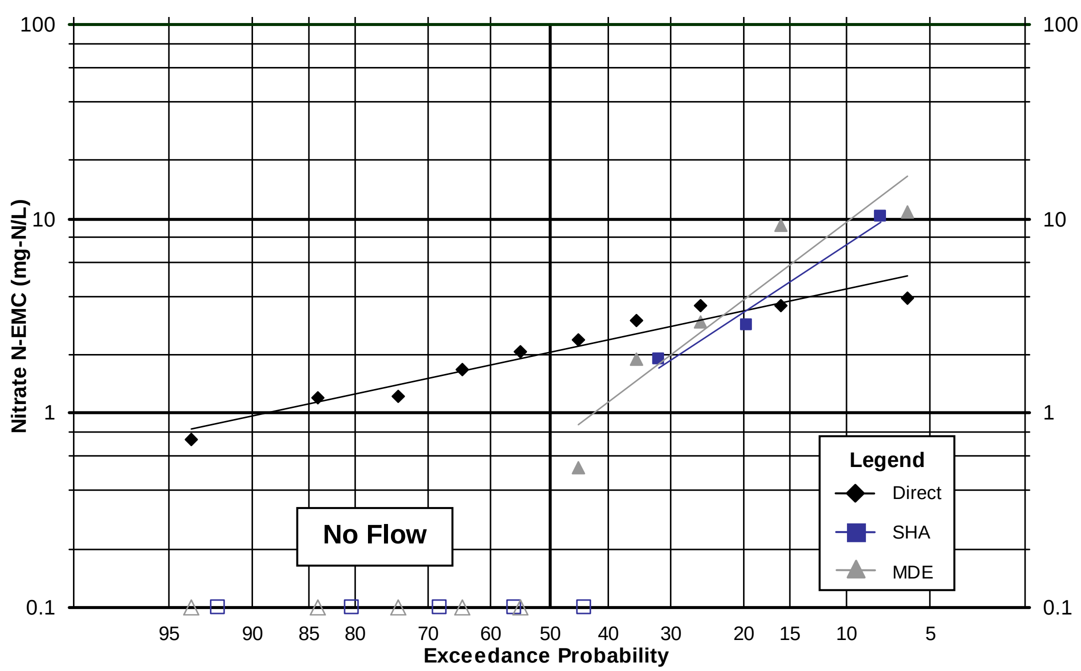

Figure 12. Nitrate N-EMC probability plot showing all storm events for influent (Direct) and swale effluent (SHA and MDE) at Rt. 32 Swales.

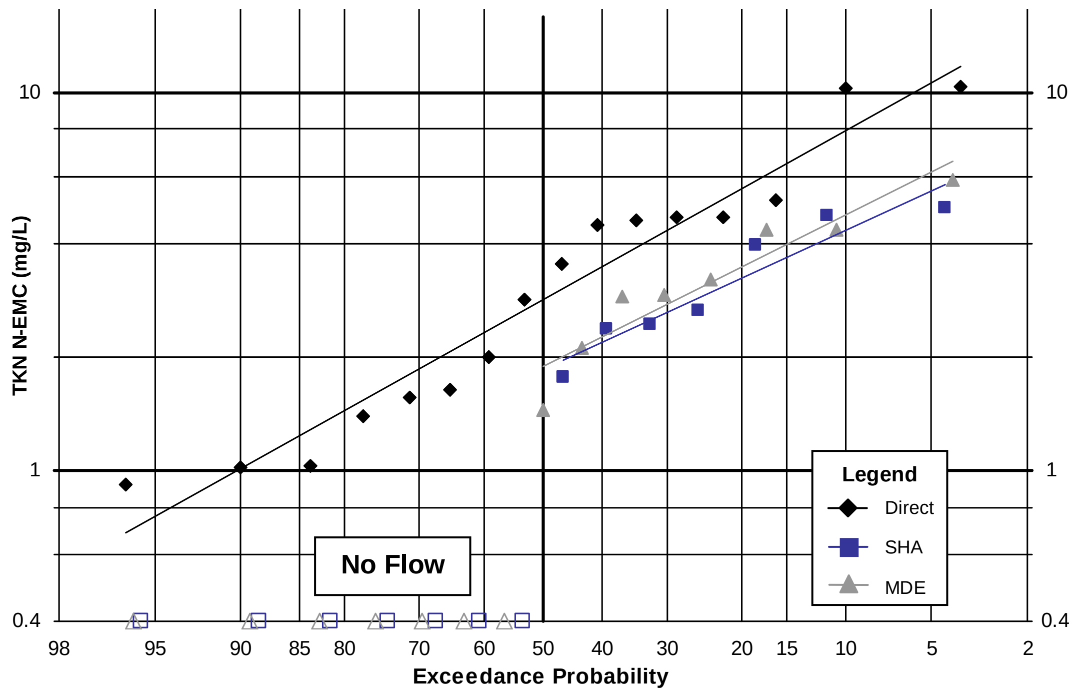

Figure 13. TKN N-EMC probability plot showing all storm events for influent (Direct) and swale effluent (SHA and MDE) at Rt. 32 Swales.

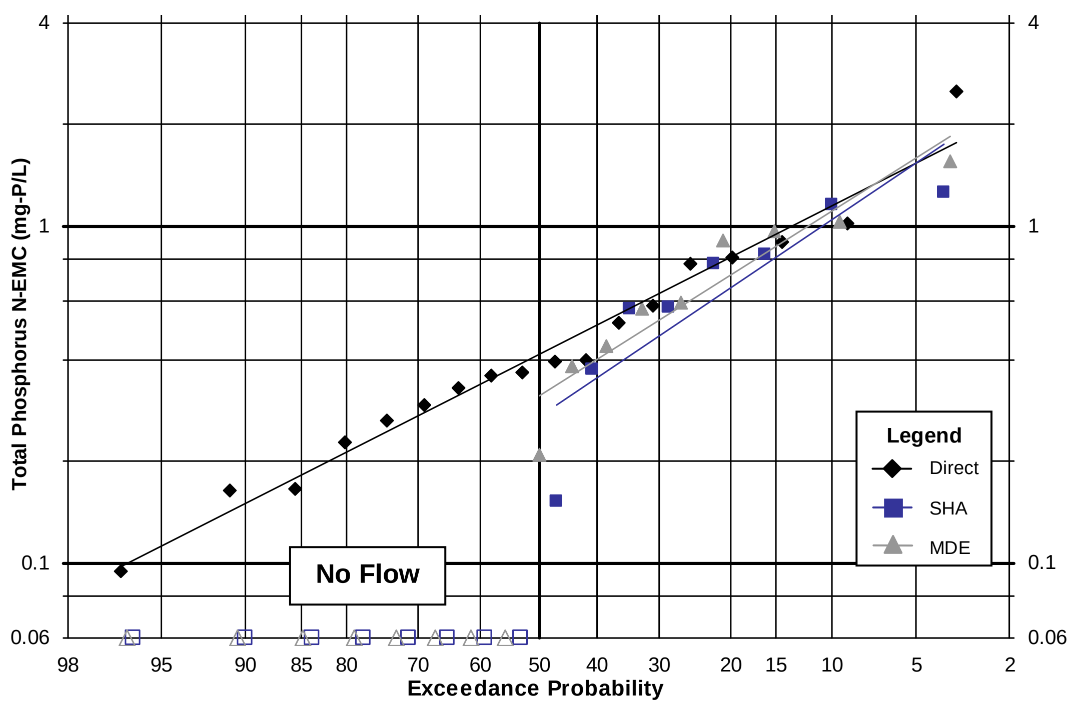

Figure 14. Total phosphorus N-EMC probability plot showing all storm events for influent (Direct) and swale effluent (SHA and MDE) at Rt. 32 Swales.

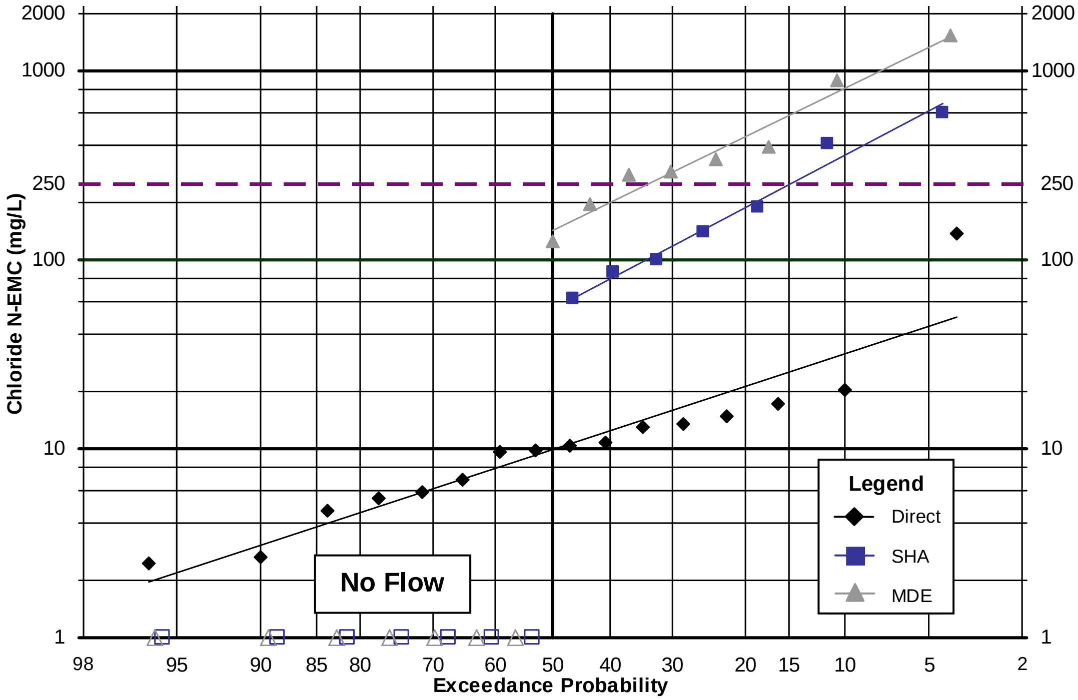

Figure 15. Chloride N-EMC probability plot showing all storm events for influent (Direct) and swale effluent (SHA and MDE) at Rt. 32 Swales. Dashed line at 250 mg/L is level considered dangerous to freshwater aquatic life.

APPENDIX E:

Mosquito Surveillance/Control Program MDSHA SWM Facilities (2003-2005)

Baltimore, Howard, Montgomery and Prince Georges Counties, Maryland

By Millersville University

Mosquito Surveillance/Control Program
MDSHA SWM Facilities (2003-2005) in Baltimore, Howard, Montogmery and Prince Georges Counties, Maryland

Technical Report

Submitted by
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REPORT SUMMARY

The rapid spread of West Nile virus (mid-Atlantic region through the southern United States) has heightened public concern pertaining to health issues associated with stormwater management facilities. Recently, a mosquito surveillance and control study was implemented by the Maryland State Highway Administration (SHA) in order to determine the role of stormwater Best Management Practices (BMPs) in the production of mosquitoes. A pilot study was conducted in 2003 to establish baseline data on mosquito diversity and larval population dynamics as they related to various types of stormwater management BMPs. This information was used as a foundation for a larger and more rigorous study in 2004-2005.

Five types of BMPs were included in this study (n = 6 replicates/BMP type):

- shallow marshes
- retention ponds
- detention/extended detention ponds
- infiltration basins, and
- infiltration trenches.

These facilities are located within four counties in Maryland: Baltimore, Howard, Montgomery and Prince George's.

Mosquito diversity and abundance were monitored every two weeks from June 6 or 10 – September 30 each year. Larval mosquitoes were collected in the field and enumerated and identified in the lab to the species level. An additional component of this study was the implementation of a larval control or abatement program in 2003-2004. The purpose of this program was to train SHA personnel in field mosquito identification and collection as well as assist with field application of a bacterial larvicide specifically formulated to control mosquito and midge larvae.

In general, stormwater BMPs did provide habitat to larval mosquitoes and in some cases, depending on the BMP type and local climatological conditions, produced significantly high numbers of mosquitoes. Mosquito production was significantly impacted by county precipitation amounts from 2004 to 2005. While mosquito production was high in July 2005, there was no significant difference in mosquito production among the four counties in this study. Specifically, the majority of mosquito species in shallow marshes, retention and in some cases detention ponds produced were of little consequence with regards to the potential of West Nile virus (WNV) transmission. Some detention ponds and infiltration basins produced larval mosquitoes implicated in transmitting WNV among birds and mammals including humans. These BMPs should be monitored carefully in the future.

As a result of this three-year effort, several recommendations detailed at the end of this report provide a framework to build an integrated, systems-based approach to manage mosquitoes as well as stormwater in a cost-effective and environmentally friendly manner.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

The entire project was funded by MDSHA and would not have been possible without the assistance of MDSHA employees Sonal Sanghavi, Greg Keenan and Michael Stewart. I would also like to acknowledge the much appreciated assistance in the field and lab by my graduate student, Jenn Davis and a team of MU undergraduate students Erin High, Jen Pyle and Kate Zimmerman whose help was indispensable throughout the duration of this project.

INTRODUCTION

Federal mandate as amended in the Clean Water Act (CWA) in 1987 requires the development and implementation of stormwater management programs by all states to abate problems with runoff and other non-point source pollution (Metzger 2004). While the CWA regulations and recommendations address sediment and other environmental problems associated with the runoff of surface waters entering local waterways, surprisingly, they do not address public health issues such as the production of habitat for nuisance and disease-carrying insects e.g., mosquitoes. Although public health and safety is a major component of all stormwater management programs, mosquito management has been overlooked. In fact, an informal nationwide survey of state stormwater regulations including some sort of strategy or action plan to deal with mosquito control revealed that of the limited information available, most has been developed through mosquito control agencies, university involvement or on a county-by-county basis.

Since initial reports of West Nile virus in 1999, public awareness and concern have increased dramatically in recent years regarding the risks associated with mosquito abundance. Because stormwater management ponds or BMPs (Best Management Practices) hold standing water, their potential as mosquito breeding habitat is high and consequently, their design and maintenance is important in reducing public health risks and concern associated with West Nile and other arboviruses. The primary functions of stormwater management BMPs include: 1) retain water to reduce or remove pollutant runoff from impervious surfaces such as roads, sidewalks and roofs; 2) provide flood control during storm events thus preventing or minimizing damage to roads, buildings and personal property and; 3) slow or impede the flow of stormwater runoff in order to reduce stream bank erosion and suspended sediment loads in adjacent or nearby streams (www.montgomerycountymd.gov/ mc/services/dep/ mosquito/ stormwater.htm). The recent public concerns about West Nile Virus have caused municipalities and developers to reevaluate mosquito and human health related issues as they relate to stormwater management.

Of the many types of stormwater management BMPs, five types were examined in thisstudy: shallow marsh, retention, detention ponds, infiltration basins and trenches. Wet ponds or wetland marshes provide control in terms of water quality and quantity. Dry or Detention ponds, if they are properly maintained usually retain water for periods less than 72 hours (EPA Technical note: Issue 71, 05/2003). The downside of stormwater management is that standing water regardless of duration does provide habitat for mosquitoes and has long been neglected in terms of disease vectors such as mosquitoes and disease-causing agents e.g., West Nile virus, Eastern Equine encephalitis and others.

Background

In terms of economic and health costs worldwide, mosquitoes are arguably medically the most important group of insects. To date, approximately 3000 species of mosquitoes exist worldwide with roughly 60 species inhabiting the state of Maryland. All mosquitoes require an aquatic habitat such as a pond, marsh, treehole, tire, natural/artificial containers, crabholes etc. in which to rear the larval stage (Laird 1988) (Figure 1).

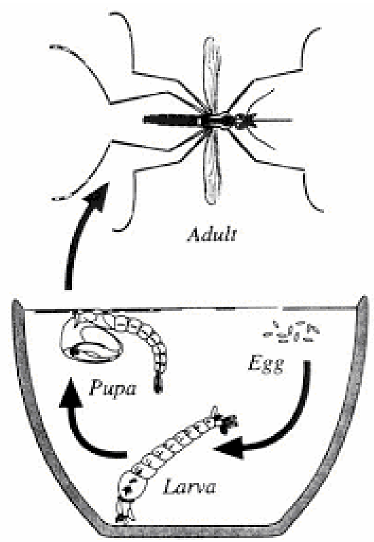


Figure 1. The mosquito life cycle includes an egg, larval and pupal stage, all restricted to an aquatic habitat. Pupae emerge as winged adult male and female mosquitoes, it is only the female that requires a blood meal and can transmit disease-causing organisms such as viruses. (Drawing courtesy of Gauge et al. 2005).

As adult mosquitoes, it is the female requiring a blood meal in order to provide protein necessary for egg yolk production and egg-laying. Mosquitoes can fly 0.5 – 1 mile for a blood meal. It is this behavior that has facilitated the evolution of many disease-causing or pathogenic organisms such as viruses, protozoa, and filarial worms.

At certain times of the year, in many areas of the United States, mosquitoes are formidable nuisance biting insects. They also are responsible for transmitting viruses such as Eastern Equine encephalitis, St. Louis encephalitis, Western Equine encephalitis, dog heartworm (filarial worm pathogen) and West Nile virus.

West Nile virus (WNV) was first identified in the United States in 1999 where it was isolated from human and horse infections in New York (CDCP, 1999). The West Nile viral encephalitis is a zoonosis in which people and horses are incidentally infected by mosquitoes that feed both on bird and mammalian hosts (Komar 2000).

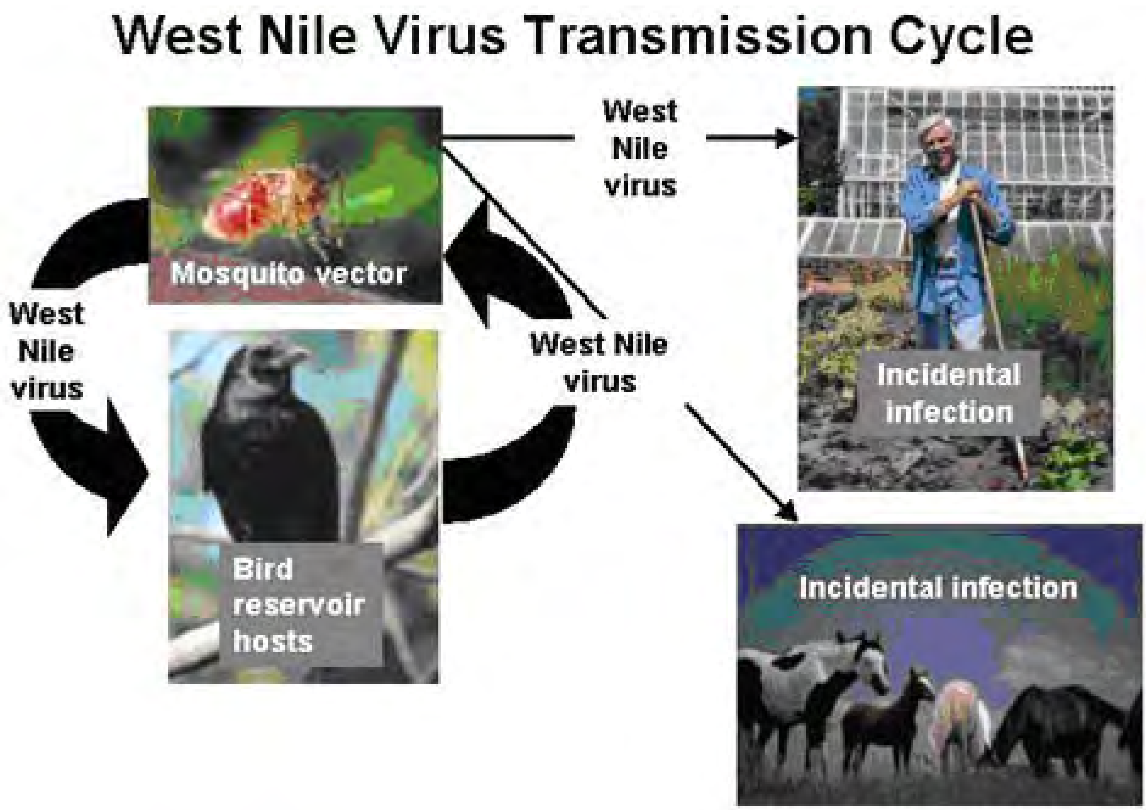


Figure 2. Birds are the primary reservoirs for WNV while humans and horses tend to be dead-end hosts for the virus, i.e., the virus cannot be transmitted from a mosquito biting an infected human/horse and causing a subsequent infection in a second bite. Photos courtesy of www.cdc.gov/ncidod/dvbid/westnile/.

By 2002, WNV had spread over most of the United States excluding Oregon, Nevada, Utah and Arizona with human cases reported from all states excluding those mentioned above and Washington, Idaho and New Mexico. In 2002, approximately 604 birds of 1650 examined for WNV tested positive from 23 counties in Maryland. In addition, 16 horses tested positive from the following 7 counties: Anne Arundel, Dorchester, Frederick, Howard, Montgomery, Prince George's and Washington. Approximately 46 mosquito pools of the 6100 pools examined in Maryland for WNV tested positive. There were 31 human WNV cases identified from nine counties in Maryland (http://edcp.org/html/wn_surv.html).

As a result of the rapid spread of WNV across the United States as well as the tremendous economic and health impact it has had on human and horse populations, the focus of mosquito abatement and control programs to regulate mosquito populations quickly turned to stormwater management BMPs. The control of mosquitoes either in the larval or adult stages involves the application of pesticides, some chemical and some biological. Such pesticide use is regulated under federal regulation under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) within the guidelines of the CWA. In 2002, the House Subcommittee on Water Resources and Environment convened a hearing to discuss the CWA and mosquito control. However, rulings on several cases resulted in mixed interpretations of the current legal situation in terms of community, industry and any other private or public entity's use of pesticides with regards to the restrictions of the CWA. In light of this problem, the Division of Emergency and Environmental Health services (within the Center for Disease Control and Protection) has suggested a more integrated systems-based approach to control mosquitoes when designing stormwater management facilities (www.cdc.gov/ncidod/dvbid/westnile/index.htm).

In order to comprehend the dynamics of how and why West Nile has increased to epidemic proportions among birds and threatened certain human populations in a relatively short time period and develop an integrated pest management strategy to control mosquito populations ensuring public health policies, an understanding of larval mosquito biology is needed (Mostashari et al. 1999; Peterson et al. 2006). Larval mosquito habitats are very diverse and include container habitats such as tree holes and tires to more open habitats such as swamps or marshes, temporary ponds natural floodwater pools and man-made stormwater ponds or basins. The significant increase of West Nile virus across the United States and especially in Maryland warrants a more thorough understanding of larval habitats in terms of the role that anthropogenic or anthropogenic habitats such as stormwater ponds play in this mosquito-borne public health issue.

Project Scope

The purpose of the first year (2003) of this project was to initiate a pilot study on the larval and adult mosquito population dynamics associated with three types of stormwater management BMPs (shallow marsh, retention and detention ponds) as well as train MDSHA personnel to collect mosquito larvae and perform control efforts for future mosquito abatement. Based on the preliminary results of this pilot study, a more thorough surveillance program of five stormwater BMPs (shallow marsh, retention, detention ponds, infiltration basins and trenches) was established for the following two years of the study and divided into two phases, a *surveillance phase* and a *control phase*. Because climatological conditions vary from year-to-year and stormwater BMPs change or evolve over time, it is unknown how larval mosquito populations change as well, thus, it is critical to maintain monitoring efforts to more fully understand this relationship. The objectives for the *surveillance phase* included: 1) an assessment of larval and adult mosquito diversity among the identified BMPs and; 2) a comparison of the spatial and temporal distributions of mosquito larvae among these types of stormwater BMP. For the *control phase*, the objectives were: 1) to initiate an abatement program and determine the efficacy of larval control among the types of stormwater BMPs examined in this study; 2) to train MDSHA personnel on mosquito surveillance, sampling and larvicide application for mosquito control and; 3) provide an integrated pest management program for MDSHA. Such a program will serve as a model or template for other county stormwater habitat management decisions as they relate to mosquito surveillance and control.

METHODS

Study Sites

Mosquito surveillance activities were conducted from May – September, 2003 – 2005. Three types of stormwater management BMPs were examined in 2003: shallow marsh, retention and detention ponds (3 replicate BMPs/type). In 2004 – 2005, two additional BMP types were added to the study: infiltration basins and trenches (6 replicate BMPs/ type) (Figures 3-7). All sites were located in Baltimore, Howard, Montgomery and Prince George's Counties, Maryland (See Appendix). Therefore, a total of 30 study sites were identified (as stated earlier) among four counties. All sites in 2004 were observed to be in an advanced state of succession (in terms of vegetation growth) and poorly maintained (as determined by trash accumulations, duration of aquatic phases in detention ponds).

Figure 3. Example of a shallow marsh BMP located in Howard County, MD.

Figure 4. Example of a retention pond BMP located in Howard County, MD (2003).

Figure 5. Example of a detention pond BMP located in Montgomery County, MD.

Figure 6. Example of an infiltration basin located in Montgomery County, MD.

Figure 7. Example of an infiltration trench located in Montgomery County, MD.

While the selection of all BMP ponds was based on logistical constraints, to better understand mosquito population biology in a variety of BMP sites, BMPs identified for this study were selected randomly adjacent to highways or major roads as well as proximity to residential neighborhoods, office complexes, schools and hospitals throughout Howard, Montgomery, Baltimore and Prince Georges counties.

Mosquito Surveillance

Larval mosquitoes (50 dips/site) were collected using 250ml mosquito dippers from around the periphery of each site from June – September (Figure 8). Each site was sampled every two weeks during the pilot study and each consecutive field season. Mosquito larvae were preserved in 95% ethanol and transported to the laboratory for identification, enumeration according to species, habitat and sample date. Mosquitoes were identified to species level using a dichotomous key from Darcie & Ward (2005).

Adult mosquitoes were only collected during the June - September 2003 sampling period with gravid and CDC CO_2 traps. Gravid traps were used to collect blood-fed female mosquitoes searching for an oviposition or egg-laying habitat and use a “stink juice” mixture composed of hay infusion with pond water and leaves as an attractant. These traps tend to collect more *Culex* species of mosquitoes than other genera which is important as certain *Culex* species (e.g., *Culex restuans* and *Cx. pipiens*) are the primary vectors of WNV among bird populations. In order to understand adult diversity more completely, CDC CO_2 traps were used to collect adult mosquitoes questing or searching for a blood meal. This trap type typically does not discriminate among mosquito taxa except for those who do not require blood meals. Adult mosquito surveillance was discontinued in 2004-2005 because of a shift in the focus of mosquito control from the adult to larval stage.

Figure 8. MU student, Erin High collecting mosquito larvae using a mosquito dipper.

Water Chemistry

Precipitation amounts were recorded on a monthly basis 2003-2005 from the Maryland State climatologist website: http://www.atmos.umd.edu/~climate/. Water chemistry such as pH and conductivity were measured using a Hanna Combo pH/EC Probe during the 2004-2005 seasons.

Larval Mosquito Control

Several of the more recent mosquito biological control agents such as bacteria (*Bacillus thuringiensis* var. *israelensis* and *Bacillus sphaericus*) must be ingested by mosquito larvae to be effective (de Barjac and Sutherland 1990). Both bacilli species are obligatory stomach poisons (Davidson and Yousten 1990) and once inside the larval mouth, generally penetrate the tissues of the digestive tract causing the death of the mosquito larva. During 2003 and 2004, control efforts were focused on larval mosquitoes and BMPs were treated with a biological insecticide, *Bacillus thuringiensis* var. *israelensis* (Bti) in 2003 and 2004. In August, 2003, mosquito control was conducted by a local pest management firm, American Pest Management, Inc. (Figure 9). Results from the initiation of this phase in 2003 were very successful in terms of controlling 98-99% of the mosquito larvae 48 hours post-treatment. In August 2004, Angels Systems conducted mosquito control efforts. The amount of larvicide used was determined as a function of the area to be treated. When control began, 3 sites per

BMP type = 15 sties per date. There were 3 control site/BMP type = 15 control sites which no larvicide was applied.

Figure 9. Local pest management person applying larvicide in a retention BMP.

To determine percent reduction from control efforts, larval samples (50 dips/site) were collected from each site approximately 24 hours prior to treatment. In 2003, one site per BMP was randomly selected as a treatment and control site. There was no replication of treatment or control per BMP due to limited number of sites. Because of low water levels at the time of treatment in 2004, there were 2 replicate for treatment and control per BMP except for Infiltration Basins (Treatment = 1 site; Control = 2 sites). Larvae were preserved as stated above and identified to species in the lab. Larval samples (50 dips/site) were collected 72 hours post-larvicidal treatment. The following formula was used to calculate the percent reduction per site as well as per species.

$$\% \text{ Reduction} = 100 – (C1/T1 \text{ X } T2/C2)$$

where C1 = average number of larvae in pre-treatment control (untreated) sites;
T1 = average number of larvae in pre-treatment (treated) sites;
C2 = average number of larvae in post-treatment control (untreated) sites;
and T2 = average number of larvae in post-treatment (treated) sites.

Statistical Analyses:

RESULTS

The findings from the overall study are divided into two categories, Part I - Pilot Study which included only 2003 results, and Part II - Two-Year Study (2004-2005), which included modifications learned from the Pilot Study.

Pilot Study (2003):

Average ambient temperatures around Washington, D.C. area were greatest in July and August, 2003. Precipitation was higher in late spring and early summer, 2003, with the least amount of rainfall occurring during July and August (Table 1). The combination of higher temperatures and lower precipitation caused water depth in the BMPs to fluctuate throughout the study period. By July 22, water depth in ponds 1(Shallow marsh), 2, 5 (Retention ponds),4,7 and 9 (Detention ponds) was significantly lower approximately 2-3 feet/pond or dry completely, as was the case with pond 9. Water levels remained low throughout August and part of September.

Table 1. Average Temperature and Total Precipitation for the Washington D.C. Area May – September, 2003

Month	Average Temperature (°F)	Total precipitation (inches)
May	59.7	8.75
June	69.2	8.27
July	75.4	6.1
August	76.2	5.6
September	67.1	7.33

http://lwf.ncdc.noaa.gov/oa/climate/research/cag3/

Larval Mosquito Surveillance

There were 4,530 larvae collected over the study season represented by nine taxa. In general, the larval mosquito fauna was similar among the three types of stormwater management BMPs throughout the duration of this season (Table 2). However, from a temporal perspective, the percent relative larval abundance differed among the three types of stormwater BMPs.

Table 2. List of Mosquito Larval Species per Stormwater BMP (June 3 – Sept. 25, 2003)

Habitat	# species	Species
Shallow Marsh	9	*Anopheles quadrimaculatus* *Anopheles punctipennis* *Culex territans* *Culex restuans* *Culex pipiens* *Culex erraticus* *Culex salinarius* *Uranotaenia saffarina* *Aedes vexans*
Retention Pond	8	*Anopheles quadrimaculatus* *Anopheles punctipennis* *Culex territans* *Culex restuans* *Culex pipiens* *Culex erraticus* *Uranotaenia saffarina* *Aedes vexans*
Detention Pond	7	*Anopheles quadrimaculatus* *Anopheles punctipennis* *Culex territans* *Culex restuans* *Culex pipiens* *Culex erraticus* *Aedes vexans*

In shallow marsh habitats, 2 taxa (*Culex territans* and *Anopheles punctipennis*) comprised 85 - 90% of the culicid population. However, July 22 marked a shift in species composition in the shallow marsh BMPs. *Culex territans* populations continued to increase post July 22, whereas anopheline (*Anopheles punctipennis* and *An. quadrimaculatus*) numbers decreased to less than 10% of the total larval abundance by September 11 (Figure 10).

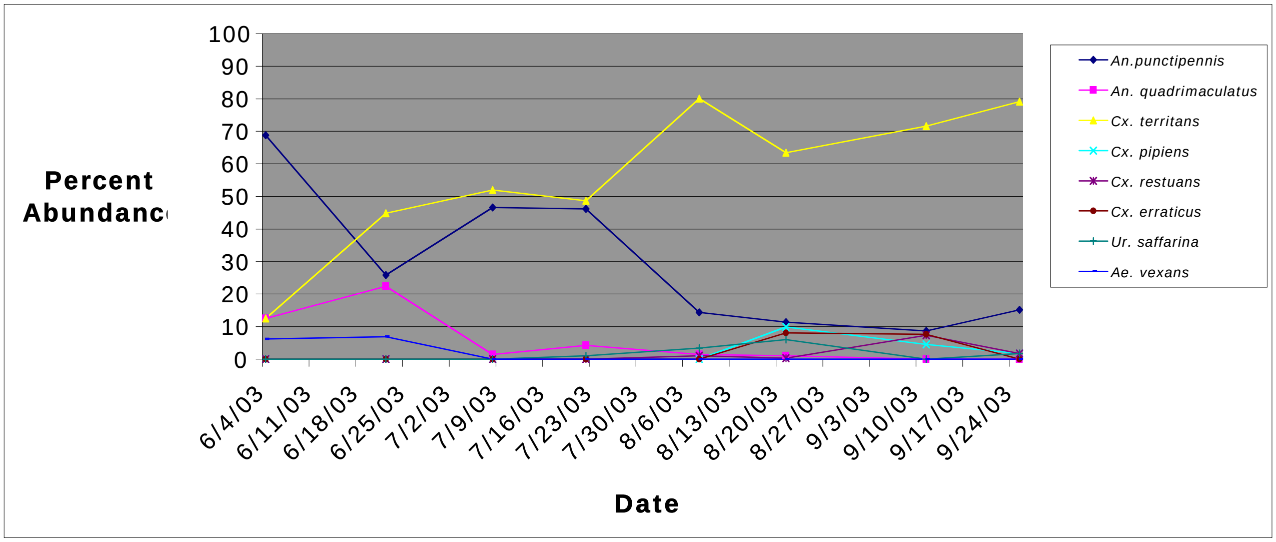


Figure 10. Percent abundance of all larval culicids collected per sample date from Shallow Marsh BMPs (n = 3 ponds). (Sample sizes per collection date: 6/4 = 16; 6/22 = 58; 7/8 = 296; 7/22 = 238; 8/8 = 146; 8/21 = 333; 9/11 = 614; 9/25 = 158.)

Contrary to shallow marsh habitats, *Cx. territans* was initially the dominant species in retention ponds but decreased in abundance by July 22, while *An. punctipennis* abundance increased in the latter half of the study (Figure 11).

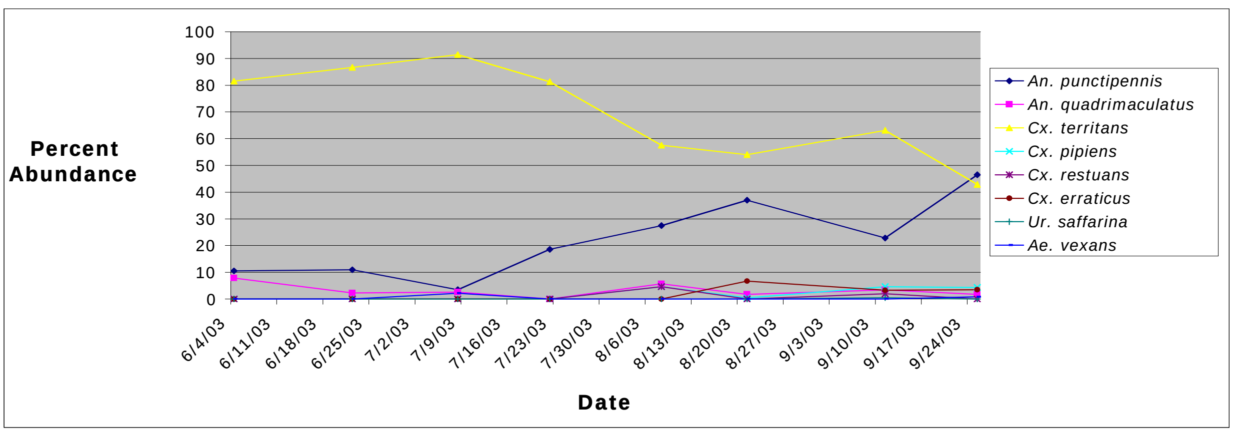


Figure 11. Percent abundance of all larval culicids collected per sample date from a Retention BMPs (n = 3 ponds). (Sample sizes per collection date: 6/4 = 38; 6/22 = 128; 7/8 = 223; 7/22 = 231; 8/8 = 193; 8/21 = 281; 9/11 = 429; 9/25 = 114).

Since standing water levels frequently fluctuate in detention ponds, larval mosquito populations tended to be variable. In detention ponds, the most abundant species early in the season, *Cx. territans*, was replaced by *Aedes vexans* and *An. punctipennis* larvae by late July. *Culex territans* increased again in abundance later in the season (Figure 12).

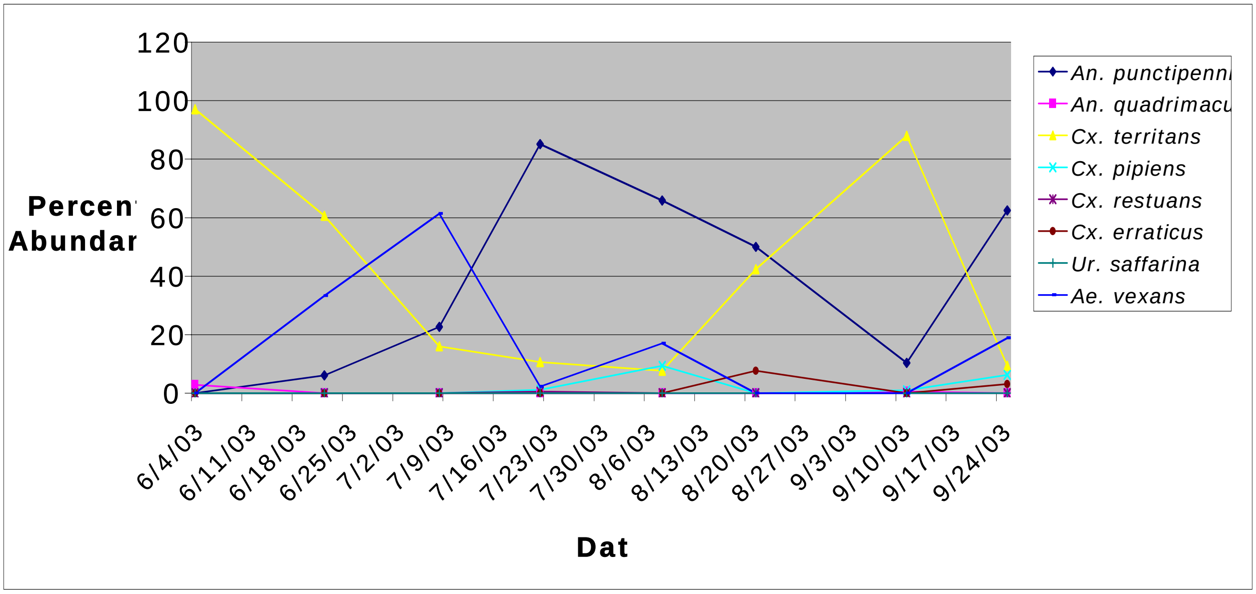


Figure 12. Percent abundance of all larval culicids collected per sample date from detention ponds (n = 3 ponds). (Sample sizes per collection date: 6/4 = 70; 6/22 = 66; 7/8 = 150; 7/22 =169; 8/8 = 302; 8/21 = 52; 9/11 = 192; 9/25 = 32).

Larval Mosquito Control

The percent reduction among shallow marsh, retention and detention ponds in 2003 did not statistically differ (Table 3). Likewise, when percent reduction was examined among the different larval taxa within the treated sites, larvicidal treatment reduced larval numbers between 98 – 100 percent, with the exception of one species in the treated detention pond (Table 4).

Table 3. Percent reduction among the three types of stormwater management BMPs examined in during the pilot study of 2003.

BMP	% Reduction
Shallow Marsh	99.6
Retention Pond	99.9
Detention Pond	99.6

Table 4. Percent reduction among dominant culicid species sampled from shallow marsh, retention and detention pond BMPs.

BMP	Species	% Reduction
Shallow Marsh	*Anopheles quadrimaculatus*	99.5
	An. punctipennis	99.2
	Culex territans	99.9
	Culex pipiens	100
Retention Pond	*An. quadrimaculatus*	99.1
	An. punctipennis	99

Table 4. Percent reduction among dominant culicid species sampled from shallow marsh, retention and detention pond BMPs.

BMP	Species	% Reduction
	Cx. territans *Cx. erraticus*	99.9.8
Detention Pond	*An. quadrimaculatus* *Cx. territans* *Aedes vexans*	98.9 negligible 99.7

Adult Mosquito Surveillance

Two types of traps were used to collect adult mosquitoes over the study period from June 3 – September 25, 2003. There were 1,456 mosquitoes collected in gravid traps (2 traps/habitat/date) represented by 9 taxa compared to 144 mosquitoes collected in CDC CO_2 traps (trap/habitat/date) represented by 7 taxa (Table 5).

Table 5. List of adult mosquito taxa collected in gravid and CDC CO_2 traps from each stormwater BMP (June 3 – Sept. 25, 2003).

Taxon	Shallow Marsh	Retention Pond	Detention Pond
Gravid Trap			
Culex restuans	X	X	X
Cx. pipiens	X	X	X
Cx. salinarius	X	X	
Cx. territans	X	X	X
Cx. spp.		X	X
Anopheles punctipennis	X	X	X
Aedes vexans	X	X	X
Ochlerotatus japonicus	X	X	X
Uranotaenia saffarina		X	
Total Number of species in each BMP	**7**	**9**	**7**
CDC CO_2 Trap			
Coquilletidia perturbans		X	
Culex restuans	X	X	X
Cx. pipiens	X		
Cx. erraticus		X	
Cx. salinarius	X	X	X
Aedes vexans	X	X	X
Anopheles punctipennis	X		
Total Number of species in each BMP	**5**	**5**	**3**

Although the sampling methods employed do not yield the statistical rigor to use inferential statistics to compare the two collection techniques, it appears that gravid traps collected more mosquitoes and a greater diversity than the CDC CO_2 traps. Seven species were collected from shallow marsh habitats, with *Culex restuans* representing the most abundant in the first half of the summer. Three other taxa, *Culex pipiens*, *Anopheles punctipennis* and *Aedes vexans* were also common in these traps (Figure 13A).

A.

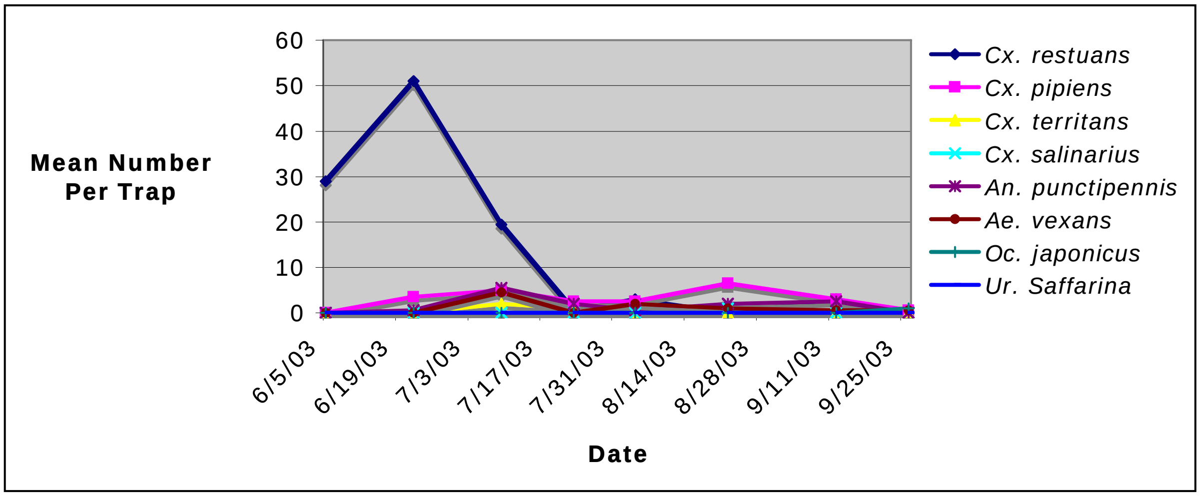
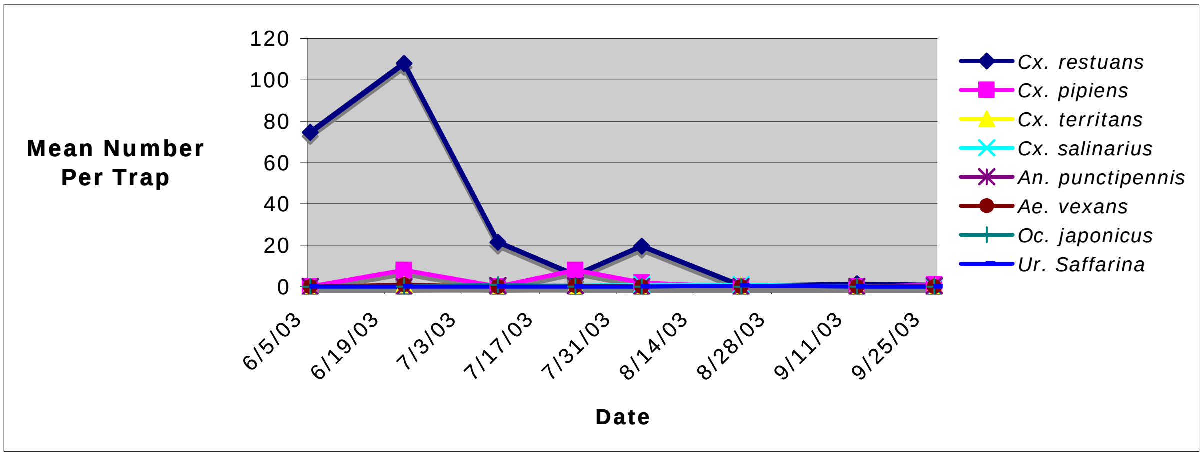


Figure 13A. Mean number of adult mosquitoes collected per gravid trap from Shallow habitats during June– September, 2003.

While gravid trap collections of adult mosquitoes from retention ponds yielded the greatest diversity of mosquitoes, most non-*Culex* taxa were represented in low abundance in this type of trap (Figure 13B). *Culex restuans* mosquitoes exhibited a bimodal peak in mean abundance per trap with greatest numbers in June and a second peak in early August, 2003. *Culex pipiens* abundance exhibited a bimodal distribution but appear to be significantly lower and lagging behind *Cx. restuans* numbers in retention ponds.

Adult mosquitoes collected in gravid traps from detention ponds showed a similar bimodal distribution in *Cx. restuans* and *Cx. pipiens* abundance to that in retention ponds (Figure 13C). However, *Cx. pipiens* numbers increased later in August, 2003 and replaced *Cx. restuans* as the most abundant adult mosquito in these traps late in the season. As in retention ponds, non-*Culex* taxa were not collected in high numbers throughout most of the season.

B.



C.

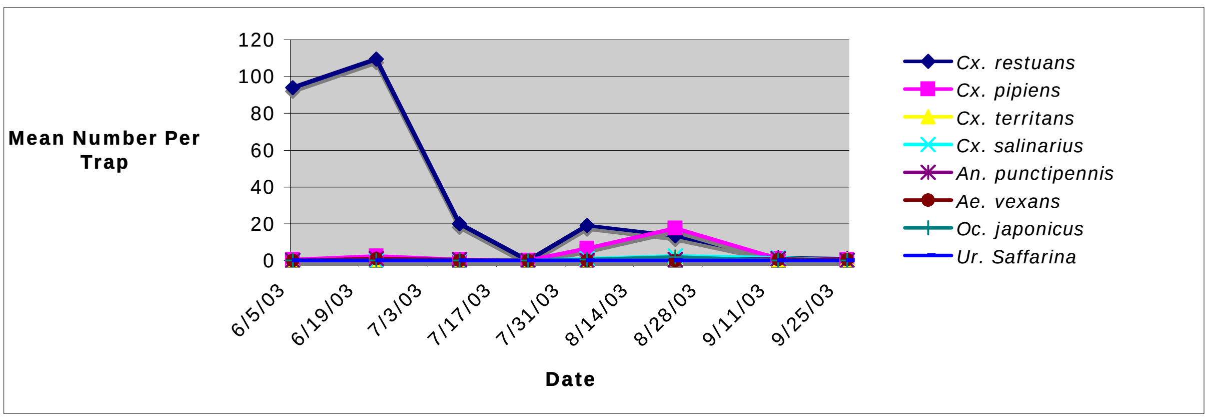
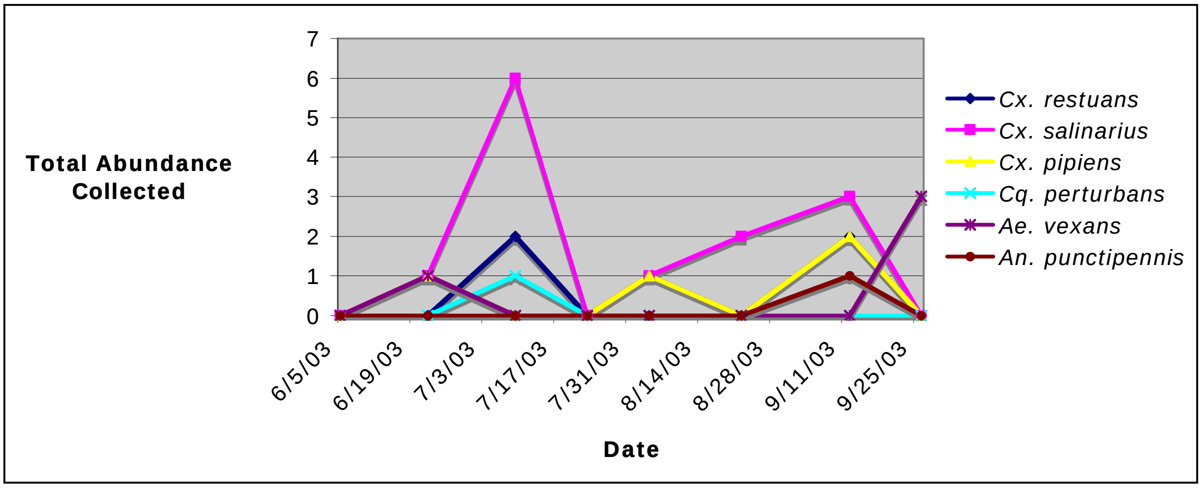


Figure 13B,C. Mean number of adult mosquitoes collected per gravid trap from Retention Ponds (B) and Detention Ponds (C) habitats during June– September, 2003.

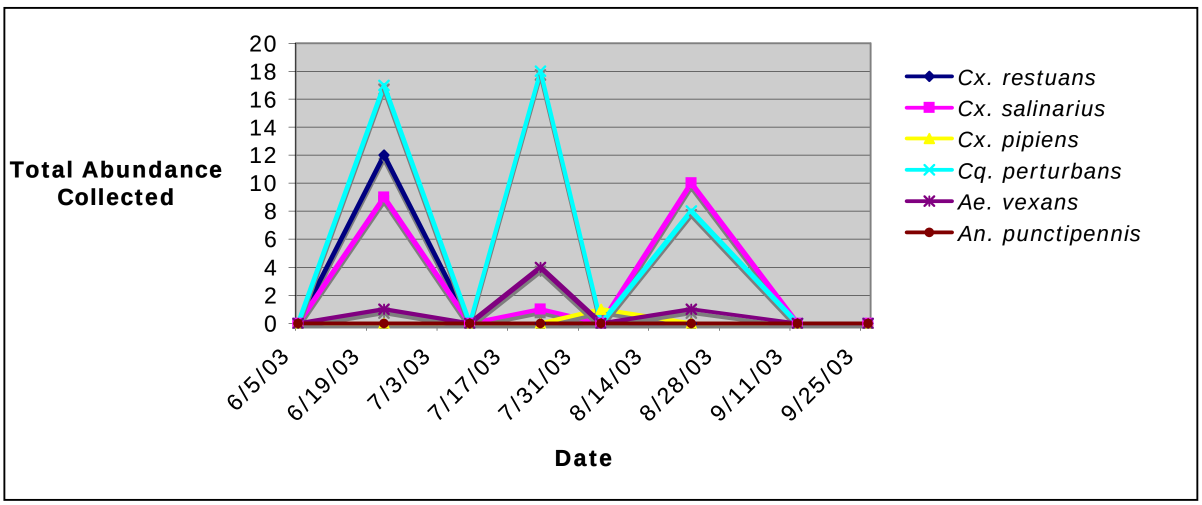
Adult mosquito collections with CDC CO_2 traps indicate the total abundance of other *Culex* species as well as non-*Culex* taxa which may play a role in the transmission of WNV such as *Anopheles punctipennis* , *Aedes vexans* and *Coquillitidia perturbans* among the BMPs. Total abundance was used because only 1 trap per BMP yielded adult mosquitoes. In shallow marsh habitats, the CDC CO_2 trap collected five mosquito species throughout the study season (Figure 14A). *Culex salinarius* (a potential bridge vector, i.e., a mosquito which may playa role in transmitting WNV to humans) and Cx. pipiens (a bird feeding mosquito) displayed a bimodal distribution in CDC trap collections, i.e., peak numbers collected were at the beginning and end of the season.

In retention ponds, CDC CO_2 trap collections show that *Cq.perturbans* and *Cx. salinarius* were most abundant in this trap type early in the season (Figure 14B). By late August, *Cq. perturbans* and *Cx. salinarius* had the greatest abundance in these traps. *Culex restuans* was abundant in these traps early in the season, while *Aedes vexans* was collected in the middle of the summer but was in low abundance by September.

A.



B.



C.

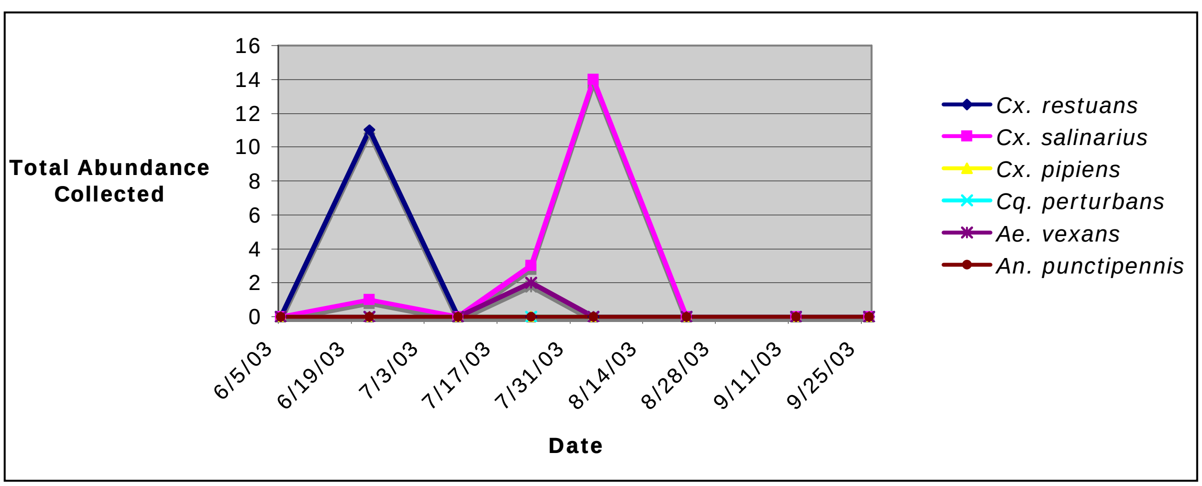


Figure 14. Percentage of adult mosquitoes collected per CDC CO_2 trap from shallow Marsh (A), Retention Ponds (B) and Detention Ponds (C) habitats during June– September, 2003.

The two most abundant mosquito taxa collected in a CDC CO_2 trap from a detention pond were *Cx. restuans*, and *Cx. salinarius* (Figure 14C). It appears that *Cx. restuans* was replaced in these collections late in the season by *Cx. salinarius*. *Aedes vexans* was collected in the CDC trap but was in very low abundance and only collected in mid season 2003.

Part II: Two-Year study (2004-2005)

After the pilot study, a two-year project was initiated with increased replication and diversity of stormwater BMPs. The results in this section pertain to the two-year study of 2004-2005.

Precipitation and Water Chemistry

Overall, significantly more rain fell in 2004 compared to 2005 (F-stat = 5.41; $P < 0.05$). The four counties within this study differed as well in total rainfall, i.e., significantly more rain fell in Baltimore County in 2004 compared to 2005 (F stat = 6.13; $P < 0.05$) (Figure 15). Although in 2005, more than 8 inches of rain fell in one location in Montgomery county, rainfall amounts did not significantly differ among the other three counties.

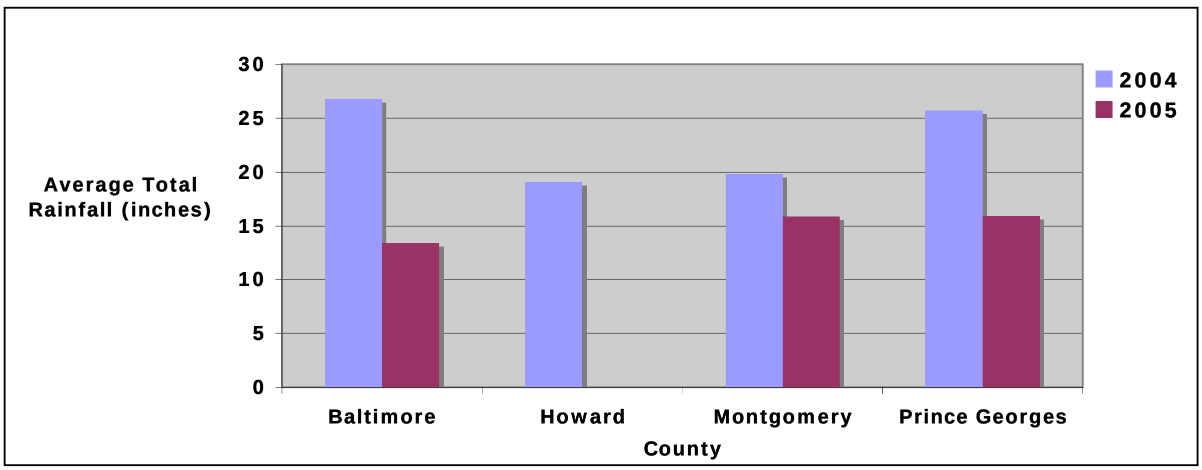


Figure 15. Total rainfall amounts for Baltimore, Howard, Montgomery and Prince Georges Counties in 2004 – 2005.

Howard County was omitted from this comparison because of the paucity of data available to compare with the other counties.

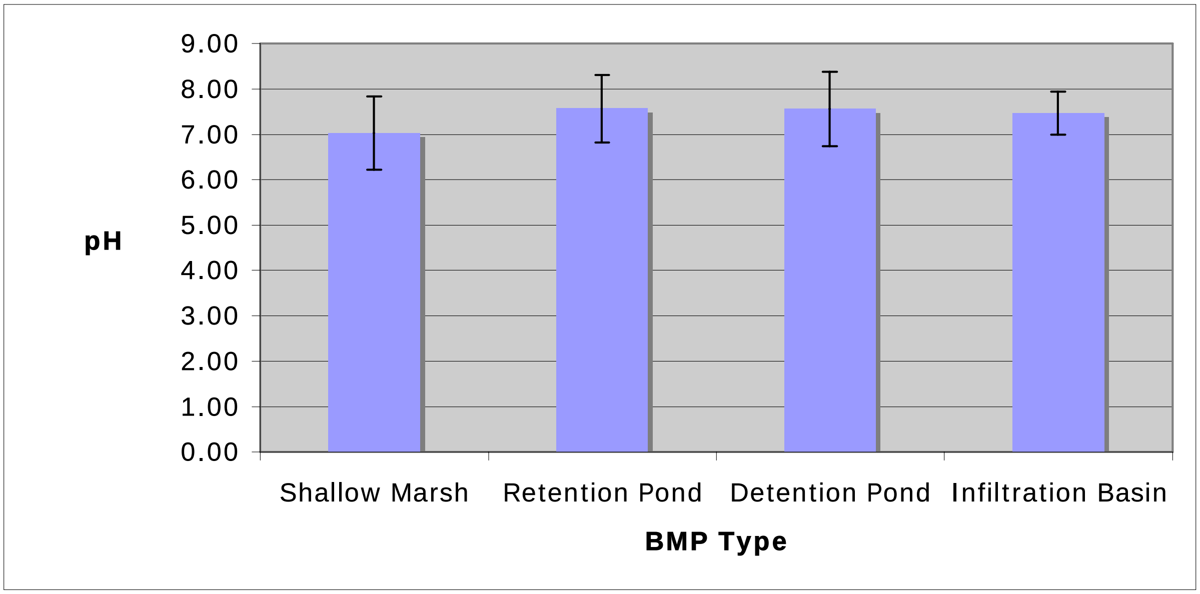


Figure 16. The average pH for all BMP types in 2005. Error bars represent 1 SD.

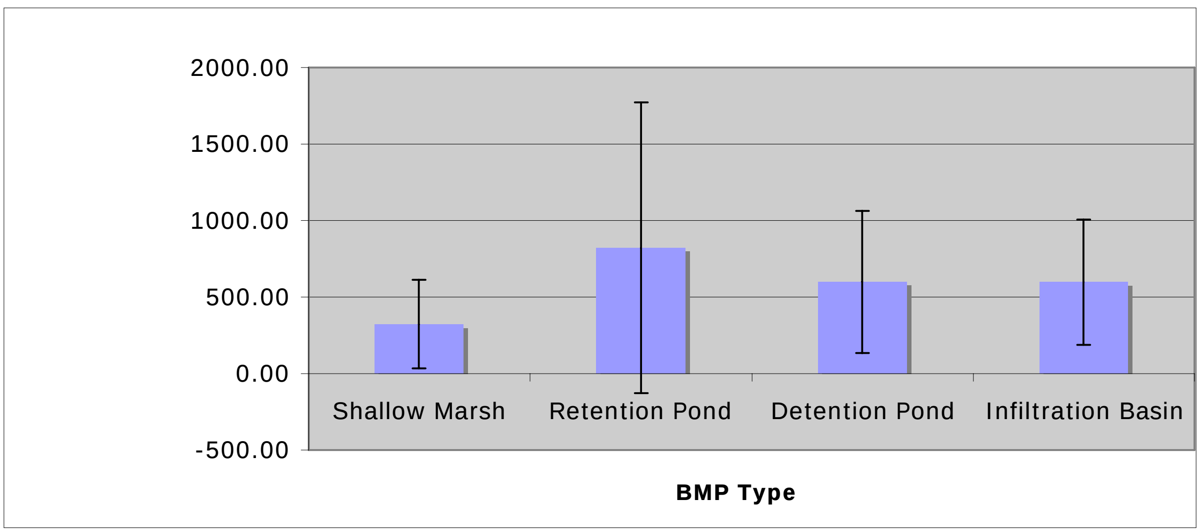


Figure 17. The average specific conductivity for all BMP types in 2005. Error bars represent 1 SD.

The pH of the shallow marsh BMP type was significantly lower compared to the other types ($F = 3.15$; $P < 0.05$) (Figure 16). The pH for Infiltration Trenches was not recorded for 2005 because no standing water was found during this time period. Because variances for specific conductivity values were heterogeneous, values were (log+1) transformed to normalize variances. However, there were no significant differences in specific conductivity observed among BMP types in 2005 (Figure 17). No standing water was found in Infiltration Trenches during the 2005 field season; therefore, no data exists for specific conductivity in this BMP type.

Larval Mosquito Surveillance

In 2003, only three types of stormwater BMPs were monitored for mosquito diversity and abundance, this is compared to five types in 2004-05. In 2003, there were 4,530 larvae collected over the study season represented by nine taxa. Larval mosquito collections in 2004 and 2005 included the addition of two BMP types (Infiltration basins and trenches) as well as increasing the number of replicate sites to six per BMP.

In 2004, a total of 10,646 mosquito larvae were collected from June - September compared to 10,945 larvae collected 2005. Larval species diversity in 2005 was similar to the Pilot Study in 2003 (Table 6). A range of approximately 3-11 different species representing 5 genera was collected from all sites during the 2004-2005 field seasons.

Table 6. List of Mosquito Larval Species per Stormwater BMP
(3 replicate sites/BMP type, June 3 – Sept. 25, 2003; 6 replicates /BMP type, June 10 – Sept. 30, 2004, 2005)

BMP	# Species/2003	# Species/2004	# Species/2005
Shallow Marsh	9	11	9
	Anopheles quadrimaculatus	*An. quadrimaculatus*	*An. quadrimaculatus*
	Anopheles punctipennis	*An. Punctipennis*	*An. punctipennis*
	Culex territans	*Cx. territans*	*Cx. territans*
	Culex restuans	*Cx. restuans*	*Cx. restuans*
	Culex pipiens	*Cx. pipiens*	*Cx. pipiens*
	Culex erraticus	*Cx. erraticus*	*Cx. erraticus*
	Culex salinarius	*Cx. salinarius*	*Ur. sappharina*
	Uranotaenia sappharina	*Ur. sappharina*	*Ae. vexans*
	Aedes vexans	*Ae. vexans*	*Ps. columbiae*
		Oc. japonicus	
		Cq. perturbans	
Retention Pond	8	10	8
	Anopheles quadrimaculatus	*An. quadrimaculatus*	*An. quadrimaculatus*
	Anopheles punctipennis	*An. punctipennis*	*An. punctipennis*
	Culex territans	*An. walkeri*	*Cx. territans*
	Culex restuans	*Cx. territans*	*Cx. restuans*
	Culex pipiens	*Cx. restuans*	*Cx. pipiens*
	Culex erraticus	*Cx. pipiens*	*Cx. erraticus*
	Uranotaenia sappharina	*Cx. erraticus*	*Ur. sappharina*
	Aedes vexans	*Cx. salinarius*	*Ae. vexans*
		Ur. sappharina	
		Ae. vexans	

Table 6. List of Mosquito Larval Species per Stormwater BMP
(3 replicate sites/BMP type, June 3 – Sept. 25, 2003; 6 replicates /BMP type, June 10 – Sept. 30, 2004, 2005)

BMP	# Species/2003	# Species/2004	# Species/2005
Detention Pond	7	10	8
	Anopheles quadrimaculatus	*An. quadrimaculatus*	*An. quadrimaculutus*
	Anopheles punctipennis	*An. punctipennis*	*An. punctipennis*
	Culex territans	*Cx. territans*	*Cx. territans*
	Culex restuans	*Cx. restuans*	*Cx. restuans*
	Culex pipiens	*Cx. pipiens*	*Cx. pipiens*
	Culex erraticus	*Cx. erraticus*	*Cx. erraticus*
	Aedes vexans	*Cx. salinarius*	*Cx. salinarius*
		Oc. japonicus	*Ae. vexans*
		Ur. sappharina	
		Ae. vexans	
Infiltration Basin	Not Sampled	11	11
		An. quadrimaculatus	*An. quadrimaculatus*
		An. punctipennis	*An. punctipennis*
		Cx. territans	*Cx. territans*
		Cx. restuans	*Cx. restuans*
		Cx. pipiens	*Cx. pipiens*
		Cx. salinarius	*Cx. salinarius*
		Cx. erraticus	*Cx. erraticus*
		Ur. sappharina	*Ur. sappharina*
		Oc. japonicus	*Oc. japonicus*
		Ae. vexans	*Ae. vexans*
		Psorophora columbiae	*Ps. columbiae*
Infiltration Trench	Not sampled	3	0
		Cx. restuans	
		Cx. pipiens	
		Oc. japonicus	

During 2004-2005, there were no significant differences in average number of larvae collected per dip among sampling dates over the study period 2004-2005 ($F = 1.35$; $P > 0.05$) (Figure 18).

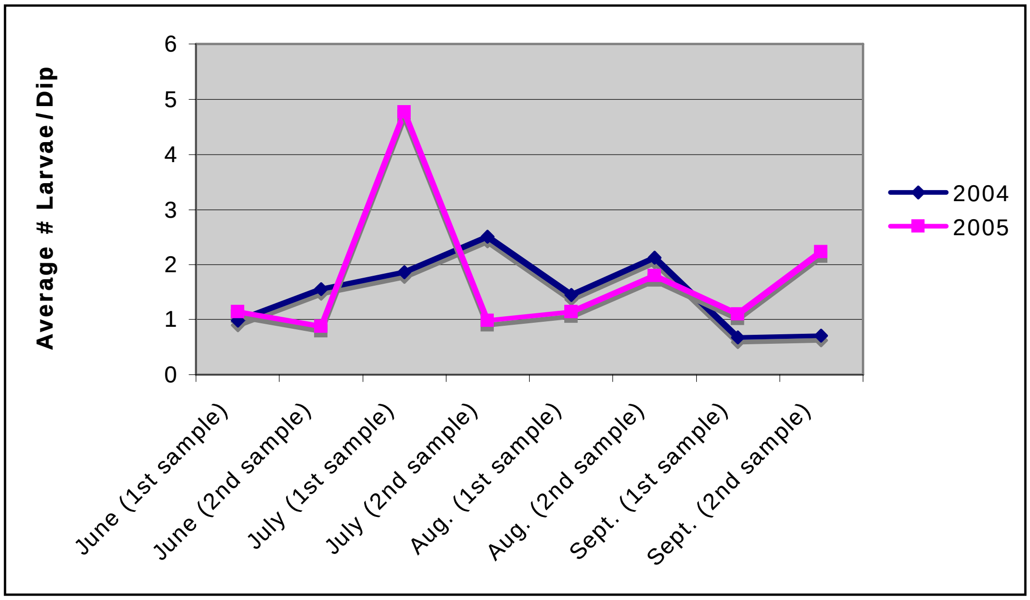


Figure 18. Average number of larvae per dip for each sample date, 2004 – 2005.

Larval mosquito densities per dip were compared among Baltimore, Howard, Montgomery and Prince Georges counties in 2004. Although the average number of larvae/dip for Montgomery and Baltimore counties appears to be significantly greater compared to Howard and PG counties, there are no statistically significant differences per county due to the high degree of variation per site (F stat = 11.8; $P > 0.05$) (Figure 19).

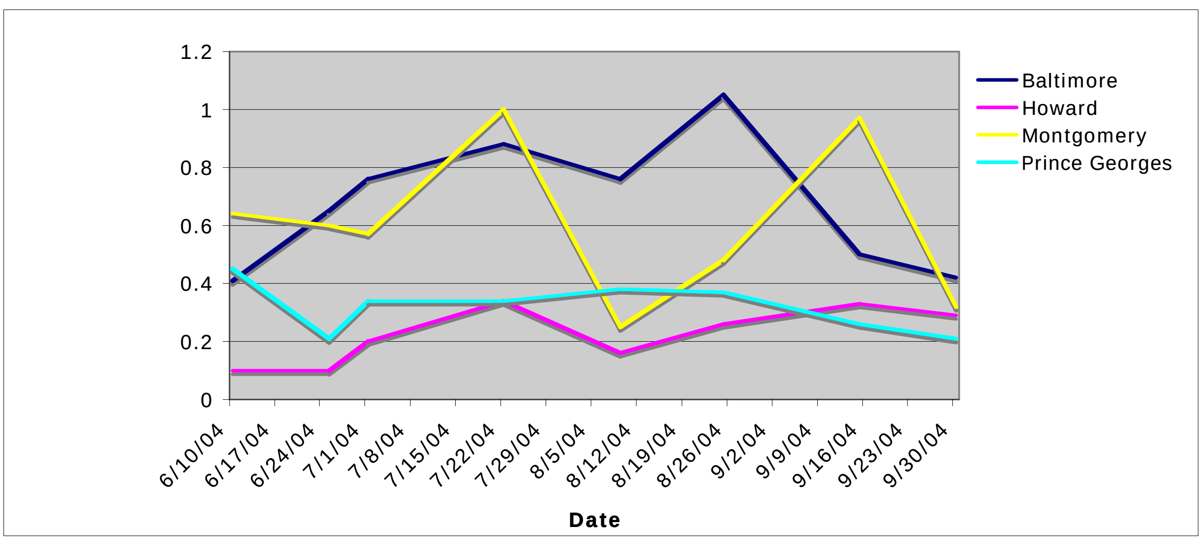


Figure 19. A comparison of larval densities collected per sampling event among the four counties included in 2004.

In 2005, larval mosquito densities per dip were significantly greater in Baltimore and Montgomery counties compared to Howard and PG counties (F = 3.44; $P < 0.05$). In addition, there were significantly more larvae per dip on the 1st July sample date in 2005 compared to all other sample dates ($F = 3.21$; $P < 0.05$) (Figure 20).

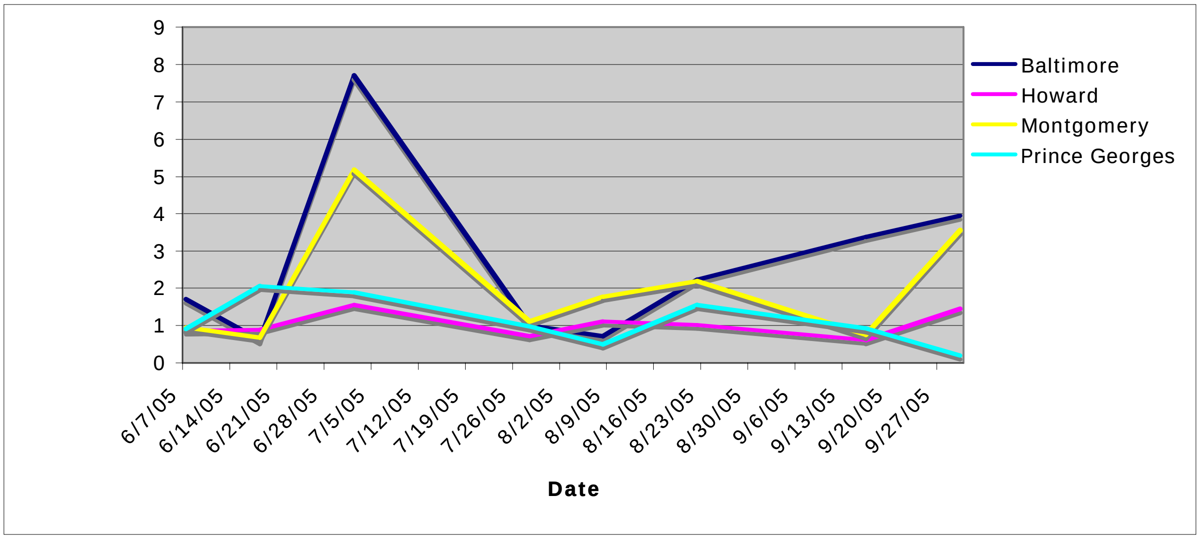


Figure 20. Average number of larvae collected per sampling event among the four counties in 2005.

To understand the difference in bridge vector mosquito production among the five types of BMPs, the percentage of those species collected per month each year was examined for each BMP type. *Culex* mosquitoes, specifically in this region of the country, typically vector WNV among bird populations due to their ornithophillic feeding habits. Although *Culex territans* does not feed on birds, it is the dominant mosquito larva on average among BMPs, therefore it was included in these analyses. Those species which are generally considered as bridge vectors meaning they serve to vector WNV between birds and mammals, include *Aedes vexans* and *Ae. albopictus*. Because *Ae. albopictus* inhabits containers and *Ae. vexans* floodwater areas, the latter was selected as the focal bridge vector in this study. Larval populations of *Culex territans*, *Cx. pipiens*, *Cx. restuans* and *Ae. vexans* were tracked throughout both field seasons to identify which BMPs will produce potential WNV vectors.

In shallow marsh BMPs, *Cx. territans* was typically the most abundant mosquito larvae during each month throughout much of both field seasons. *Aedes vexans* was a dominant species during the 2005 field season (Figure 21). In 2005, the percentage of *Culex pipiens*, and *Cx. restuans* larvae collected was lower compared to 2004.

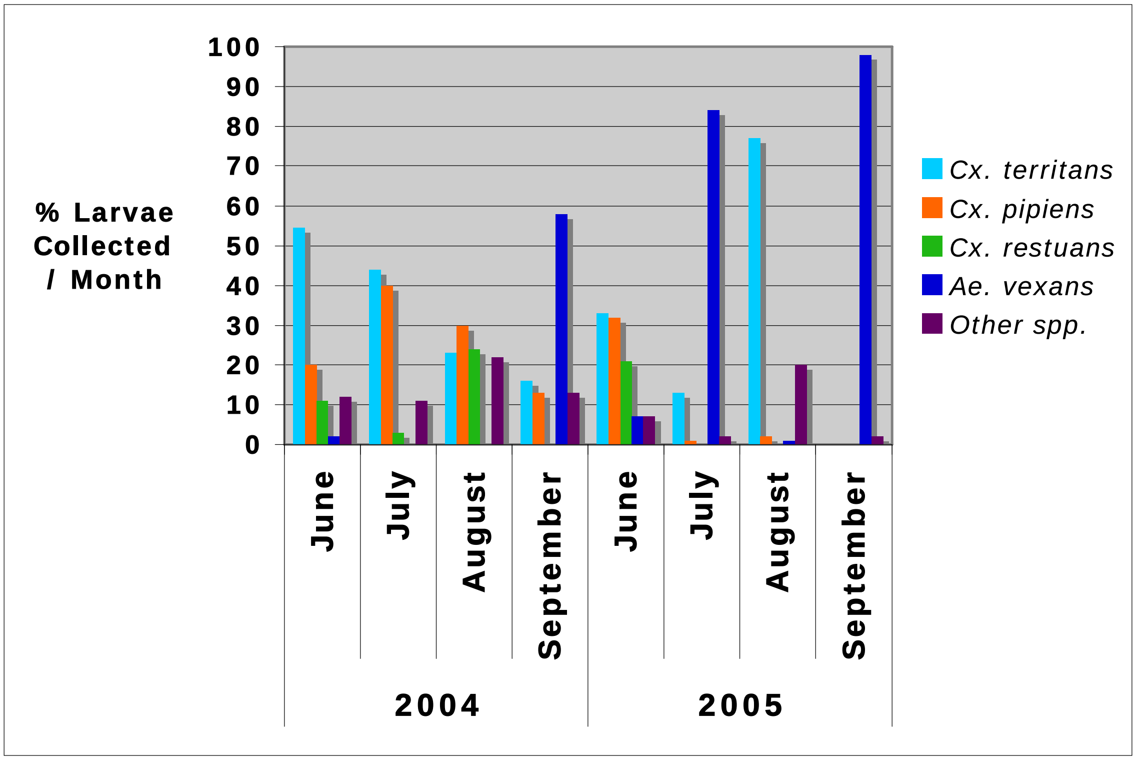


Figure 21. The percentage of the major mosquito bird and mammal vectors of WNV collected from shallow marshes during each month of 2004-2005.

Retention ponds did not typically produce a high percentage of mosquitoes responsible for WNV transmission. *Culex territans* (2004) and other species such as *Anopheles punctipennis* and *Uranotaenia sappharina* were more abundant than WNV vector species in 2005, a year with low precipitation (Figure 22). One exception, the percentage of *Aedes vexans* larvae was significantly greater than all other species in July 2005. The dry period prior to July followed by a significant amount of rainfall during July resulted in a dramatic increase in *Aedes vexans*.

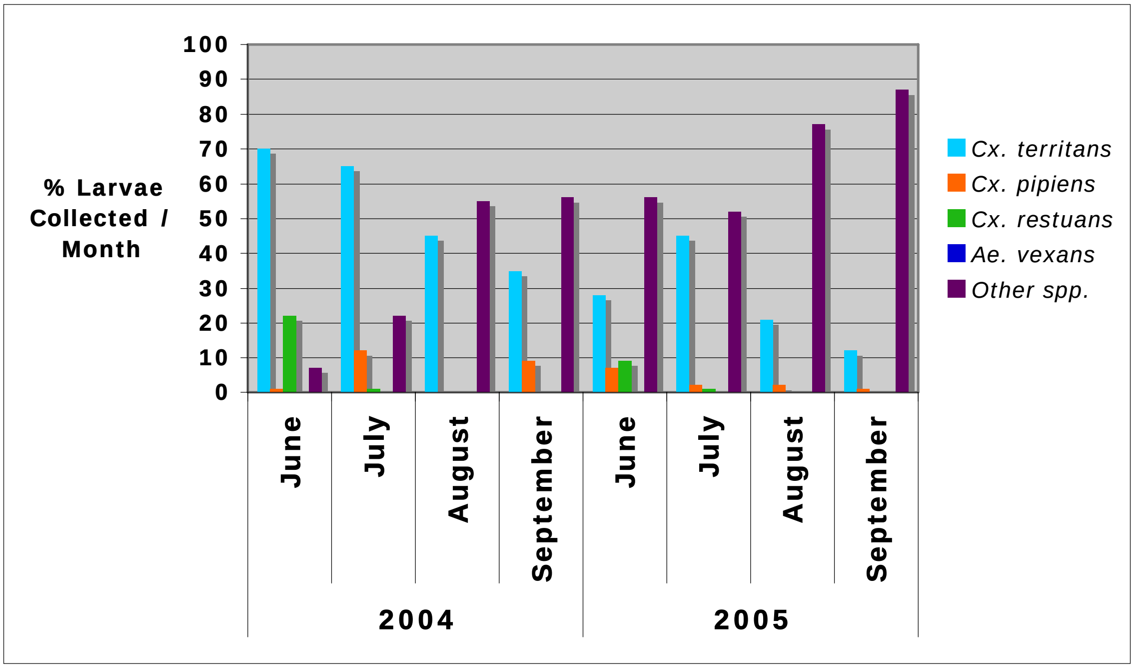


Figure 22. The percentage of the major mosquito bird and mammal vectors of WNV collected from retention ponds during each month of 2004-2005.

The percentage of WNV vector species was significantly lower in detention ponds druing both seasons (Figure 23). Similar to retention ponds, the percentage of *Cx. territans* and other taxa such as several anopheline species, *An. quadrimaculatus* and *An. punctipennis* was significantly greater in 2004 and 2005. The percentage of *Aedes vexans* was greatest in July 2005 coinciding with a high amount of rainfall during that month.

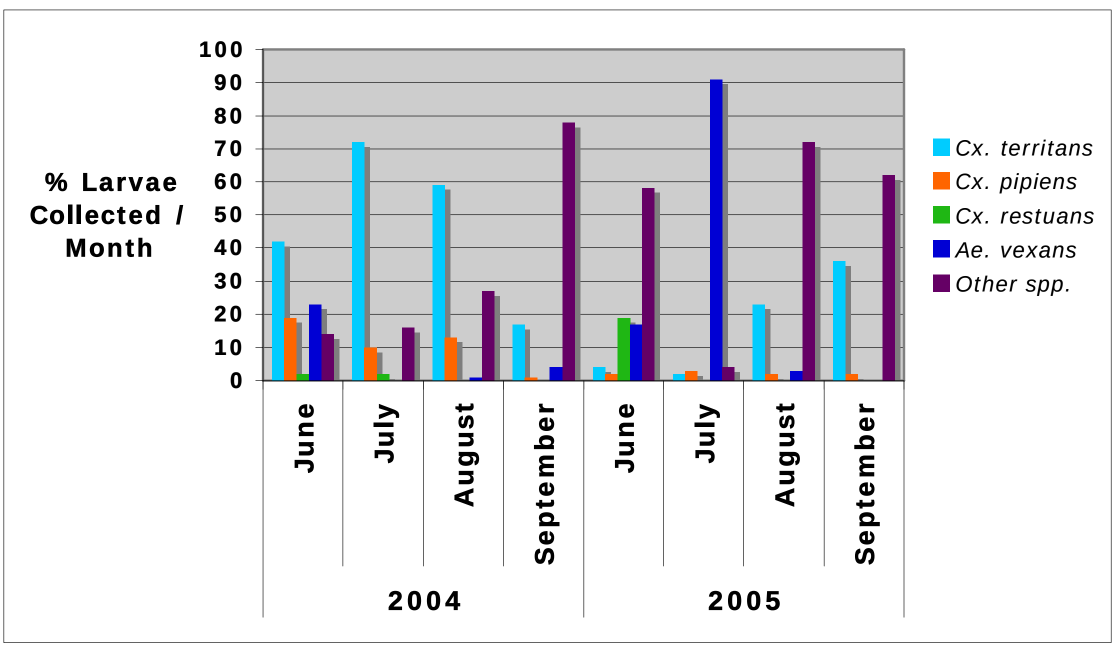


Figure 23. The percentage of the major mosquito bird and mammal vectors of WNV collected from detention/extended detention ponds during each month of 2004-2005.

In 2004 – 2005, two additional BMP types were added to the study, Infiltration Basins and Infiltration Trenches. There was significantly more rain in 2004 compared to 2005; as a result, infiltration basins supported significantly more WNV vector larval species such as *Cx. pipiens* and *Cx. restuans* than other taxa (Figure 24). However, during a low precipitation year (2005), basins produced significantly more *Ae. vexans* than any other taxa when basins contained water. By the end of both field seasons, infiltration basins produced more WNV vector larval species than any other BMP.

Infiltration trenches did not produce significant numbers of larvae during either year (Figure 25). Of those species collected from infiltration trenches, two taxa, *Cx. pipiens* and *Cx. restuans* accounted for approximately 45% of the total larvae collected.

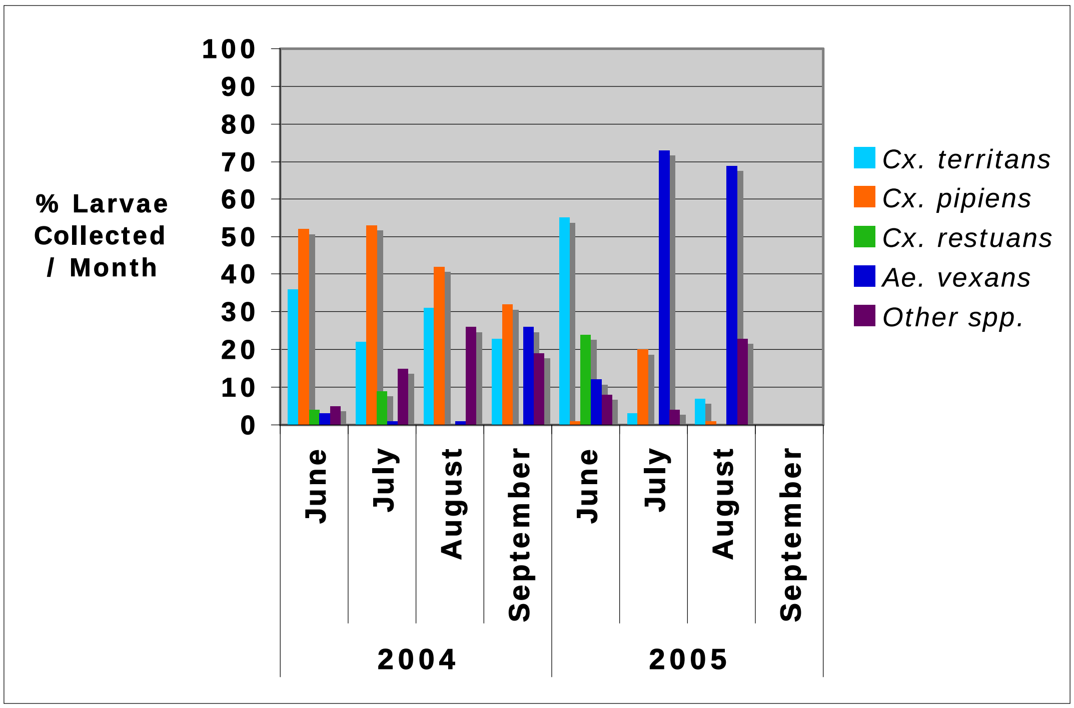


Figure 24. The percentage of the major mosquito bird and mammal vectors of WNV collected from infiltration basins during each month of 2004-2005. No data for September 2005 due to all basins being dry.

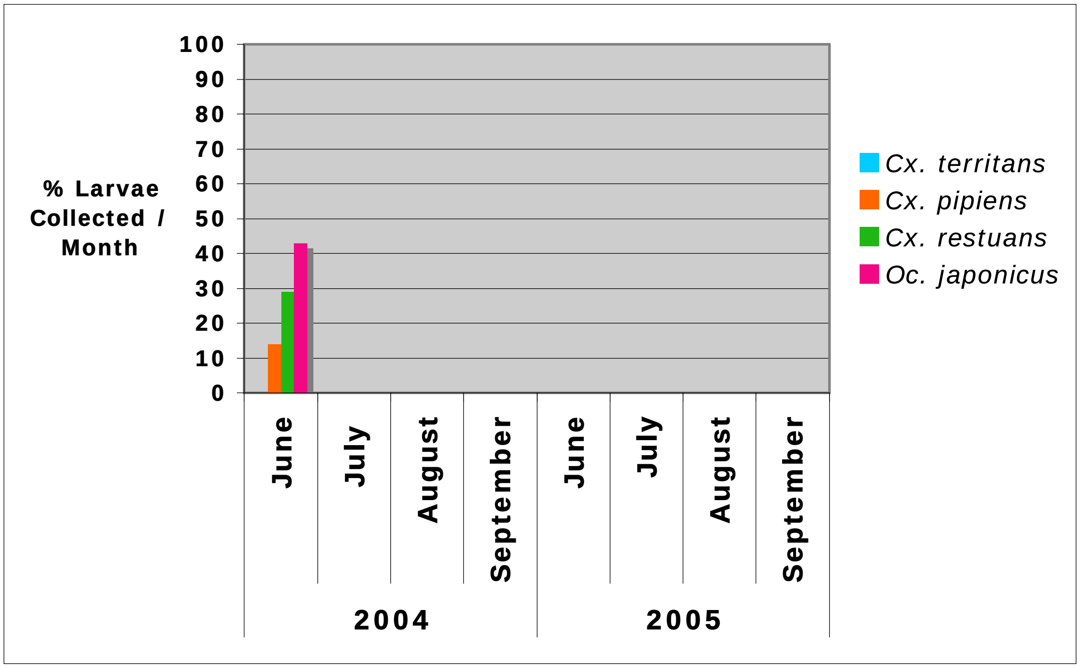


Figure 25. The percentage of mosquito larvae collected from infiltration trenches during each month of 2004-2005.

Mosquito Control Treatment

Larval control during one bout of bacteriacide treatment in 2004 resulted in a significant reduction of larval numbers on average across all BMP types (Table 7).

Table 7. Percent reduction among stormwater BMP type in August, 2004

BMP Type	% Reduction
Shallow Marsh	99.16
Retention Pond	98.74
Detention-type Pond	100.00
Infiltration Basin	99.97
Infiltration Trench	N/A

DISCUSSION

Since mosquito-borne illnesses in the United States have largely been eliminated as a health risk (while their vectors remain), Americans have not regarded these diseases as a threat until the recent introduction and rapid spread of West Nile virus changed this view. Public education on how to reduce larval mosquito habitat has been the primary focus of many state and private mosquito control agencies when combating the threat of WNV or any other arthropod-borne illness. Stormwater management facilities, which are required under NPDES regulations to address stormwater runoff quantity and quality, are a potential habitat for mosquito larvae. The Maryland State Highway Administration (MDSHA) is interested in addressing the issue of stormwater management and mosquito surveillance/control so that decisions concerning stormwater management design and construction can be based on empirical scientific research. This research has focused on larval mosquito population dynamics and incorporated strategies to minimize mosquito production and issues related to mosquito nuisance and mosquito-borne illnesses such as WNV.

Many statewide mosquito surveillance programs and in some cases privately consulted projects do not incorporate rigorous spatial or temporal components in their monitoring efforts. That is, for some projects, convenience and/or logistical issues may influence selection of surveillance sites. and are not based on valid scientific inquiry to address specific management questions. For example, in 2004, a private consulting firm hired by Prince George's County to evaluate mosquito production presented findings that stormwater BMPs are not major producers of mosquito larvae. This was based solely on 2 samples taken one week apart in June 2004 sacrificing both replication of site types and limited monitoring. This example underscores the importance of thorough empirical research when making environmental management decisions. For example, the Pilot Study in 2003 allowed a preliminary yet scientifically rigorous understanding of which mosquito species inhabited three types of BMPs as well as their population dynamics over a complete field season (June – September). It should be noted that this study did not differentiate between detention and extended detention ponds. Results for these BMP types were combined in both the pilot and two-year studies.

<u>Pilot Study</u>

In 2003, Howard and Montgomery county sites received approximately 1/3 or less rain than during the 2004/2005 seasons. Although precipitation amounts were lower in 2003 compared to 2004-'05, larval mosquito diversity was similar to that observed in 2005. Temporal population dynamics of mosquito larvae among Shallow Marsh, Retention and Detention ponds indicated that a frog-feeding mosquito species, *Culex territans* was the dominant mosquito larva produced by all BMP types. In fact, those mosquito taxa cited as primary bird and mammal vectors of WNV (such as *Cx. pipiens*, *Cx. restuans* and *Ae. vexans*) represented the lowest numbers collected per dip on average throughout the entire season of 2003. While certain stormwater BMPs in Maryland are arguably large producers of mosquitoes depending on the time of year and amount of precipitation, the pilot study provided data indicating that those mosquito species implicated in the transmission of WNV among birds and mammals are on average not a significant percentage collected per dip.

It is common for the general public to associate biting adult mosquitoes with marshes or structures such as stormwater management facilities. For this reason, it is imperative for MDSHA to understand that adult mosquitoes will sometimes fly great distances for a blood meal. Consequently, people living near BMPs will often assume BMPs are associated with nearby biting mosquito populations. In order to provide MDSHA with at least an initial understanding of those species flying near or around BMPs, adult monitoring was conducted during the first year of the study.

Since stormwater management is federally mandated, it is likely that mosquito abatement programs will have to accompany future stormwater management design/construction as well as maintenance; therefore, a self-maintained MDSHA control/abatement program for stormwater facility management was initiated. During the 2003 season, an MDSHA employee worked closely with a local pest management firm to initiate a larval control program. The decision to focus on larval control was prompted by the following: 1) environmental safety: the use of biological larvicides is more environmentally friendly; 2) less training required; 3) cost-benefit advantages: although the larvicide (*Bacillus sphaericus*) has a longer residual time or the duration it remains an effective larvicide is longer, it is more expensive than the chosen larvcide – *Bacillus thuringiensis*; and; 4) MDSHA is only responsible for those larvae produced in BMPs not transient adult mosquitoes on SHA property. It would be unreasonable for MDSHA to be responsible for controlling those adults breeding in other types of habitats away from the BMPs. The result of the treatment in all BMPs was a 98-100% efficacy rating. That is, larval mosquito abundance was reduced to negligible numbers.

During the first year of the project, adult mosquito abundance was also similar to larval populations inhabiting stormwater BMPs. However, there were several other adult species collected, such as *Ochlerotatus japonicus* certain *Culex* species and *Coquilletidia perturbans*, that were not very abundant in larval collections either due to the sampling protocol used (*Cq. perturbans*) or because BMPs are not the primary habitat for this species (*Oc. japonicus*). It should be noted that while *Cq. perturbans* was not abundant in larval collections, this species is associated with high amounts of emergent vegetation, such as cattails, that they tap for oxygen. This species is also an avid biter of humans and has been known to feed on birds; hence it is a potential risk for WNV transmission. Therefore, as is detailed in the Recommendations section of this document, large amounts of cattail growth should be reduced in stormwater BMPs to reduce numbers of this potential bridge vector.

Two-Year Monitoring Study

The pilot study provided the foundation upon which a more rigorous and complete analysis was built in 2004-2005, which displayed how BMPs influence mosquito production and what factors may contribute to the potential risk of disease.

Stormwater BMPs change or evolve over time often becoming overgrown with vegetation or littered with debris, which may cause them to malfunction. It is currently unknown how mosquito populations change in conjunction with these BMP changes. Thus, it was critical to maintain monitoring efforts and expand the number of types of BMPs and replication of these types as well as the duration of the monitoring program.

Precipitation amounts in 2004 were sometimes nearly double those of 2005 and nearly triple those in 2003. While rainfall was significantly greater in 2004, mosquito abundance was nearly equal between 2004 -2005. This finding is important when identifying those factors that may lead to outbreaks of WNV with regards to mosquito production and rainfall. It is important to note that nearly a third of all larval mosquitoes collected in 2005 occurred after a low rainfall period, early in the summer (consequently some sites were marginally wet or dry) followed by a large rainfall event (early July'05). This is highlighted by the problem that *Aedes vexans*, the floodwater mosquito, and potential bridge vector and vigorous human biter, thrives during these periods of intermittent rains, especially if precipitation is great and flooding is increased around the periphery of BMPs. This flooding triggers the synchronized hatching of hundreds of thousands or more of this species. Large increases in *Ae. vexans* numbers per dip in all BMPs during July of 2005 and during September after an August drought support this finding. Consequently, it is imperative that MDSHA monitor rainfall near problem BMPs in order to avoid outbreaks of complaints about mosquitoes and potentially risk of disease.

The climatological differences between 2004-2005 allowed a more thorough understanding of most mosquito taxa inhabiting stormwater BMPs in this study. During this two-year period, larval diversity increased with the additional BMPs in this study including evidence that larval mosquitoes will utilize infiltration trenches during a wet year. While infiltration trenches may appear to be nothing more than dry stones, some can hold pockets of water capable of producing mosquitoes. Infiltration trenches should be regarded as potential mosquito breeding sites during wet periods, therefore periodic inspection of them would be suggested during such periods. Although mosquito abundance appeared greater from collections in Baltimore and Montgomery counties, this difference is most likely a function of the number of sites located in each county. For example, we sampled only two retention ponds in Prince George's County.

It is important to note, that the majority of mosquito taxa observed in most of the BMPs, save infiltration basins; typically included those species that are of minor consequence in the transmission of WNV or other mosquito-borne illnesses. Again, this reflected the findings from the pilot year. It is also important to note that infiltration basins, if left unmanaged, generate large amounts of organic debris and sometimes behave similar to a detention pond with prolonged periods of water before drying. This is ideal habitat for the floodwater mosquito, *Aedes vexans*, the potential bridge vector of WNV. Supporting this contention, *Aedes vexans* were abundant in the larvae collected in Baltimore and Montgomery counties within all BMPs, especially infiltration basins after 8 inches of rainfall.

In 2005, MDSHA performed several maintenance modifications that may have influenced surrounding microclimates, rate of evaporation and water temperature in several BMP sites. One site was mowed (site 18), trees were removed at certain sites (sites 10, 11), and one site underwent significant construction (site 13). While not quantified, it was noted that more ponds completely dried up earlier in 2005 compared to 2004. Although no water present might indicate a source reduction, periodic rains after dry periods presents an ideal situation for the production of *Ae. vexans* mosquitoes.

Larval control efforts in 2004 resulted in 98-100% reduction in all BMPs except for Infiltration Trenches. This type of BMP is designed to dewater in 72 hours and consequently all replicate sites were dry upon completion of the treatment activity. The MDSHA employee did not require further training, the protocol was easily followed and results were similar to the treatment effort in 2003. There were no treatment activities in 2005 for the following reasons: 1) lack of precipitation and the fact that BMP maintenance may possibly have resulted in BMPs drying up in the second half of the 2005 field season and; 2) as a result of decreased water levels, larval populations were on average 50% less per dip in late July (prior to an August treatment date) compared to 2004 (Figure 18). Also, because efficacy was so high in 2004 with twice as many larvae, it was decided that no treatment effort would be necessary in 2005. The program was viewed as a success and should be part of a management plan.

***Special Notes:**

1) Prince George's County requested that 2 retention pond sites from a previous study be included in the MDSHA mosquito project. In their project, few if any larvae were found in the 20 dips taken during two sample periods in mid June 2004. Furthermore, the larvae collected were only identified to the generic level. In this study, there were 8 species found in Site 29 and 10 species found in Site 30. The average number of larvae collected per dip was calculated and presented in the Appendix.

2) Site 13 (MDSHA # 03108) was removed during construction at the end of the 2005 season. A new BMP was constructed further north by mid-September, 2005.

MDSHA INTEGRATED PEST MANAGEMENT PROGRAM

It has been suggested that control and prevention of mosquito-borne illnesses such as West Nile virus should be grounded in a well-established integrated mosquito management program at the local level (Nasci 2002). However, such programs may not be based on local empirical research and may not address the specific needs of this locality. I would recommend that local level programs be derived from research studies such as this one in order to meet such needs in a more cost-effective and relevant manner. Based on the results of this study, I am making the following recommendations to ensure that an MDSHA mosquito management program incorporates a systems-based approach:

- Identify BMPs that are in proximity to hospitals, schools, retirement homes and focus maintenance on cleaning litter, removing floating and emergent vegetation and regularly mowing the periphery.

- Prior to the construction of new BMPs, consider design options for structures regarding slope of the basin (moving water will deter mosquitoes from laying eggs – e.g. site 7) and slope of the banks (generally, BMPs in this study with steep banks tended to not have as much emergent vegetation and did not produce large numbers of mosquitoes – site 8).

- This study indicates that detention/extended detention ponds and Infiltration Basins that displayed regularly fluctuating water level produced large numbers of WNV bird and mammal feeding mosquito species. It is the intermittent wet/dry periods that attract these species of mosquitoes. Shallow marshes and Retention ponds typically produced mosquitoes that play minor or no role in the transmission of WNV. If detention ponds and infiltration basins are required, periodic mosquito monitoring is recommended, especially for ponds located in highly populated areas. Perhaps the use of hybrid BMPs that allow a wet pond element, extended detention component and a wetland element may address the issues stated above (Downey et al 2003).

- Anecdotal evidence over the span of this project has shown that BMP types that have evolved to hold water indefinitely such as shallow marshes, generally have a higher abundance of natural predators (such as dragonfly and waterboatmen insects) of larval mosquitoes. As the quantitative evidence in this study shows, these ponds typically have lower numbers of WNV vector larva. Therefore, MDSHA might consider stormwater BMP designs that minimize larval survival such as steep banks, reduce emergent vegetation and systems that do not experience several wet/dry cycles over a summer season.

- MDSHA should consider monitoring weather fronts and precipitation amounts, especially if storms are heavy in areas near detention ponds and infiltration basins as these BMPs typically experience wet/dry periods which promote significant production of *Aedes vexans* and *Culex pipiens*, both of which are important vectors of WNV among birds and mammals. In the event that heavy precipitation does occur around areas with these types of BMPs, MDSHA should monitor these sites for the presence of mosquito larvae.

- MDSHA should consider making resources available for MDSHA personnel to be trained to recognize mosquito larvae. Training/certification programs may also be established. Mosquito control in Maryland is administered by the Department of Agriculture and Department of Health and Mental Hygiene and who may provide training in these areas. Threshold levels for treatment should be established either by field sampling to determine when larval numbers exceed an average of 20 larvae/dip based on a 50 dip minimum (This number was based on anecdotal evidence indicating that when larval numbers were 20 larvae/dip, flying and biting adults were typically abundant) or by formal complaints by the public or SHA maintenance workers responsible for on-going maintenance and operation of BMP facilities. It is not imperative that all BMPs be treated with bacterial larvicides, only those identified through monitoring or complaints.

- If pesticide use for control is required, there are many options available, both chemical and biological, to control larval mosquitoes, however, the bacterial larvicides used in this study provided an effective, environmentally friendly and cost-effective approach to control mosquitoes in BMPs. Therefore, I recommend using Bti or Bs, as these bacterial larvicides will effectively control mosquito larvae and not harm water quality or non-target invertebrates significantly.

- MDSHA should consider providing a phone number for the general public to call to provide information regarding BMPs with mosquito nuisance problems. This will empower individuals and allow open communication between the general public as well as allow them to feel they are working with SHA for their own benefit.

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APPENDICES

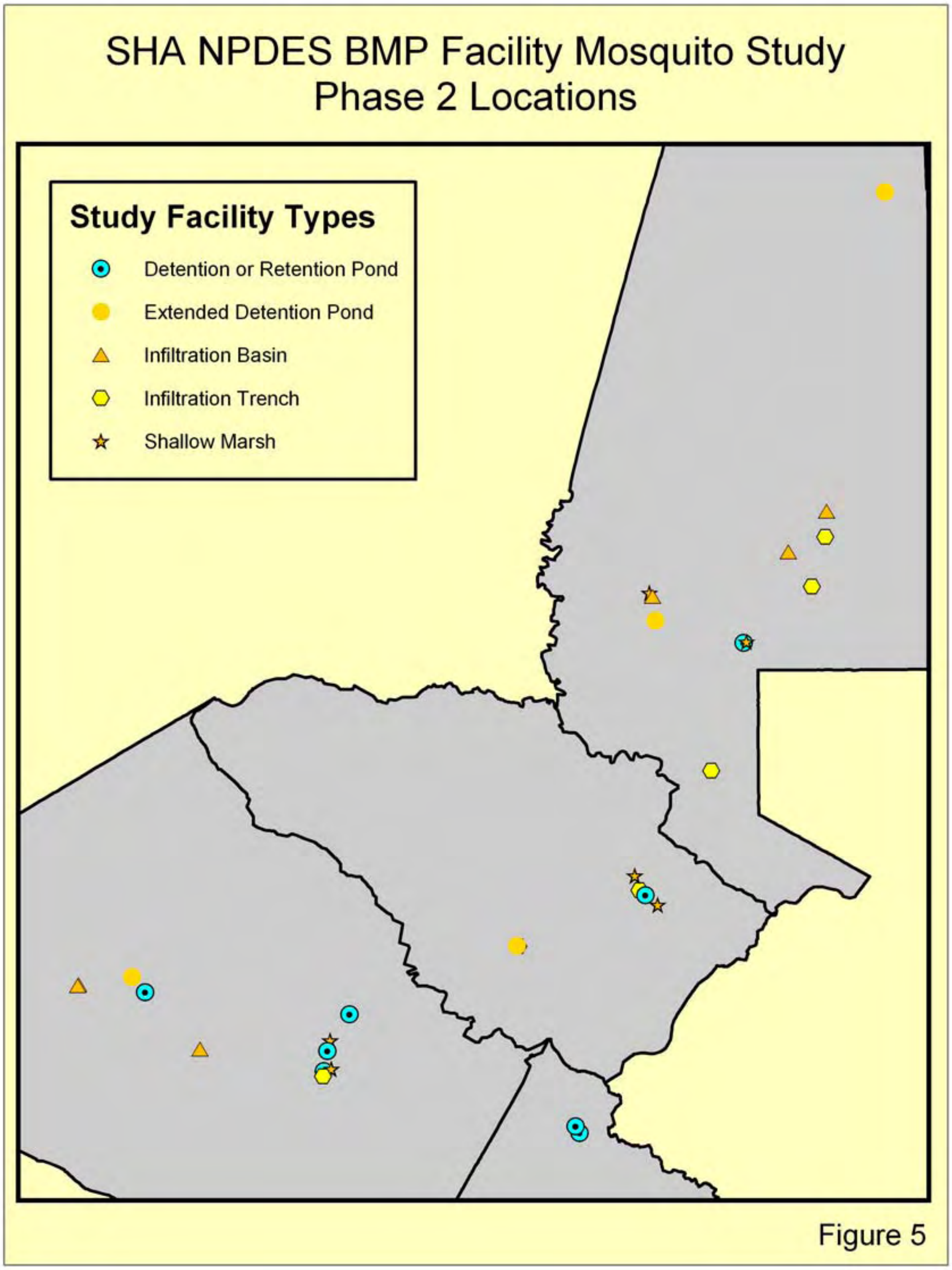
Appendix I. **Map of all BMPs throughout Baltimore, Howard, Montgomery and Prince George's County**

Appendix II. **Site Photo and Summary of Mosquito Data –** (includes MDSHA I.D.#, species list, number of larvae per dip for 2004, 2005)

1) **Shallow Marsh BMP**
2) **Retention Pond BMP**
3) **Detention/Extended Detention Pond BMP**
4) **Infiltration Basin BMP**
5) **Infiltration Trench BMP**

Appendix III. **List of States with Stormwater Management and/or Mosquito Control websites**

Appendix I. Map of all BMPs throughout Baltimore, Howard, Montgomery and Prince George's County

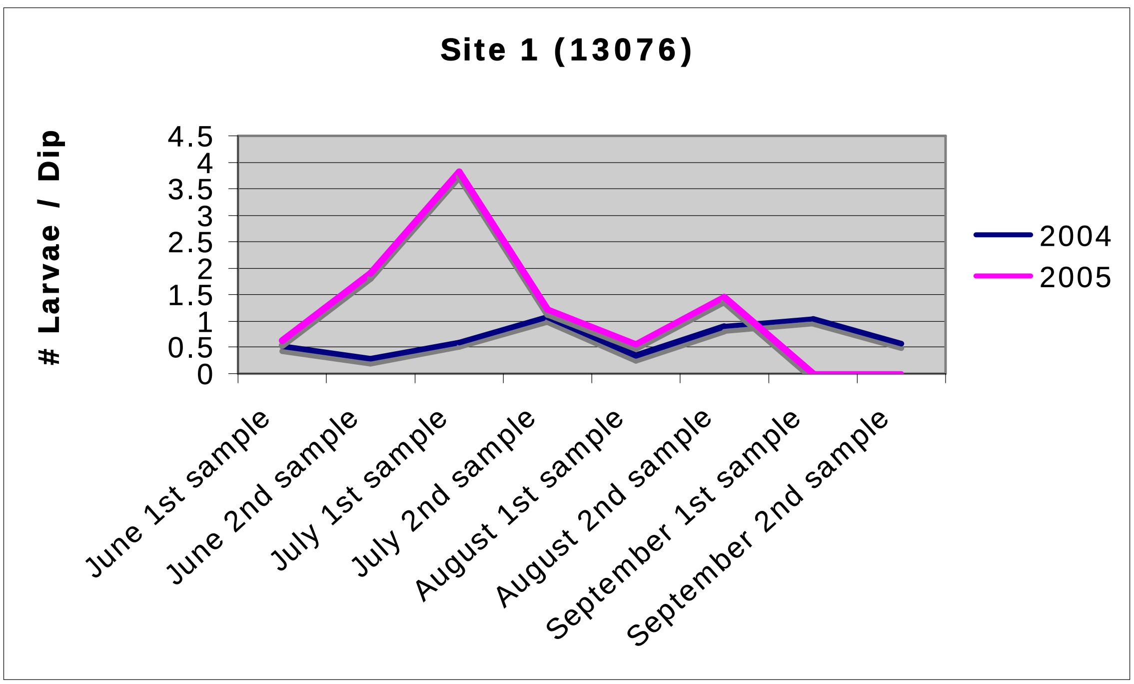


Appendix II.

Site Photos and Summary of Mosquito Data

1) Shallow Marsh BMPs:

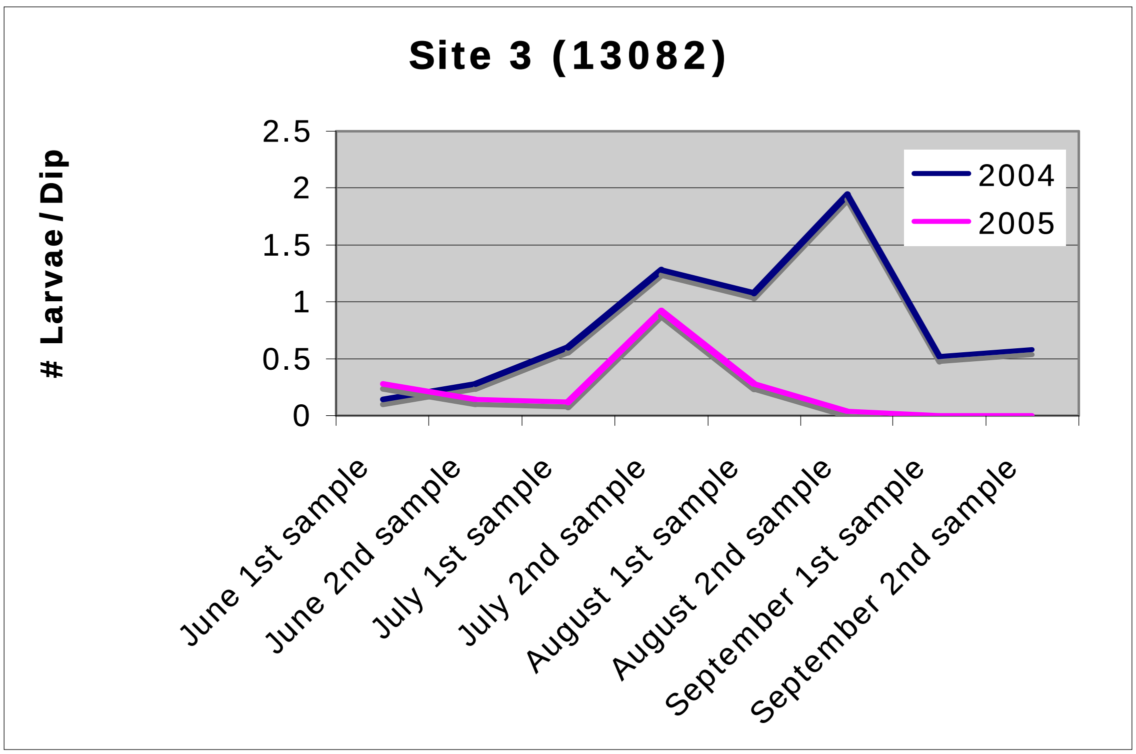
Site # 1 (MDSHA# 13076)



SPECIES LIST:

Anopheles quadrimaculas	*An. punctipennis*	*Culex territans*
Cx. erraticus	*Cx. pipiens*	*Aedes vexans*

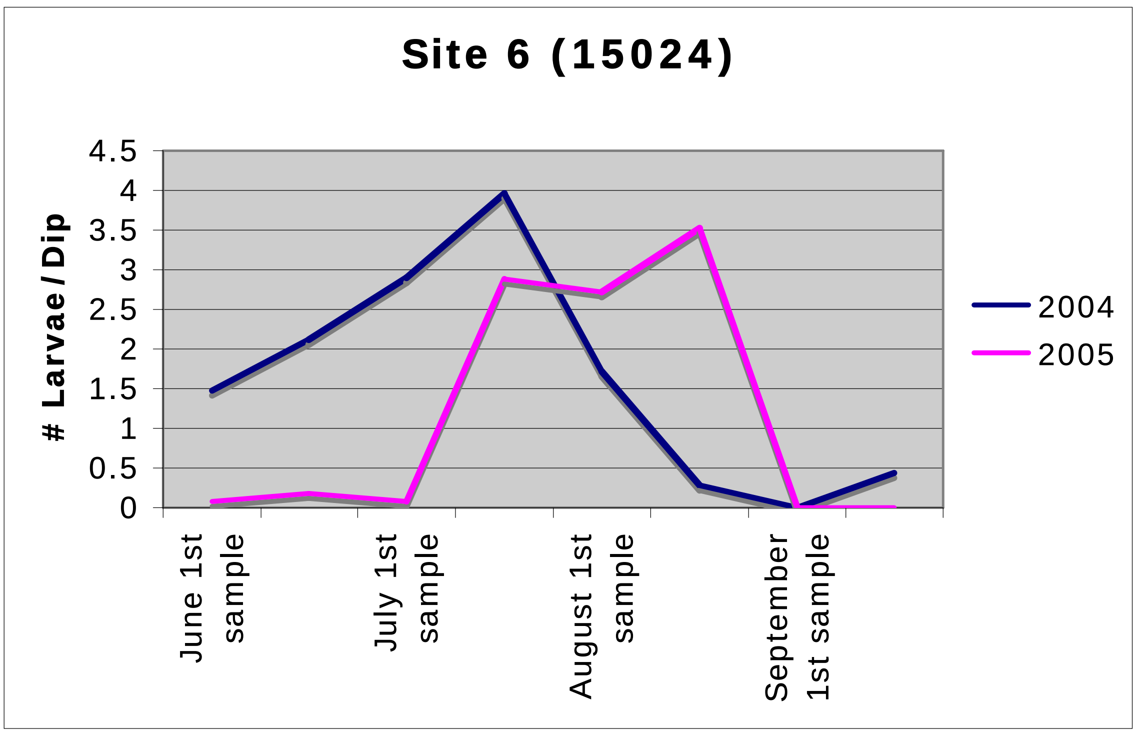
Site #3 (MDSHA # 13082)



SPECIES LIST

Anopheles quadrimaculatus
Cx. erraticus
An. punctipennis
Cx. pipiens
Culex territans
Uranotaenia sappharina

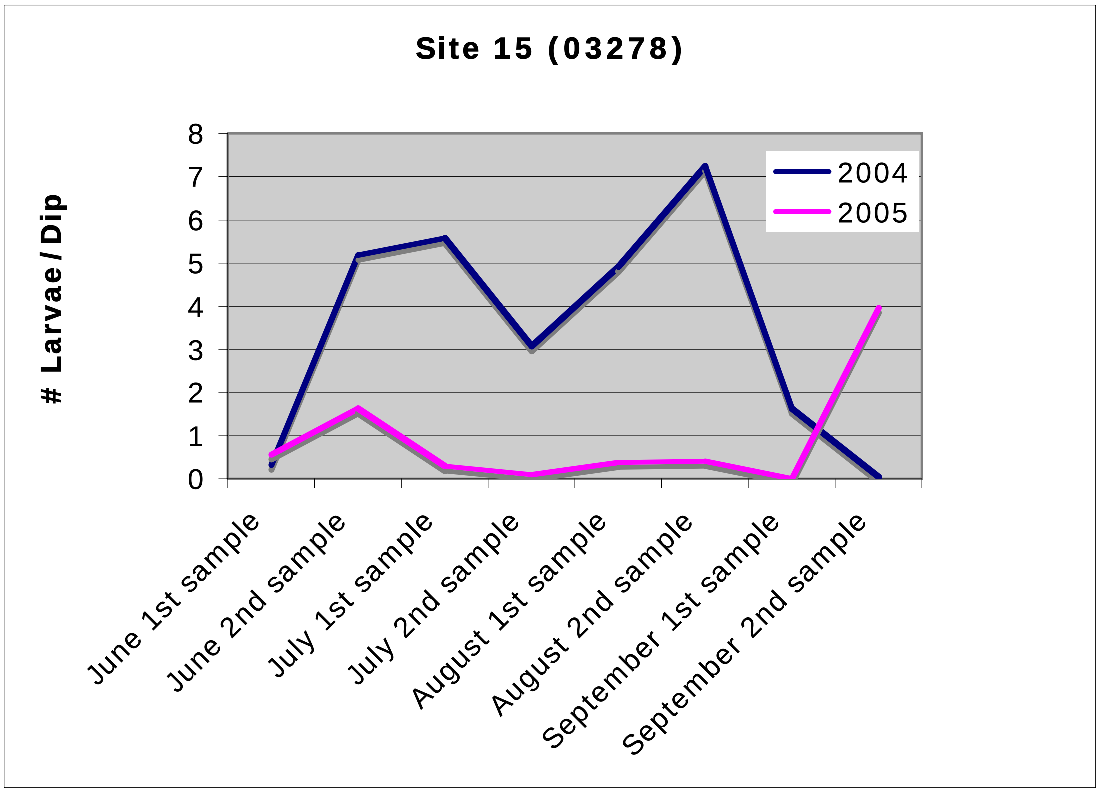
Site #6 (MDSHA # 15024)



SPECIES LIST

Anopheles quadrimaculatus	*An. punctipennis*	*Culex territans*
Cx. salinarius	*Cx. pipiens*	*Uranotaenia sappharina*

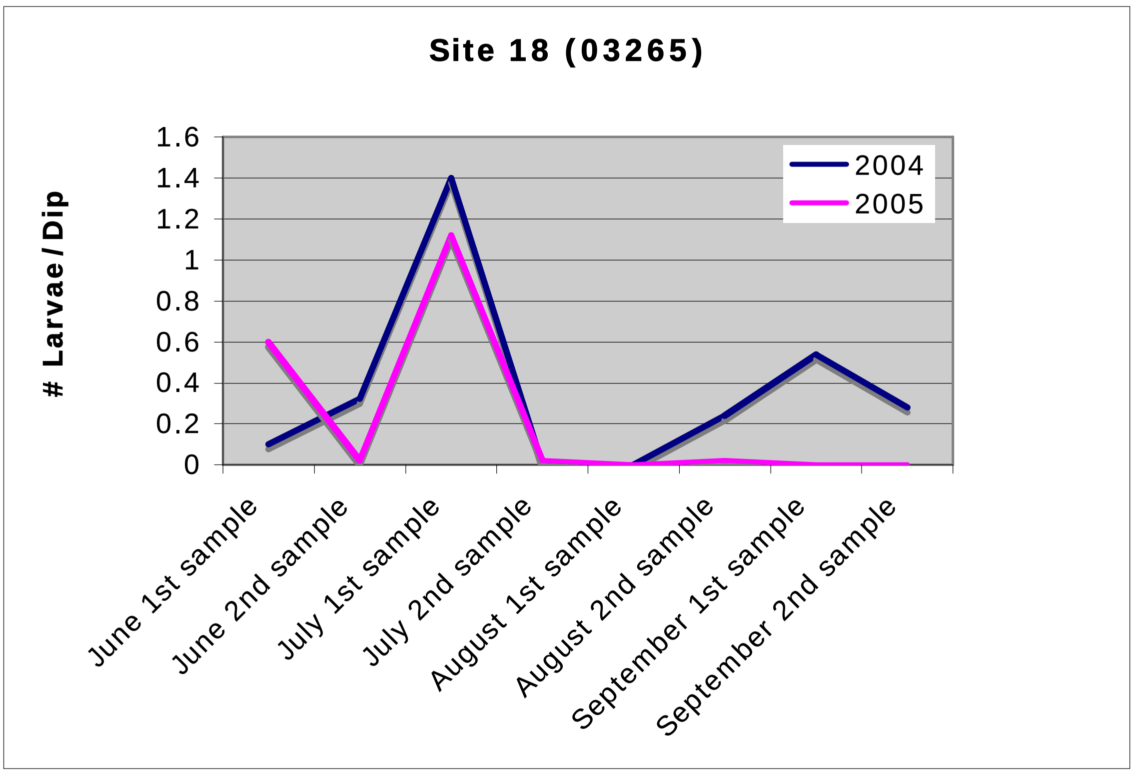
Site #15 (MDSHA # 03278)



SPECIES LIST

Anopheles quadrimaculatus	*An. punctipennis*	*Culex territans*
Ochlerotatus japonicus	*Cx. pipiens*	*Cx. restuans*
Cx. salinarius	*Aedes vexans*	*Psorophora columbiae*

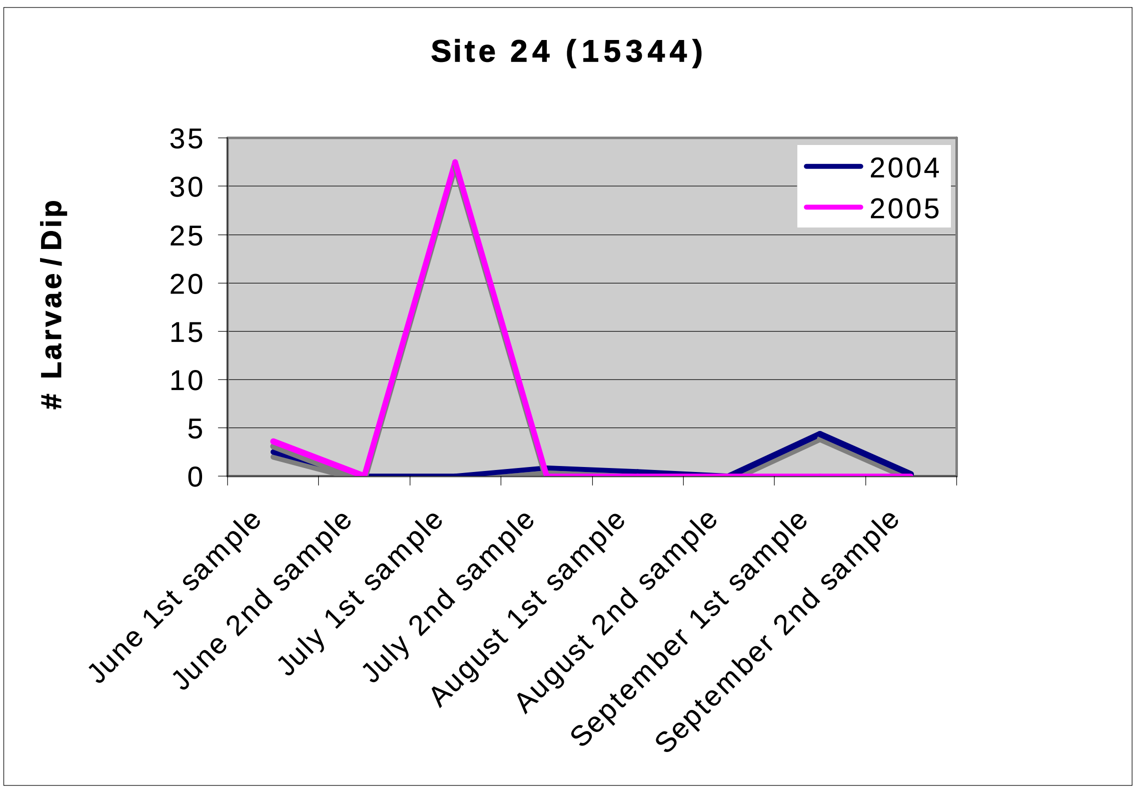
Site #18 (MDSHA# 03265)



SPECIES LIST

Anopheles quadrimaculatus
An. punctipennis
Culex territans
Cx. restuans
Cx. pipiens

Site # 24 (MDSHA # 15344)

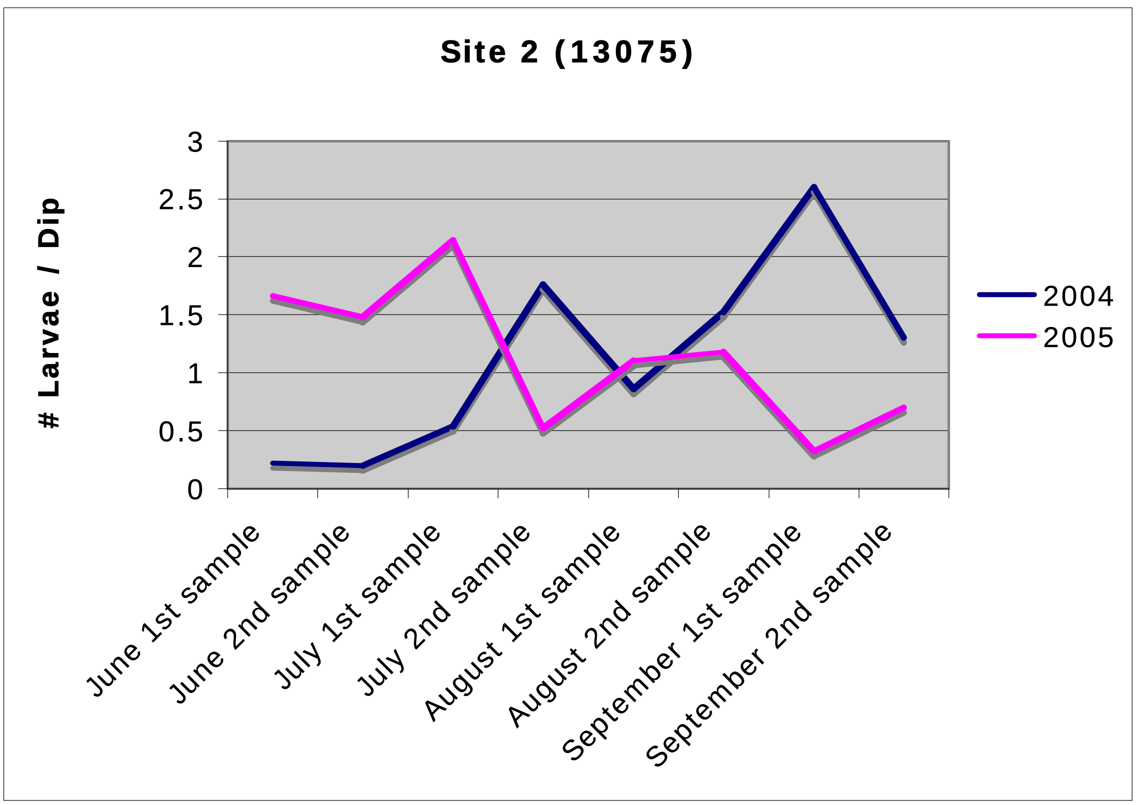


SPECIES LIST

Anopheles quadrimaculatus
Cx. restuans
An. punctipennis
Cx. pipiens
Culex territans
Psorophora columbiae

2) Rentention Ponds (BMPs):

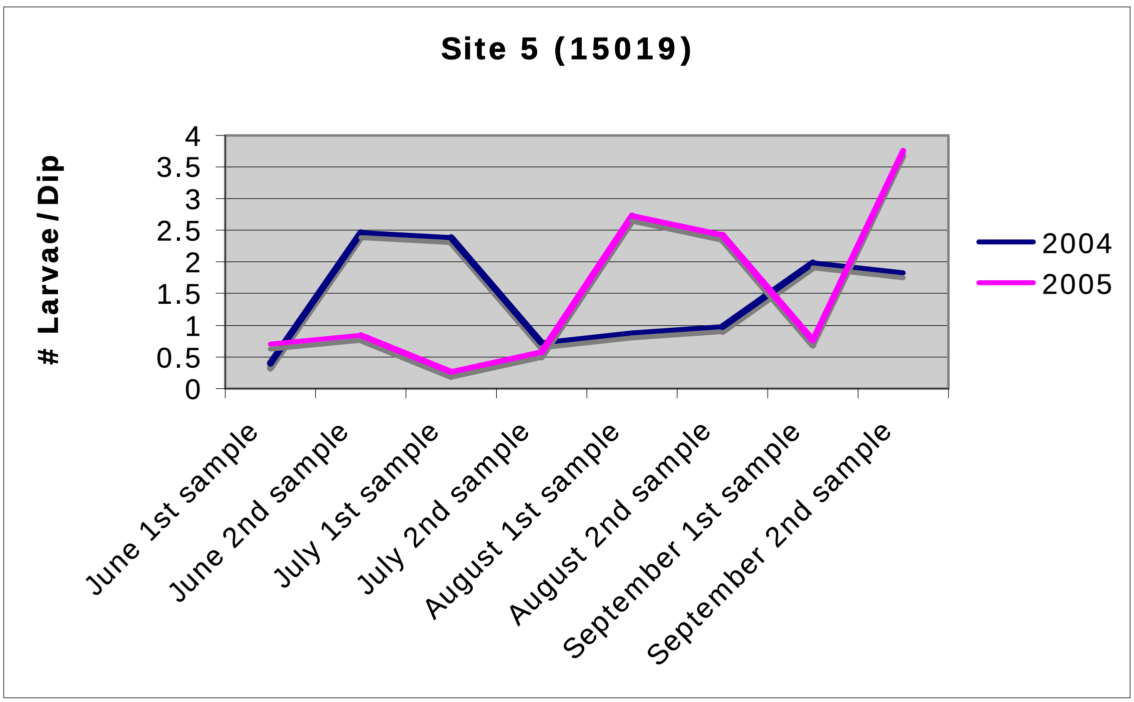
Site #2 (MDSHA #13075)



SPECIES LIST

Anopheles quadrimaculatus	*An. punctipennis*	*Culex territans*
Uranotaenia sappharina	*Cx. erraticus*	*Cx. saliniarius*
Cx. pipiens	*Cx. restuans*	*Psorophora columbiae*

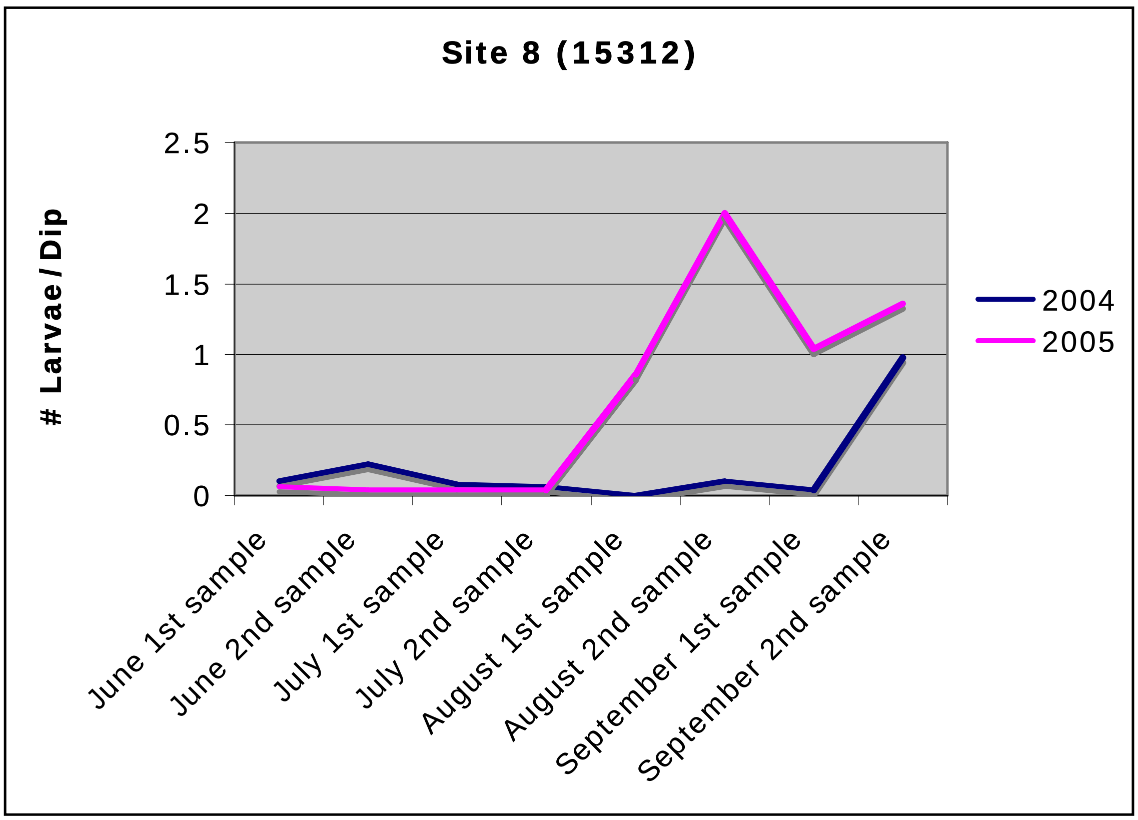
Site #5 (MDSHA #15019)



SPECIES LIST

Anopheles quadrimaculatus	*An. punctipennis*	*Culex territans*
Cx. erraticus	*Cx. pipiens*	*Uranotaenia sappharina*
Cx. restuans	*Cx. salinarius*	

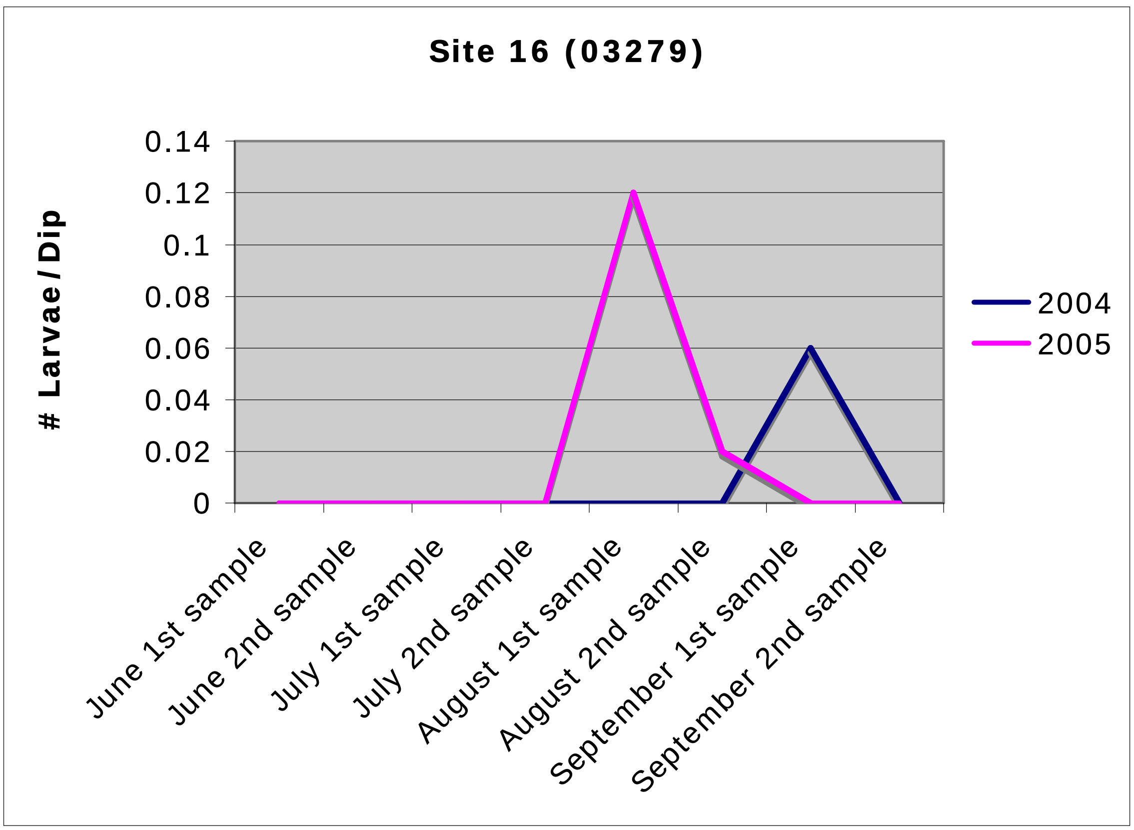
Site # 8 (MDSHA# 15312)



SPECIES LIST

Anopheles quadrimaculatus
An. punctipennis
Culex territans
Cx. restuans
Uranotaenia sappharina
Aedes vexans

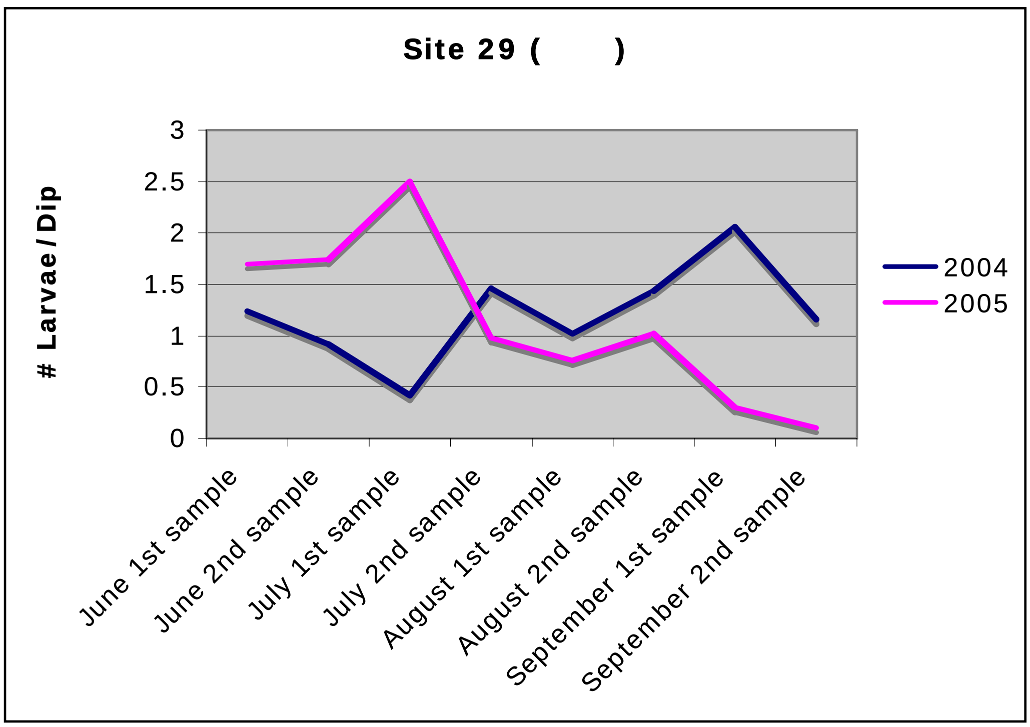
Site # 16 (MDSHA #03279)



SPECIES LIST

Anopheles quadrimaculatus *An. punctipennis* *Cx. pipiens Uranotaenia sappharina*

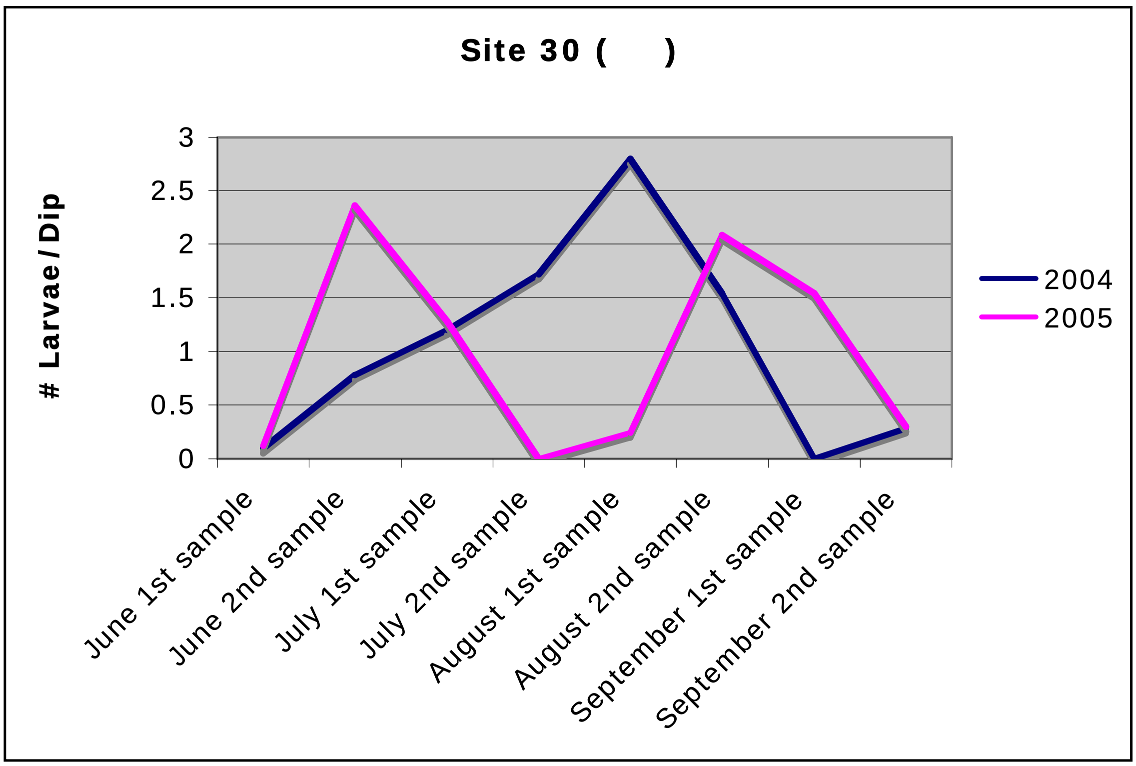
Site # 29 (MDSHA # PG county)



SPECIES LIST 2004 – 05

Anopheles quadrimaculatus
An. punctipennis
Culex territans
Cx. pipiens
Cx. erraticus
Cx. salinarius
Aedes vexans
Uranotaenia sappharina

Site #30 (PG County#   )

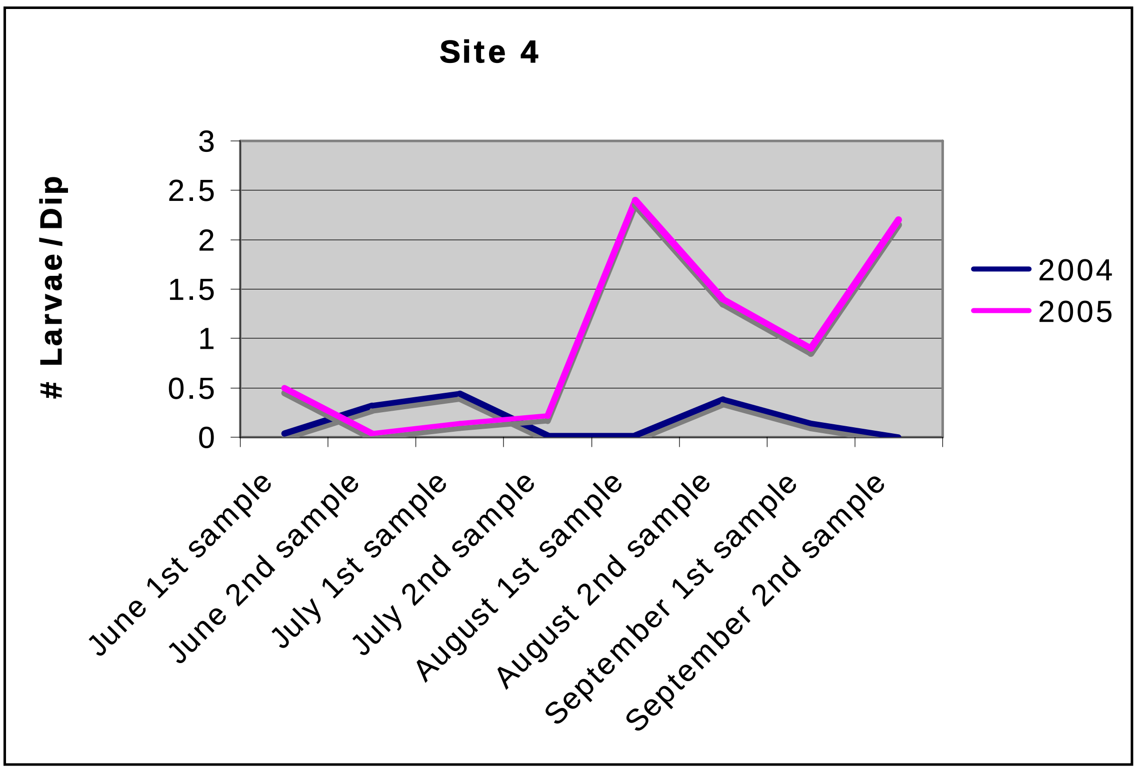


SPECIES LIST

Anopheles quadrimaculatus
Culex territans
Cx. salinarius
Aedes vexans
An. punctipennis
Cx. pipiens
Cx. restuans
An. walkeri ?
Cx. erraticus
Uranotaenia sappharina

3) Detention Ponds (BMPs):

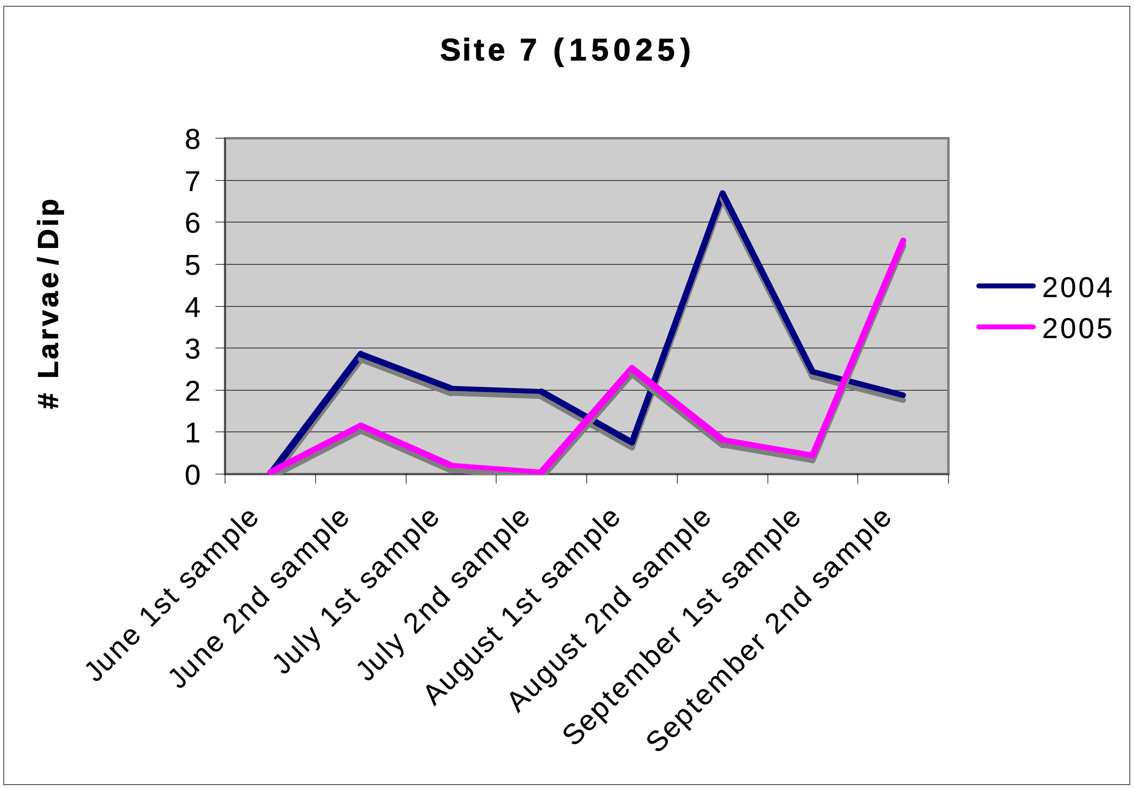
Site # 4 (MDSHA # 13033)



SPECIES LIST

Anopheles quadrimaculatus
Aedes vexans
Psorophora columbiae
An. punctipennis
Cx. pipiens
Uranotaenia sappharina
Culex territans
Cx. erraticus

Site #7 (MDSHA# 15025)



SPECIES LIST

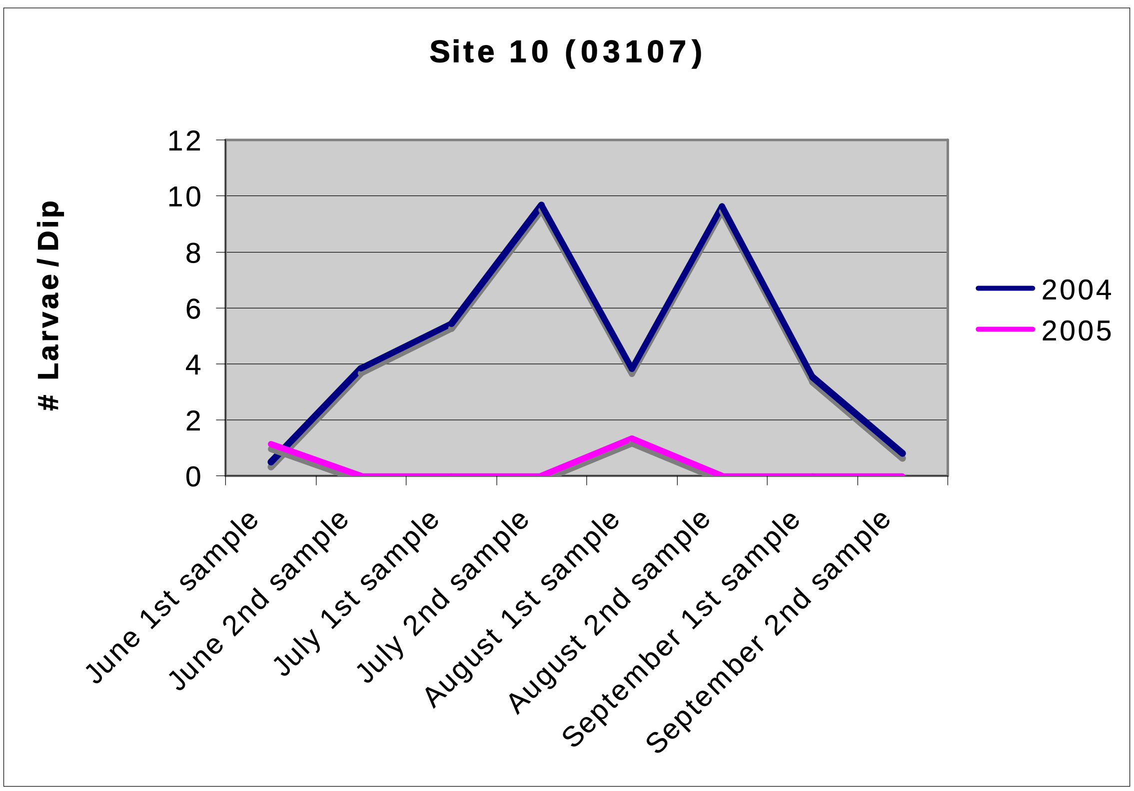
Anopheles punctipennis
Cx. restuans
Cx. salinarius
Culex territans
Aedes vexans
Uranotaenia sappharina
Cx. pipiens
Cx. erraticus

Site #9 (MDSHA# 15313)

SPECIES LIST

Anopheles punctipennis
Aedes vexans
Culex pipiens
Cx. salinarius

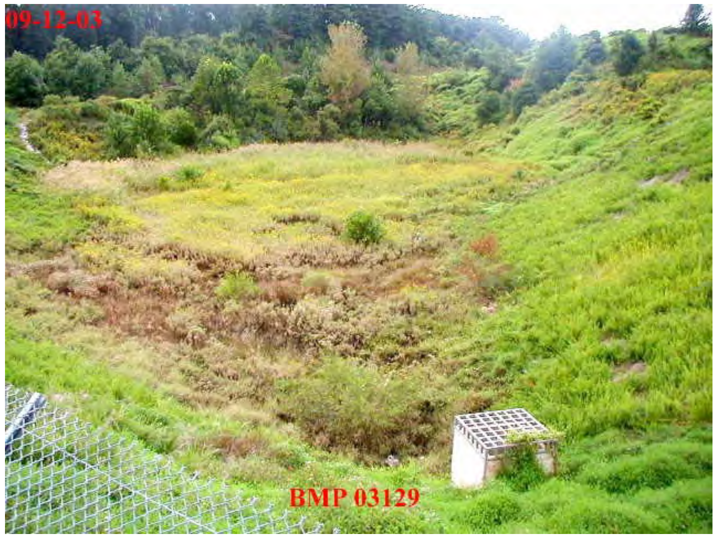
Site 10 (MDSHA# 03107)

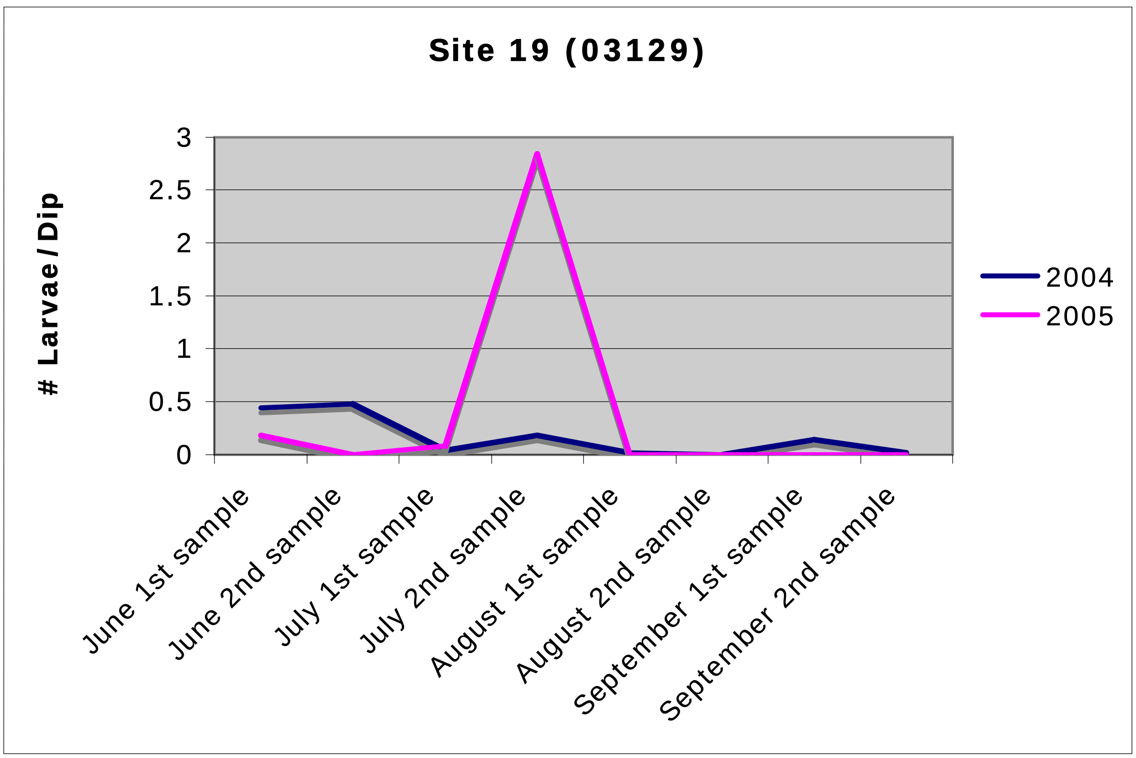


SPECIES LIST

Anopheles punctipennis
An. quadrimaculatus
Culex territans
Cx. salinarius
Cx. erraticus

Site 19 (MDSHA #03129)





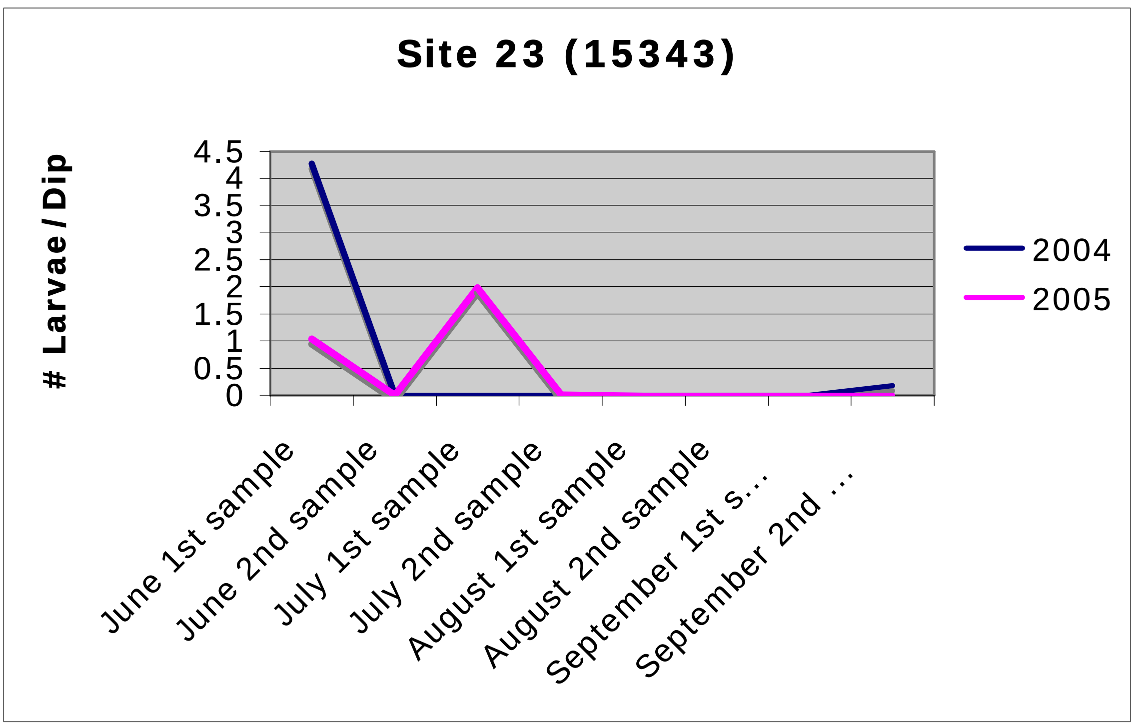
SPECIES LIST

Anopheles punctipennis

Culex territans

Aedes vexans

Site 23 (MDSHA# 15343)

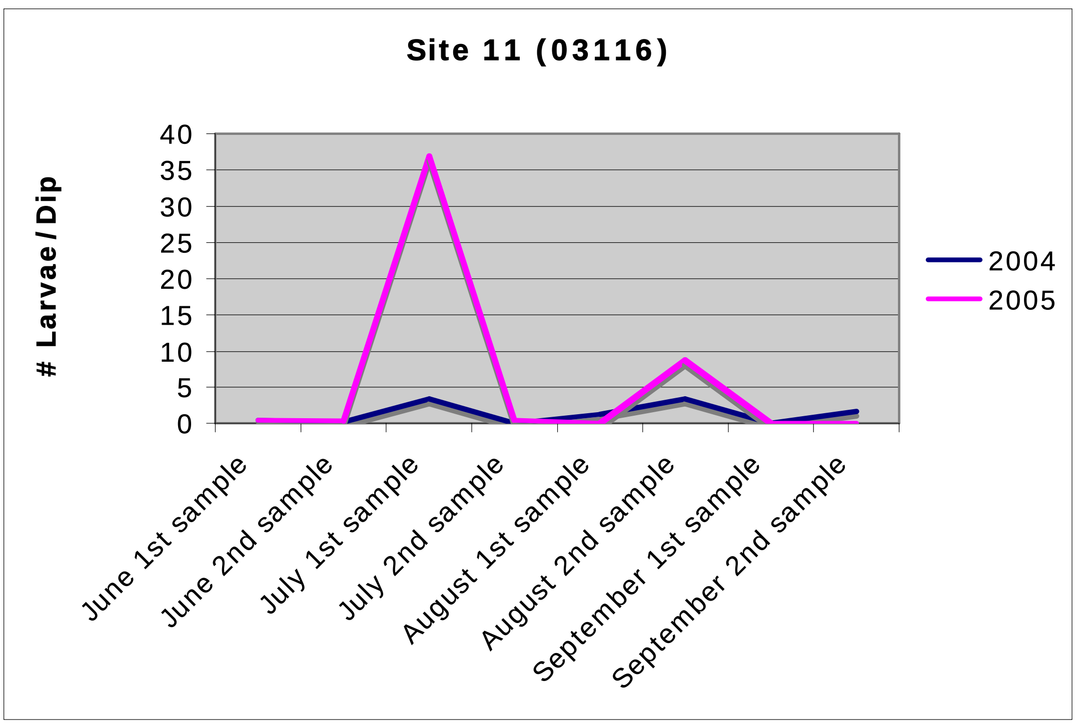


SPECIES LIST

Anopheles punctipennis
Aedes vexans
Culex restuans
Cx. territans
Cx. pipiens

4) Infiltration Basin BMP

Site 11 (MDSHA #03116)

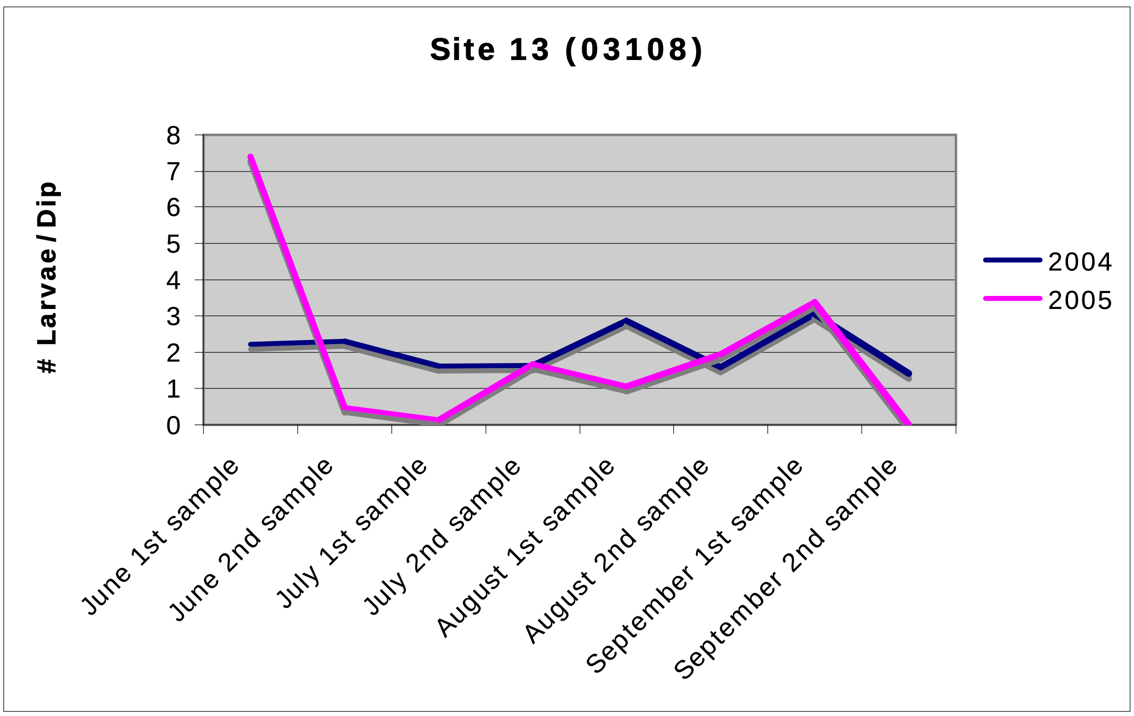


SPECIES LIST

Anopheles punctipennis	*An. quadrimaculatus*	*Culex territans*
Cx. pipiens	*Aedes vexans*	*Cx. restuans*
Cx. salinarius	*Ochlerotatus japonicus*	*Uranotaenia sappharina*
Psorophora columbiae		

Site 13 (MDSHA #03108)

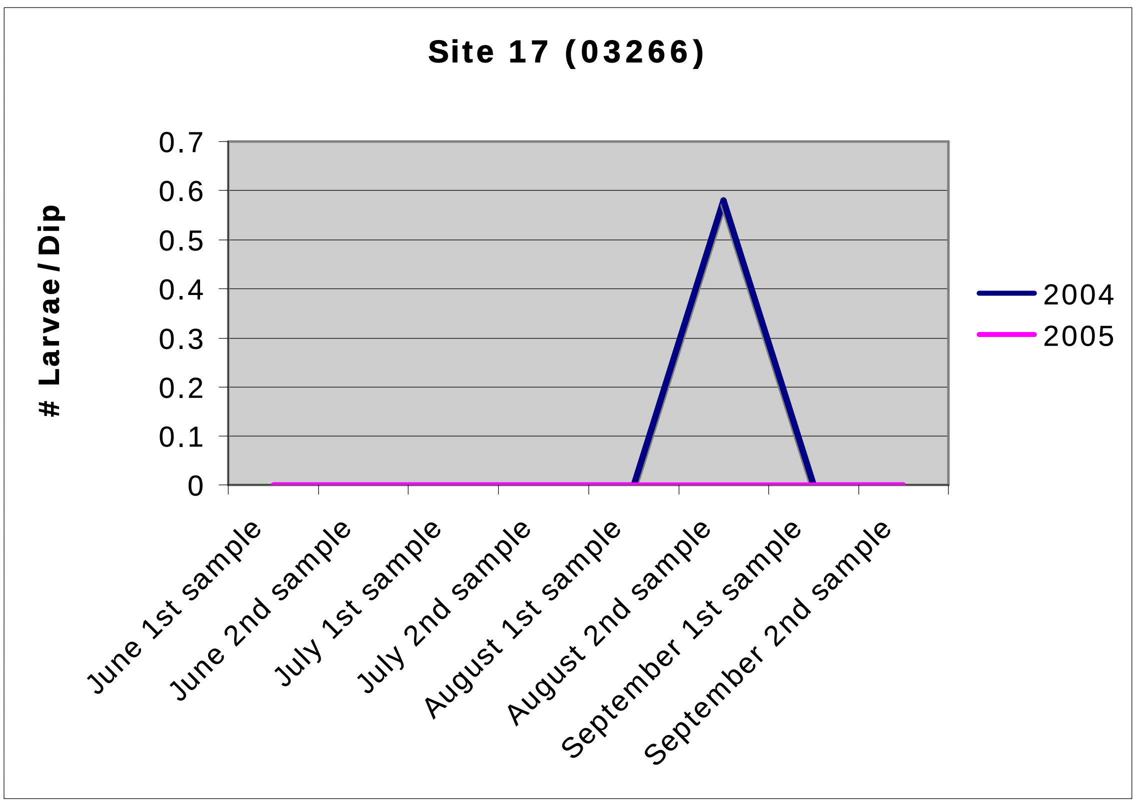
Prior to reconstruction on 9/15/05 **Post reconstruction 2/10/06**



SPECIES LIST

Anopheles punctipennis
Ochlerotatus japonicus
Aedes vexans
Cx. restuans
An. quadrimaculatus
Uranotaenia sappharina
Cx. pipiens
Psorophora columbiae
Culex territans
Cx. erraticus
Cx. salinarius

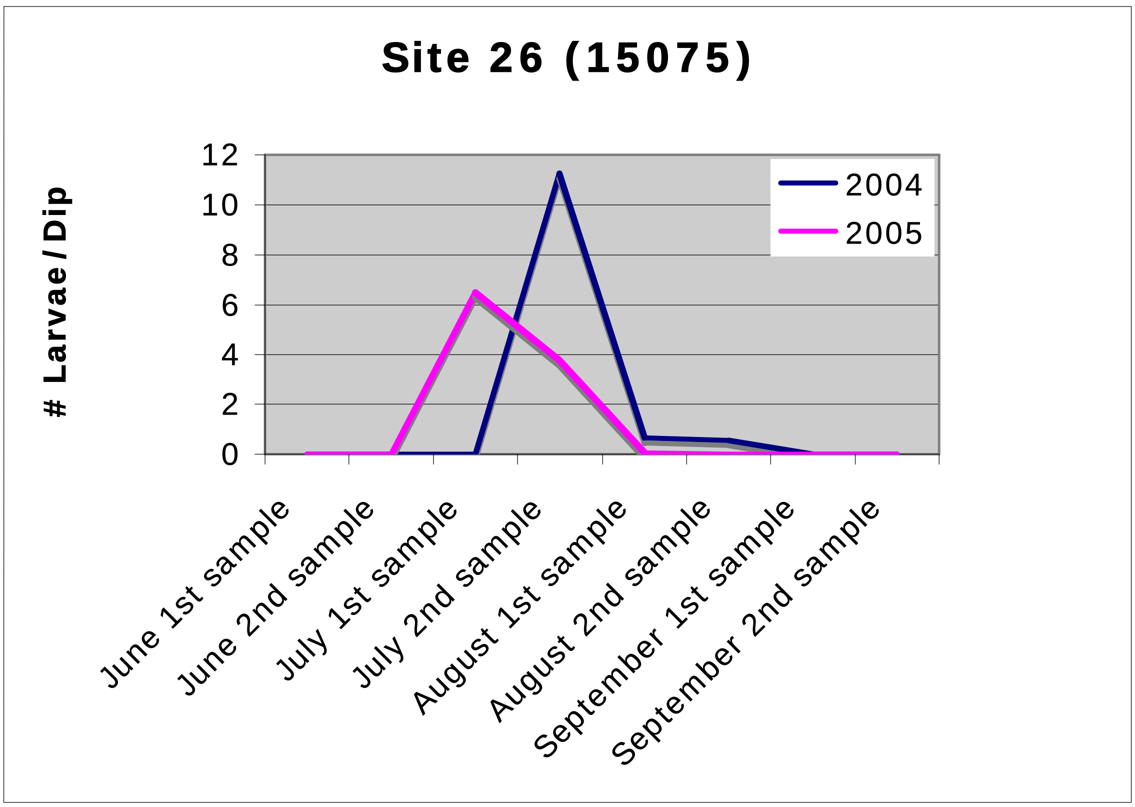
Site 17 (MDSHA #03266)



SPECIES LIST

Anopheles punctipennis

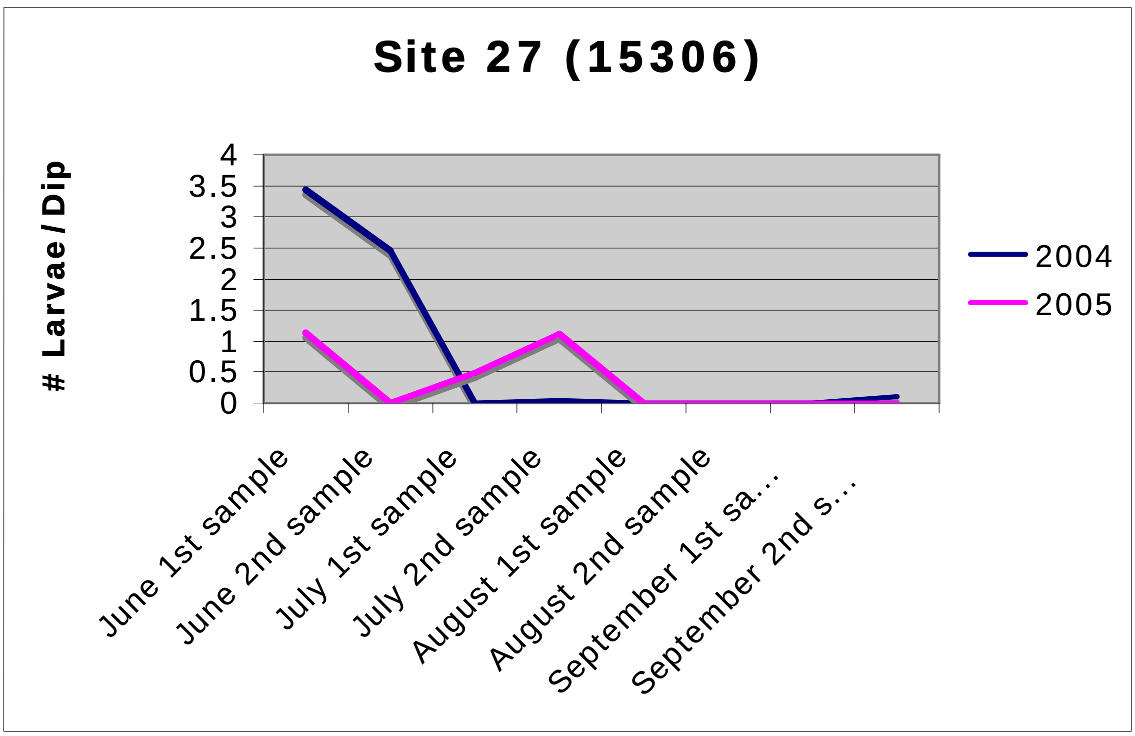
Site 26 (MDSHA# 15075)



SPECIES LIST

Anopheles punctipennis
Cx. salinarius
Culex territans
Aedes vecxans
Cx. pipiens
Psorophora columbiae

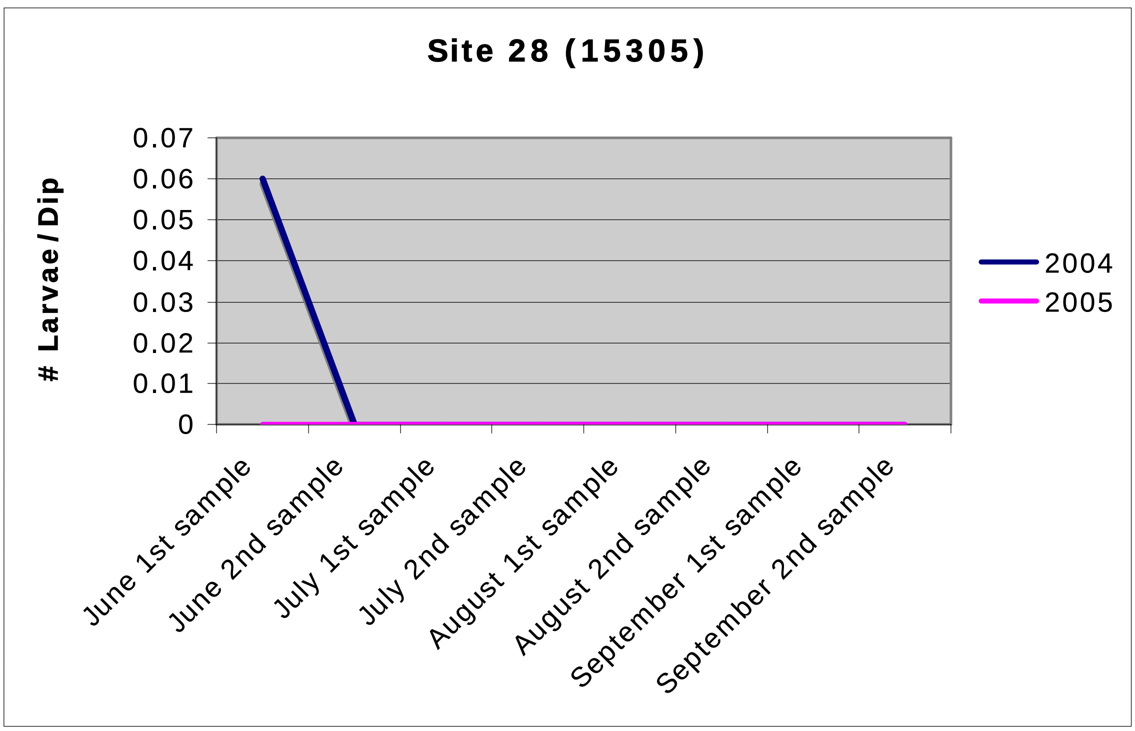
Site 27 (MDSHA # 15306)



SPECIES LIST

Culex pipiens quadrimaculatus	*Cx. restuans*	*Anopheles*
Psorophora columbiae	*Aedes vexans*	

Site 28 (MDSHA# 15305)



SPECIES LIST

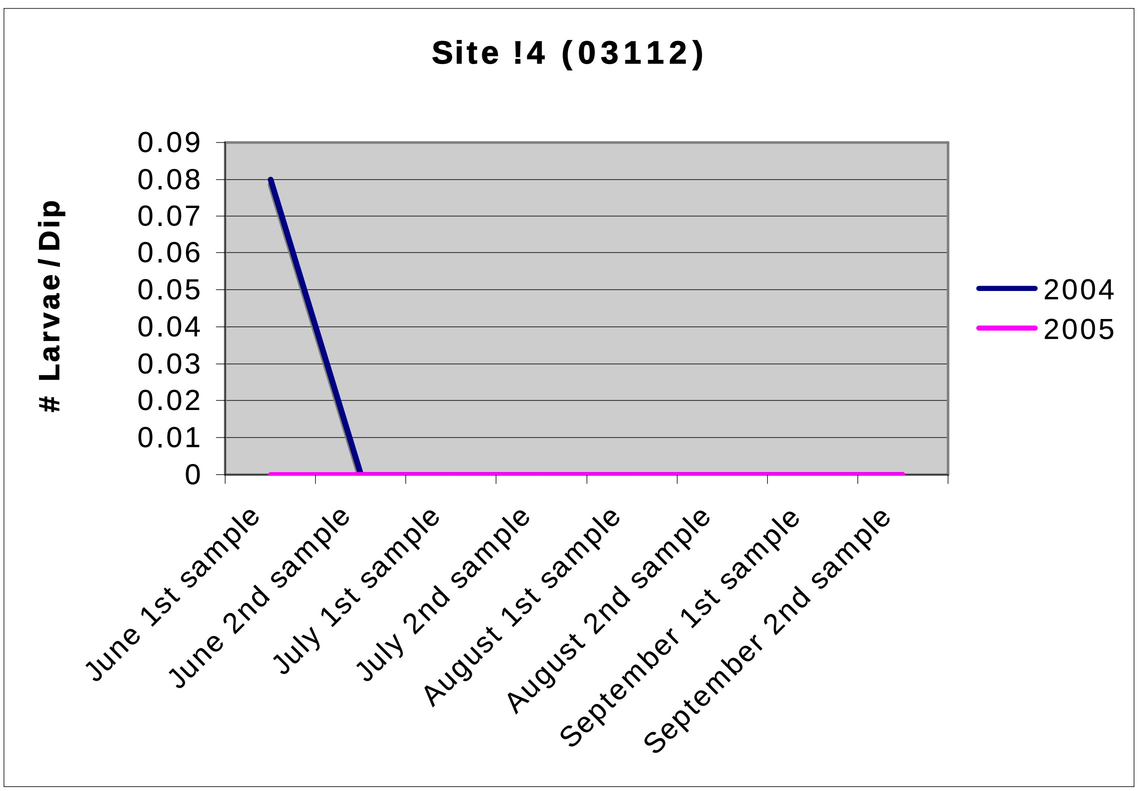
Culex restuans

5) Infiltration Trench BMPs

Site 12 (MDSHA# 03152)

NO LARVAE COLLECTED 2004-05

Site 14 (MDSHA# 03112)



SPECIES LIST

Ochlerotatus japonicus

Site 20 (MDSHA# 03124)

NO LARVAE COLLECTED 2004-05

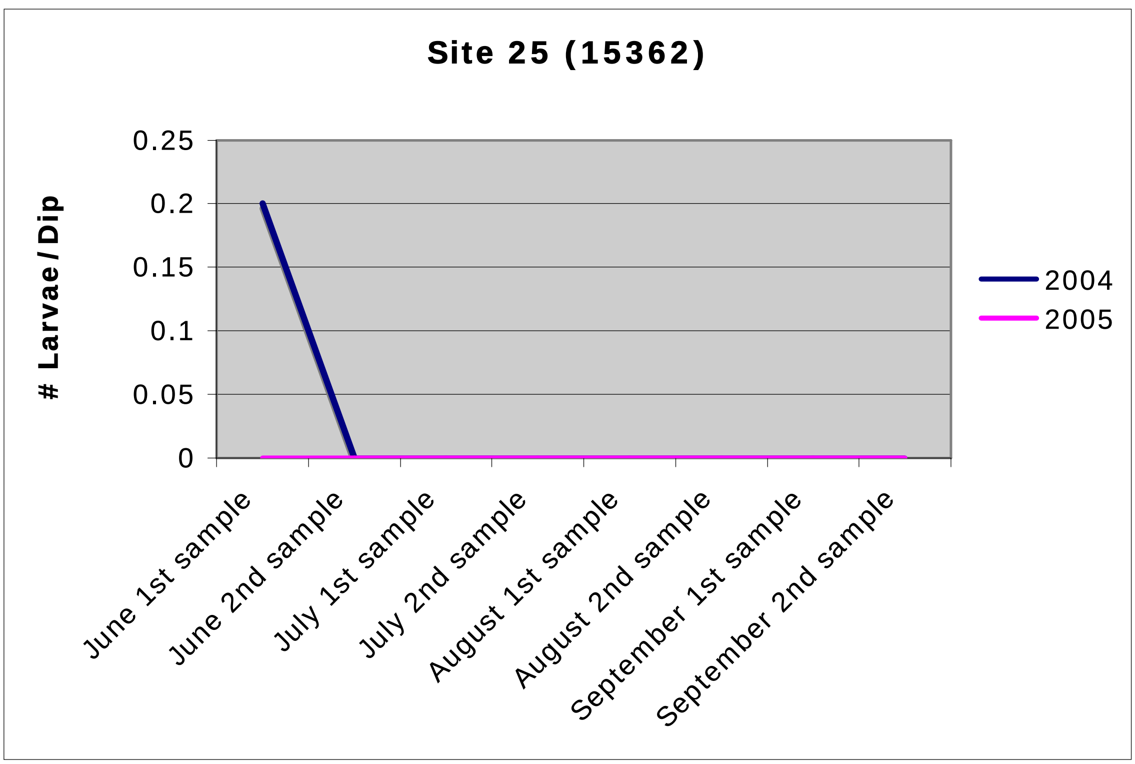
Site 21 (MDSHA# 13087)

NO LARVAE COLLECTED 2004-05

Site 22 (MDSHA#13015)

NO LARVAE COLLECTED 2004-05

Site 25 (MDSHA# 15362)



SPECIES LIST

Culex pipiens *Cx. restuans* *Ochlerotatus japonicus*

Appendix III.

List of States with Stormwater Management and /or Mosquito Control Websites

State	Stormwater Regulations		Mosquito Control
Alabama	None found		None found
Alaska	None found		None found
Arizona	http://azdeq.gov/environ/water/permits/stormwater.html		http://www.westnileaz.com/wnv_monitoring.htm; http://www.maricopa.gov/ENVSVC/BUSINESS/NEWS/pesticides.pdf (dealt with by each individual county)
Arkansas	http://www.awag.org/pp_slideshow/Stormwater_Forum_Fayetteville/Larson.pdf		http://www.healthyarkansas.com/pdf/0802_faqs.pdf
California	(only information pertaining to drainage & water conservation)		http://www.rmc.ca.gov/vector_index.html
Colorado	http://www.dot.state.co.us/environmental/envWaterQual/wqlinks.asp		http://www.cdphe.state.co.us/wq/PermitsUnit/mosquito.pdf; http://www.cdphe.state.co.us/dc/zoonosis/wnv/wnvhom.html
Connecticut	http://www.dep.state.ct.us/whatshap/press/2005/101905.htm		http://www.dep.state.ct.us/whatshap/press/2001/mf0409a.htm
Delaware	http://www.dnrec.state.de.us/water2000/Sections/SurfWater/DWRSurfWat.htm		http://www.dnrec.state.de.us/fw/moswel.htm
Florida	http://www.co.palm-beach.fl.us/erm/protection/surfstorm.asp		http://www.co.palm-beach.fl.us/erm/mosquito/index.asp; http://www.co.leon.fl.us/mosquito/; http://www.stlucieco.gov/msq/fog/programs/Basic%20Mosquito%20Control.pdf (controlled as a county issue)
Georgia	http://www.p2ad.org/Assets/Documents/govt_dod_regulatoryNov00.htm		http://agr.georgia.gov/00/article/0,2086,38902732_0_41314992,00.html; http://crd.dnr.state.ga.us/assets/documents/GA_Sound_Spring_04.pdf
Hawaii	None found		None found

State	Stormwater Regulations		Mosquito Control
Idaho	http://adm.idaho.gov/adminrules/rules/idapa58/0102.pdf (vague, only surface water addressed)		http://agri.idaho.gov/Categories/Pesticides/Documents/License%20Documents/proAppInfo.pdf (vague, general pest control)
Illinois	None found		None found
Indiana	http://www.in.gov/idem/guides/permit/water/stormwaterconstruction.html; http://www.in.gov/dnr/soilcons/pdfs/stormwater.pdf		http://www.ecn.purdue.edu/SafeWater/Ponds/WQ-41-W.pdf; http://www.ecn.purdue.edu/SafeWater/Ponds/mosquitoes1.htm
Iowa	None found		http://www.ces.purdue.edu/waterquality/ponds.htm#mosquito
Kansas	http://www.kdheks.gov/stormwater/index.html		http://www.kdheks.gov/kdhe_news/2004/jun/state_prepares_for_return_of_west_nile_virus.pdf; http://www.kdheks.gov/pdf/hef/ag1162.pdf
Kentucky	http://www.water.ky.gov/permitting/wastewaterpermitting/KPDES/storm/		http://www.kyagr.com/enviro_out/pestweed/programs/mosquito/; http://www.daviessky.org/departments/ema/mosquito_control.pdf
Louisiana	None found		None found
Maine	http://www.maine.gov/dep/blwq/docstand/stormwater/index.htm		yes (links are not working)
Maryland	http://www.menv.com/waterwastewater.shtml		http://www.edcp.org/html/west_nile.html
Massachusetts	http://mass.gov/dep/water/laws/policies.htm#storm		http://www.mass.gov/dph/wnv/faq_mos.htm
Michigan	http://www.deq.state.mi.us/documents/deq-ess-nps-savvy-bmp.pdf		http://www.deq.state.mi.us/documents/deq-wd-mosquito-generalcert001.pdf
Minnesota	http://www.pca.state.mn.us/publications/gp5-08.pdf		http://www.mmcd.org/distbr~2.pdf
Mississippi	http://www.dmr.state.ms.us/CoastalEcology/Storm/SECTION-3/Section-3-Text.pdf		http://msucares.com/news/print/fcenews/fce98/980615dg.htm (no state wide agency, just individual farmers & businesses)

State	Stormwater Regulations		Mosquito Control
Missouri	website not working		website not working
Montana	http://www.mt.gov/dma/des/Library/PDM/PDM-Final%20Draft/Mitigation%20Strategy.pdf#xml=http://search2.discoveringmontana.com/cgi-bin/texis.cgi/webinator/search/xml.txt?query=+stormwater+regulations&pr=Search2&prox=page&rorder=500&rprox=500&rdfreq=500&rwfre		(presently have document that is proposing a control plan) http://www.mt.gov/maco/Legislature/05LegislativeResolutions/2004-3MosquitoDistricts.htm
Nebraska	http://www.lincoln.ne.gov/city/pworks/watrshed/flood/overview/reg01.htm		http://pested.unl.edu/thelabel/tloct01.htm; http://www.agr.state.ne.us/regulate/bpi/pes/actbm.htm
Nevada	(was mentioned but no specific website found)		http://www.astho.org/pubs/MosquitoControlInterim7804.pdf (attemping as of 2004)
New Hampshire	http://www.des.state.nh.us/Stormwater/		None found
New Jersey	http://www.state.nj.us/dep/dwq/municstw.html#aboutprogram		http://www.state.nj.us/dep/mosquito/
New Mexico	(information only pertaining to water quality)		None found
New York	http://www.dec.state.ny.us/website/dow/toolbox/toolbox.htm		(state employs agencies, but having difficulties with a company) http://www.dec.state.ny.us/website/press/pressrel/2001/2001x95.html
North Carolina	http://www.ncstormwater.org/		http://www.co.dare.nc.us/depts/Public_Works/mosquito.htm
North Dakota	http://www.health.state.nd.us/WQ/Storm/StormWaterHome.htm		http://www.ndhan.gov/data/mrNews/WNV-positive%20chickens%2007.191.pdf (testing done but no state wide control program)

State	Stormwater Regulations	Mosquito Control
Ohio	http://www.dot.state.oh.us/ltap/Stormwater/1227-1247.pdf	http://www.ohioagriculture.gov/plant/curr/pr/plnt-pr-index.stm (individual pesticide use, no state wide control program)
Oklahoma	http://www.acogok.org/Programs_and_Services/Water_Resources/Storm_Water.asp	http://www.acogok.org/Newsroom/View_News.asp?article=78 (in development as of 2004)
Oregon	http://www.deq.state.or.us/wq/wqpermit/stormwa.htm	http://www.dfw.state.or.us/fish/diseases/backgrounder_WNV_gambusia.pdf; http://oregon.gov/DHS/ph/acd/diseases/wnile/wnile.shtml
Pennsylvania	http://www.depweb.state.pa.us/southeastro/cwp/view.asp?a=3&Q=460302&southeastroNav=	http://www.depweb.state.pa.us/news/cwp/view.asp?a=1278&q=470711; http://www.westnile.state.pa.us/
Rhode Island	None found	None found
South Carolina	http://www.scdhec.net/eqc/water/html/swnpdes.html#regulations	no state wide control program, only do-it-yourself tips
South Dakota	http://www.state.sd.us/denr/DES/Surfacewater/stormwater.htm	http://www.state.sd.us/doh/WNVgrants/index.htm
Tennessee	http://tennessee.gov/agriculture/nps/2004-319-ar.pdf	http://www.epa.gov/agriculture/tipm.html (only overall pest management)
Texas	http://www.twdb.state.tx.us/publications/newsletters/waterfortexas/wftfall02/art10non.htm (97% of texas is privately owned therefore, most stormwater management must be voluntary by the owner)	(no state wide control program, only do-it-yourself permits for small & large scale pesticide use)
Utah	http://search.utah.gov/retina/public/suggest.do;jsessionid=85E66D7C246D5B7CFE2D61213E3A7F4D?title=Storm+Water+Program&id=&links=%5BSTORMWAT%2CREGUL%5D&reference=http%3A%2F%2Fwaterquality.utah.gov%2Fupdes%2Fstormwater.htm	http://search.utah.gov/retina/public/suggest.do?title=State+of+Utah+Department+of+Agriculture+and+Food&id=&links=%5BMOSQUITO%2CCONTROL%5D&reference=http%3A%2F%2Fag.utah.gov%2Fpressrel%2FWNVFunds05.html
Vermont	http://www.anr.state.vt.us/cleanandclear/rep2004/stormwatermanagement44-49.pdf	http://www.healthyvermonters.info/dcb/052001.shtml (this is more of a survellience and response plan, not a constant control program)

State	Stormwater Regulations		Mosquito Control
Virginia	http://www.dcr.virginia.gov/sw/stormwat.htm		http://www.vdacs.virginia.gov/animals/wnv.html (only informative information about WNV, nothing about a control plan)
Washington	http://www.ecy.wa.gov/pubs/0510002.pdf		http://www.ecy.wa.gov/biblio/0210057.html; http://www.ecy.wa.gov/biblio/0310023.html
West Virginia	None found		None found
Wisconsin	http://dnr.wi.gov/org/water/wm/nps/stormwater/muni.htm; http://dnr.wi.gov/org/water/wm/glwsp/ssaplan/controls.htm		http://www.datcp.state.wi.us/arm/environment/insects/west-nile/wnv_home.jsp; http://www.datcp.state.wi.us/core/insectspesticides/insectspesticides.jsp (no state wide program, only do-it-yourself or large business)
Wyoming	http://deq.state.wy.us/wqd/WYPDES_Permitting/WYPDES_Storm_Water/stormwater.asp		http://www.uwyo.edu/AgAdmin/news/Mosquitoes.htm (overview of a study trying a new form of repelling mosquitos, to benefit of cattle economy as well as address WNV)

APPENDIX F:

SWM Facility Visual and Environmental Quality - Safety Criteria

Review Guidelines

Stormwater Management Facility Visual & Environmental Quality And Safety Criteria

Review Guidelines

Prepared by

Maryland State Highway Administration
Highway Hydraulics Division

October, 2006

SHA
State Highway Administration
Driven to Excel
Maryland Department of Transportation

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1. Introduction

This manual will assist stormwater management (SWM) facility visual quality (VQ) reviewers in determining compliance of stormwater management facility design projects with State Highway Administration (SHA) visual quality, environmental quality and safety policy and criteria. It is important that stormwater management facilities fit within the surrounding environmental and community context. It is also important to protect the public from safety hazards associated with the functioning of these facilities. In order to ensure these concerns are addressed, we are providing these guidelines for the visual and environmental quality review process. This program is managed through the Office of Highway Development (OHD) Highway Hydraulics Division (HHD).

Reviewers will provide comments for a variety of facility types designed by a number of different entities. These can include SHA consultant design, in-house design, Access Permit (AP) / Utility Permits (UP), and SHA District special projects. For consultant, in-house or special projects, a copy of the plans, bid book, and stormwater management report should be reviewed.

For AP/UP reviews, the developer does not use SHA standard specifications. The necessary information and review comments need to be conveyed to the Developer using the access permit review process. AP/UP reviews will require looking at the developer’s plans, SWM report and specifications. The HHD *Guidelines for Development Adjacent to State Highways* should also be consulted for AP/UP reviews.

2. Review Process

VQ reviewers should follow the process outlined below:

- SHA Highway Hydraulics SWM Visual Quality Team will assign the project to a VQ reviewer. The project VQ reviewer should contact the project stormwater management designer and/or HHD contact to obtain project documents to be reviewed.

> *Note: The SHA SWM VQ team keeps a database of all the projects assigned for VQ review on the ProjectWise site. The VQ reviewers should consult the database frequently to acquire new review assignments.*

- The VQ reviewer should keep the project review database current by inputting information pertaining to their project reviews. The project review database is located on the ProjectWise site.

- The VQ reviewer should utilize this guideline and checklist to review the SWM facilities (including computations, drawings, specifications, and estimates). The VQ reviewer will then produce a comment letter with the completed checklist attached that will be distributed to the SWM VQ team and the HHD project contact.

- The VQ reviewer should perform a site visit and produce photo documentation of the site. The site visit can be part of the P.I. Investigation meeting.

- Photos, review comment letters and project information will be stored on ProjectWise. Training is available if needed.

- The reviewer will continue to contact the project SWM designer and/or HHD contact throughout the project milestones to ensure that comments are addressed and new information is received and reviewed. *The reviewer should be proactive in coordinating with the designer in order to ensure comments are provided and responded to at all milestones.*

- Reviewers will coordinate their comments through the HHD project assignee keeping the SHA VQ team copied on all correspondence and emails.

- The VQ reviewer should contact the SHA SWM VQ team if they have any questions or need assistance with unusual situations.

3. Data Check

3.1 Submission Requirements

Part of the review process includes ensuring that the submitted plans, details, and specifications provide accurate data and that facilities are appropriate for the site and desired outcome. This is important for safety and for the proper functionality of the SWM facility. In order to accomplish this, having the right documents to review is important. The SWM designers should submit:

- 2 copies SWM grading/layout plans, details including outfall structures, planting plans and details (half-size sets are preferred). Electronic copies in PDF format can be provided instead.

- 1 copy SWM report including drainage area mapping (can be returned when the review is complete). Electronic copies in PDF format can be provided instead.

- 2 copies IFB (Bid Book) for the project. Electronic copies in PDF format can be provided instead.

- A schedule including anticipated dates for Preliminary Investigation (PI), Semi-final Review (SFR), Final Review (FR), Advertisement, Bid Opening and Notice to Proceed.

3.2 Visit Site

A field site visit should be conducted by the reviewer or designated personnel. The purpose of the field visit is to:

1. Assess the visibility and context of the site. If the facility is not visible from the road, other transportation facilities, or surrounding land uses focus evaluation on non-aesthetic features. If the facility is visible from intensive uses such as residences, schools, and recreation areas or from high-use transportation facilities such as park-and-ride facilities or highway loop ramps, particular attention should be given to the aesthetics of the stormwater facility.

2. Identify potential problems or constraints.

3. Identify opportunities that can offer some advantage.

4. Take photos of all aspects of the facility that are being checked. Photographs should document problems and constraints, but are also useful for documenting exemplary features of the site which may be desirable to preserve. Upload the photos to ProjectWise.

3.3 Verify Existing BMP Inspection Results

If this is an AP/UP Review or BMP retrofit project, check the SHA BMP database for latest inspection results. Incorporate any required work for the facility into the project. Contact the SHA BMP Program for a print out of the inspection report.

3.4 Assess Appropriateness of BMP Type

Each SWM facility should be reviewed to determine if the type of facility proposed for the particular site is appropriate. The following considerations can affect the selection of type.

1. To assess appropriateness considering the factors of watershed, terrain, treatment suitability, physical feasibility, community, environment, and permits, refer to the *2000 Maryland Stormwater Design Manual,* Chapter 4, Guide to BMP Selection and Location in the State of Maryland.

   In addition, it may be useful to refer to Chapter 2, Unified Stormwater Sizing Criteria, Chapter 3, Performance Criteria for Urban BMP Design, Appendix A, Landscaping Guidance for Stormwater BMPs and Appendix. D.3, Short Cut Method for a Wetland Drawdown Assessment.

2. Check proximity to airports, particularly BWI-Thurgood Marshall Airport and Martin State Airport, which have Airport Zoning Districts. The Martin State Airport Zoning District is contained within a circle, the radius of which is 17,500 feet from a point with coordinates of 39°19'34" North Latitude and 76°24'54" West Longitude (See Figure 1.a).

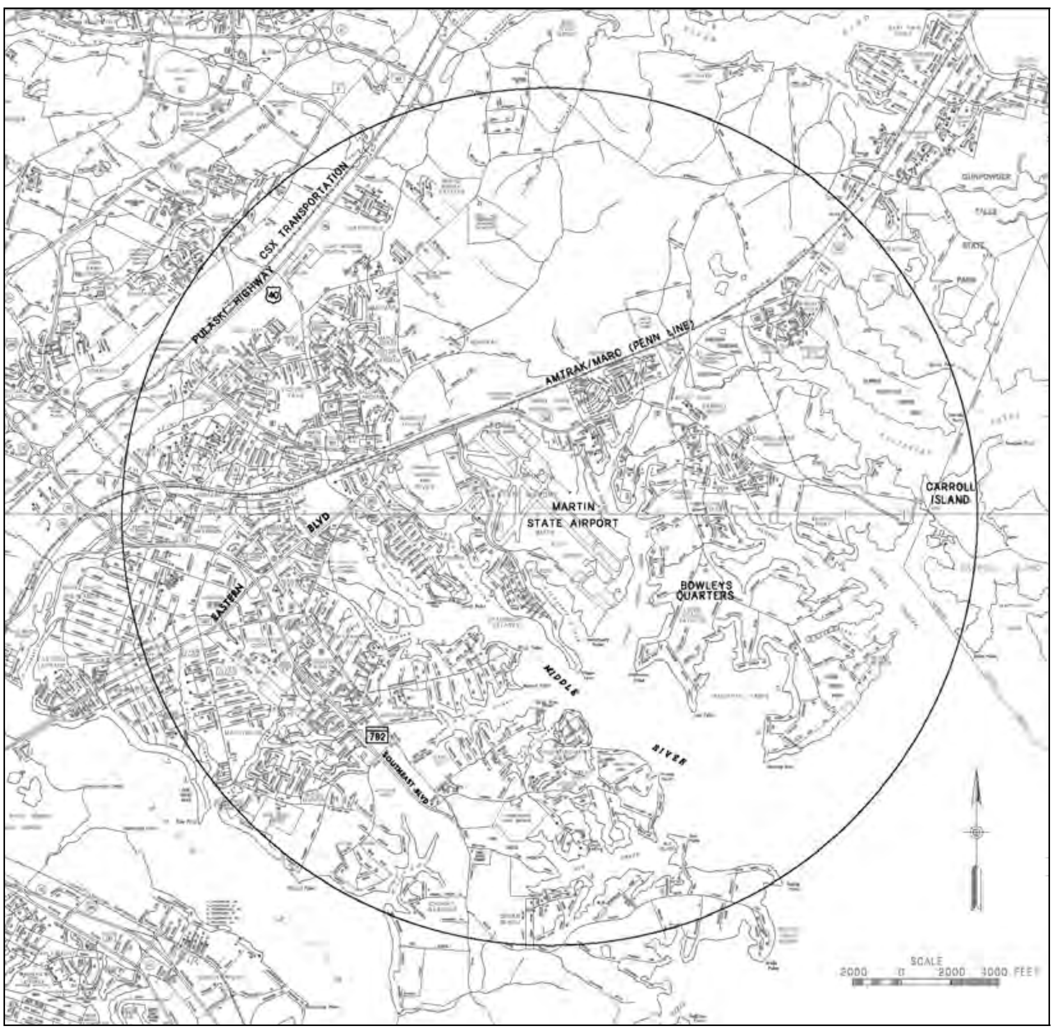


Figure 1.a – Martin State Airport Zoning District

The BWI-Thurgood Marshall Airport Zoning District is the land area contained within a circle, the radius of which is 4 miles from a point with Maryland grid coordinates of E 893,909.99—N 490,279.30 (See Figure 1.b).

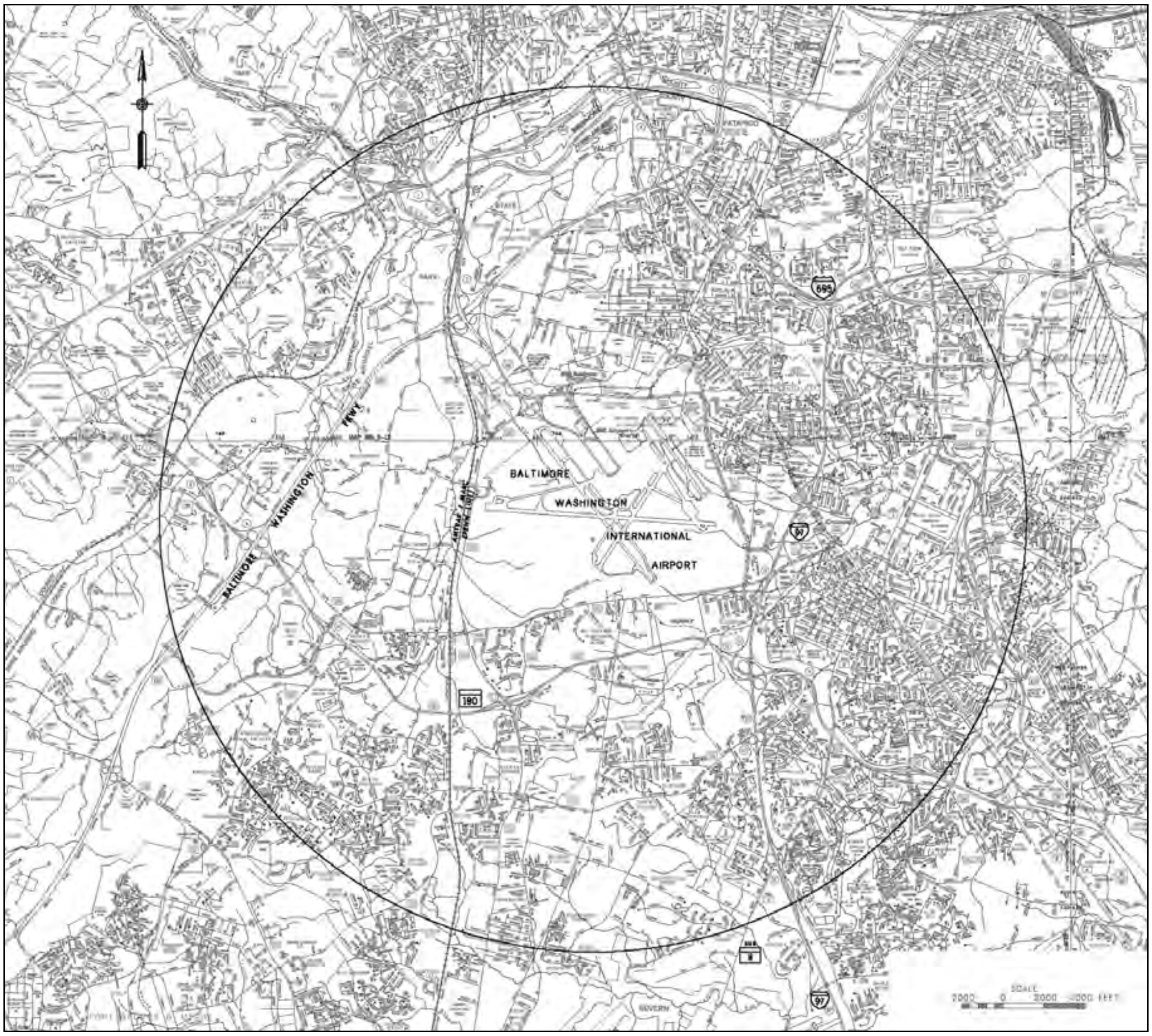


Figure 1.b – BWI Airport Zoning District

Verify that facility types in these zones meet Maryland Aviation Administration (MAA) restrictions (bird strike prevention and wildlife restriction) or restrictions at local and military airports. Refer to *MAA Design Standards – Bird Deterrent Systems (DST-2001-09), Exhibit 'A': MAA Criteria for Stormwater Management within the BWI Airport Zone* and the latest listing Approved Plants for BWI and/or Martins Airports (Appendix to the *Specifications for Performing Landscaping Activities for the Maryland Aviation Administration).* Generally, wet pools, wetlands and wet swales are not permitted in these areas and any plant material that is used must have low wildlife value.

3. Check watershed stream use classifications for use III and IV restrictions. These watersheds have shortened extended detention times and require attention to thermal impacts that facilities might impart to receiving waters. Special planting for shade may

mitigate thermal impacts. (See Appendix D.9, MD Stream Use Designations, of the *2000 Maryland Stormwater Design Manual*).

4. Check if the facility lies within the Chesapeake Bay Critical Area, defined as all water and submerged lands of the Chesapeake Bay to the head of tide, and all land and water within 1000 feet of mean high water or from the edge of tidal wetlands. (See Appendix D.4, Stormwater Criteria for Maryland Critical Area IDA Zone, of *2000 Maryland Stormwater Design Manual*.) If within the Critical Area, check for additional requirements that may apply which may impact type of facility chosen.

5. Check if the facility lies within the Coastal Bays Program limits. The Coastal Bays Program protects the land and waters of Assawoman, Isle of Wight, Sinepuxent, Newport, and Chincoteague bays. To the east of Route 113, the 175-square-mile watershed of the coastal bays includes Berlin, Ocean City, parts of Snow Hill and Pocomoke and the Assawoman, Isle of Wight, Sinepuxent, Newport, and Chincoteague bays. If within this watershed, check latest Coastal Bay development criteria for recommended practices related to stormwater management, such as the "Recommended Model Development Principles for Worcester County" (ref. www.mdcoastalbays.org).

3.5 Check BMP Capacity Requirements

1. The SWM report should be consulted for facility sizing requirements to identify the potential for adjusting landforms, shape and slope steepness if necessary. This can be accomplished by reviewing the capacity computations to see if the facility is oversized. If more WQv or CPv treatment is provided than required, there may be the potential to make adjustments.

2. Look upstream for additional WQv potential to reduce volumes at the facility or provide additional treatment.

3.6 Verify Environmental Features

1. Review impacts to environmental elements including jurisdictional wetlands and streams (waters of the US) and their buffers, 100-year floodplains, and forests. Evaluate whether impacts are necessary or could be avoided through a different design, facility type or debiting the water quality bank.

2. Check to ensure the above impacts are accounted in permits. Coordinate with Environmental Programs Division (EPD) assignee to confirm.

3. If BMP is located within a new ROW or easement, and it impacts or is adjacent to potential 4(f) resource (such as a park, historic property, wildlife refuge, trail, etc.), coordinate with Project Planning Division (PPD) assignee to confirm that impact is accounted in the NEPA/MEPA process.

3.7 Verify Water Quality Bank Balance

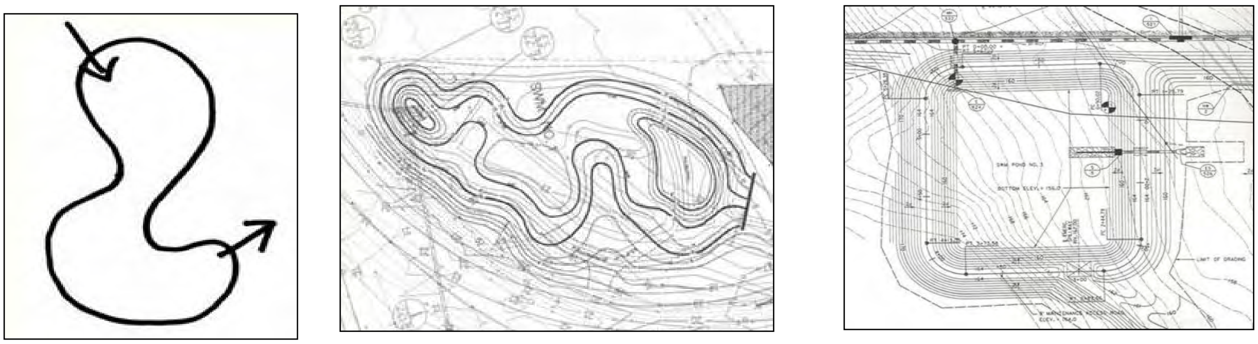
The HHD maintains an agreement with the Maryland Department of the Environment (MDE) that allows us to obtain credits or debits for water quality requirements on projects. This process is referred to as the water quality (WQ) bank. Allowances are made to debit the bank when water quality treatment cannot be provided. The option to debit the bank is limited to instances where BMP facility installation is not feasible or will incur environmental impacts. Debits to the WQ bank require HHD and MDE approval.

The VQ reviewer should review instances where the designer is proposing to debit the WQ bank to ensure that the reasons are valid and to verify that the bank balance has not exceeded the maximum debit allowance.

4. Shape, Form and Grading

4.1 Evaluate Shape and Form

Contour grading at SWM facilities should incorporate curvilinear, naturalistic, and irregular shapes with minimal straight lines and sharp angles. Geometric or simple shapes, such as rectangles or ovals, provide little visual interest and should be avoided. (See Figure 2).



Concept Stage **Curvilinear and Natural** **Simple and Geometric (Avoid)**

Figure 2. BMP Shape Examples

Landforms, such as baffles and peninsulas, should be graded into the facility shape to increase the flow path and provide visual interest. Landforms should be curvilinear or natural in design, characterized by rolling topography and rounded forms, and blend well with the surrounding landscape. Avoid geometric or simple shapes, forms and contouring. (See Figure 3)

Curvilinear **Simple (Avoid)**

Figure 3. BMP Landform Examples

4.2 Check Slope Steepness

Grade steepness should be dictated by safety and mowability.

4.2.1 Mowing Requirements

Grading design should facilitate mowing in areas requiring routine mowing. Access should be provided to all mowing areas from the maintenance access (see below). Dimensions and turning requirements of standard mowing equipment shall also be considered in the design.

Areas that require routine mowing, outlined in Table 1, should be 4:1 or flatter in steepness.

Table 1. Areas Requiring Routine Mowing

1. Maintenance Access
2. Code 378 SWM embankment (both upstream and downstream faces)
3. 15 ft. clear zone at Code 378 SWM embankment toe
4. Around SWM outfall structure
5. Emergency spillway
6. Bottom and side slopes of dry swales and surface sand filters
7. Filter strips at grass channels, infiltration basins, infiltration trenches, dry swales and bioretention areas

4.2.2 Safety Grading Requirements

SHA policy requires that safety features be provided in SWM facilities rather than fencing the facility or placing railings at outfall structures. Safety features include grading and signs (for information on signs, see *Maryland Standard Sign Book*, Standard No. 195-6 “No Trespassing State Highway Administration”). Facilities with 2 ft. deep permanent water or deeper (including forebays) require safety grading. Safety grading features include:

1. Side Slopes should be 4:1 or flatter. This includes both stand-alone Code 378 SWM embankments and roadway Code 378 SWM embankments. Cut slopes with reforestation can be steeper than 4:1 with SHA approval.

2. Benches should be placed around the perimeter of permanent pools that are 2 ft. deep or deeper. The benches should be a minimum 15 ft. wide and centered at the permanent pool elevation with a grade of 12:1 or flatter. (See Figure 4.a)

3. MDE requires that a safety railing be placed at endwalls and outfall structures that are 48 in. or greater in height (page 3.15 of the *2000 Maryland Stormwater Design Manual*.) SHA policy requires that SWM outfall structures be designed so that they do not exceed this height in order to eliminate the need for railings. This can be accomplished by grading a bench around the structure. This bench should extend a minimum of 5 ft. beyond the structure on all sides. (See Figure 4.b).

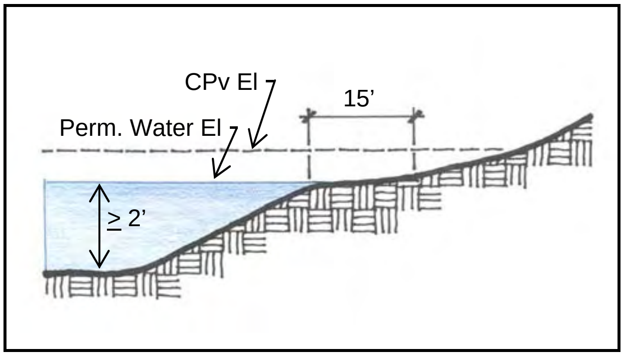


Figure 4.a Safety Bench Example

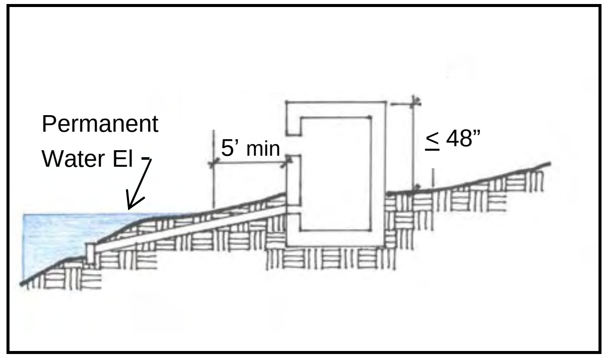


Figure 4.b Bench Around Structure

Figure 4. Safety Benches

If safety grading is not feasible for the facility or outfall structure, the designer must demonstrate this to the Division Chief of HHD using grading studies, sketches or other means as appropriate. Fencing can only be used as a last resort and written approval must be obtained from the Administration before proceeding with fence or railing design and specification.

5. Outfall Risers and Weir Structures

Outfall structures and weirs can potentially be visually obtrusive aspects of a stormwater management facility. The reviewer should look at the design of these structures to make sure that they blend into the surroundings. In some contexts, the structure may be designed as an architectural feature. The structures should not present any safety hazards and should be designed to facilitate maintenance.

5.1 Verify Safety Features at SWM Riser and Weir Structures:

1. Top Dimension -- Minimum 4ft.-2in. dimension or greater on two consecutive sides adjacent to the manhole cover should be provided at the top of riser structures that are 30 in. or greater in height. This will allow room to maneuvering the manhole cover from the frame. (See Figure 5)

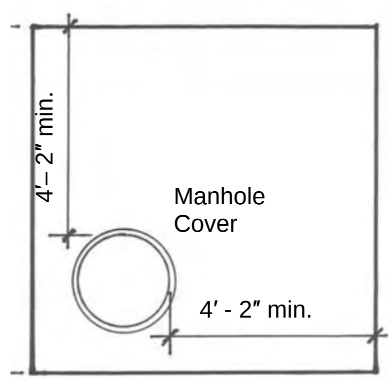


Figure 5.   Plan at Riser Structure

2. Height – See Section 4.2.2 for information on safety grading at SWM outfall structures and endwalls.

5.2 Assess Aesthetics of Outfall Structures:

1. The structure design should be appropriate and attractive. Check detailing for visual quality.

2. There should be no flat grates on top of the outfall structure. If modified inlet structures are used at bioretention facilities and sand filters, the inlet grate should be modified so it is not flat.

3. Trash racks should be provided and should not be flat on the top. The visual quality of these should be assessed.

4. Low flow device placement and type should be appropriate. The use of submerged devices is preferable.

6. Fences and Railings

6.1 Verify Fence Approval

The use of fences to enclose SWM facilities should be avoided whenever possible so that the facility is accessible for future maintenance activities. The reviewer should check to make sure that a fence is absolutely necessary and if the use of fencing has been approved by the Division Chief, HHD. If changes to the SWM facility design would make a fence unnecessary (see section 4.2), these changes should be noted and recommended. When fences are used they should blend into the surroundings.

6.2 Verify SWM Fence Requirements and Design

When fencing is required and approval for fencing has been obtained from the HHD Division Chief, it should be designed according to the criteria below (See Figure 6). This criteria does not apply to right-of-way fencing.

1. 42 in. height.
2. Black or brown vinyl coated chain link with top rail or decorative fencing when high visibility warrants the added expense. The same color choice and detailing should be used throughout the project.
3. 12 ft. wide double gate for maintenance access.
4. Visually unobtrusive placement.

Figure 6. Black Vinyl Coated Chain Link Fence with Top Rail

6.3 Verify Railing Requirements and Design at Hydraulic Structures

Safety should be considered in the design of hydraulic structures such as headwalls and end walls. Railings should be provided at endwalls and headwalls that are 48 inches or greater in height from the ground surface (including submerged ground surface) and should be designed according to the following criteria:

1. 42 inch height.

2. Black or brown vinyl coated chain link with top rail (see Figure 7).

Figure 7. Chain Link Railing at Endwall

7. Stabilized Maintenance Access

Maintenance is an important aspect of the continued functionality and appearance of a stormwater facility. A stabilized maintenance access from a public right-of-way to all SWM facilities should be provided.

7.1 Placement

1. The access road should connect to the facility bottom, forebay bottom, inflow and outflow structures.

2. When possible, space should be provided at the top and bottom of the access to allow large maintenance vehicles to turn completely around. Room should be provided at the entrance for a maintenance truck with trailer to pull completely off the roadway without blocking the maintenance access.

3. The surface of the maintenance access road should be a minimum of 1 ft. above any permanent water surface.

4. The access should be graded into the landforms by benching into side slopes somewhat parallel to contours rather than ramping down side slopes perpendicular to the contours. Benching reduces erosion by breaking runoff travel path at slopes and is also more visually appealing. (See Figure 8)

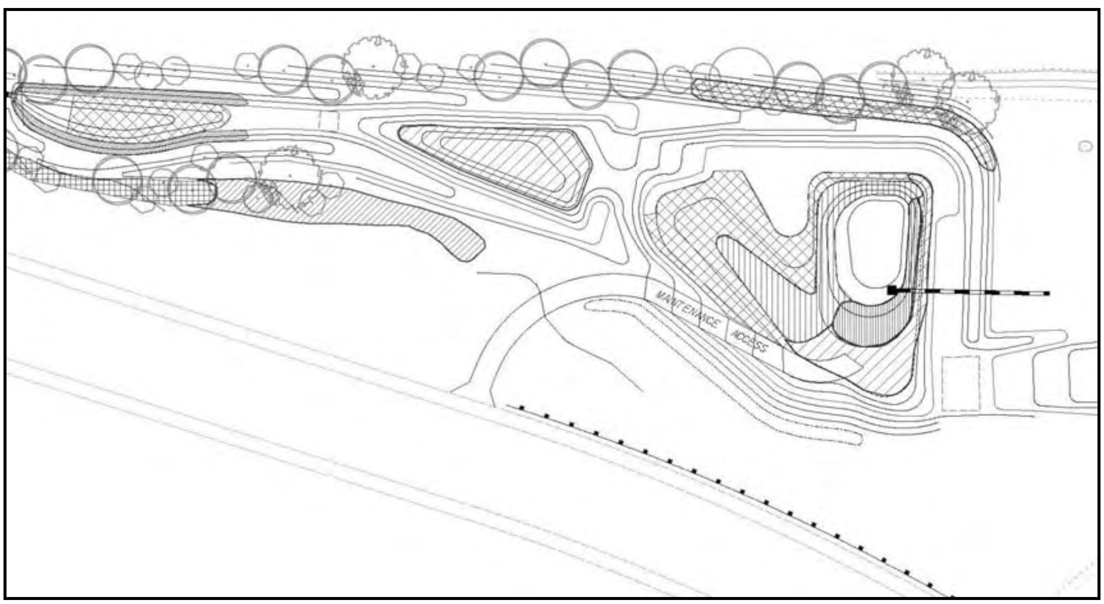


Figure 8 – Benched Access Road

7.2 Design Requirements and Detailing

1. Minimum width of 12 ft should be provided. A 10 ft. width may be acceptable when limited right-of-way or other factors require.

2. The maintenance access should be constructed with a 6 in. depth cellular confinement system filled with open graded aggregate, topped with 4 inches of topsoil and seeded and mulched.

3. The preferred maximum slope at maintenance access is 8:1 (12%). Slopes as steep as 6.6:1 (15%) may be used when conditions warrant.

7.3 Entrance Requirements

1. Access should be provided from a public roadway right-of-way. If the roadway is a high speed, limited access facility, consideration should be given to the safety of maintenance vehicles slowing and pulling off the roadway. For instance, a widened, stabilized shoulder may be needed. Consider both entering and exiting the facility when reviewing the facility design for this requirement.

2. If the roadway is closed section with curb and gutter, a concrete apron should be provided with depressed curb. (See Figure 9)

3. The entrance should not be blocked with traffic barrier, parking or other permanent obstructions.

4. If traffic barrier is used along the roadway, an opening should be provided to accommodate the maintenance access entrance. End treatments and opening configurations at traffic barrier should adhere to the *AASHTO Roadside Design Guidelines* and SHA *Traffic Barrier Guidelines*.

5. A 12 ft. wide double gate should be provided where fencing is used at the stabilized maintenance access. A method to secure the gate in the closed position should be included in the design detailing and an exterior grade padlock and with 2 keys should be provided to the Administration for each gate.

Figure 9. Concrete Apron Provided at Maintenance Access

8. Planting

Plantings can provide visual improvement to stormwater facilities, but offer other important benefits as well. Plants provide nutrient removal, shade, particulate pollutant removal, wildlife habitat and natural heritage continuation. It is important that native plants be used and that the plants selected are native to the particular area. This avoids the accidental introduction of invasive species, ensures greater likelihood of plant survival and adaptability, and allows the facility to merge into the adjacent landscape.

8.1 Woody Plant Restrictions and Buffer Zones

Planting of woody species, including live fascines, should adhere to Pond Code 378 restrictions at SWM embankments and SWM outfall structures. The following should also apply:

1. No woody material shall be planted on the SWM embankment (roadway and non-roadway), within 15 feet of the toe of SWM embankment fill or within 25 feet of the SWM outfall structure.

2. A 15-foot buffer zone within Administration right-of-way should be provided at the toe of Code 378 SWM embankments (roadway and non-roadway) that shall be maintained free of woody vegetation. (See Figure 10)

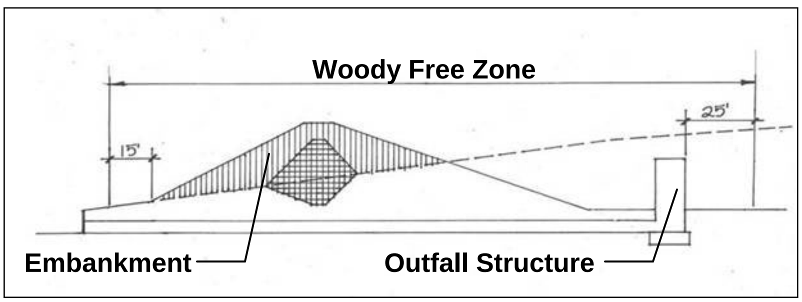


Figure 10 – Woody Plant Restriction Area at Code 378 SWM Embankment

8.2 Planting Height Restrictions at SWM Embankments

SWM embankments and buffer zones shall be planted with warm season grasses and/or turf grass that can be maintained to a height of 10 inches.

8.3 Plantings within Airport Zones

Plantings within Airport Zoning Districts should be in compliance with the most recent Maryland Aviation Administration requirements.

8.4 Soil Amendments (Fertilizer, Lime, Compost)

1. Soil amendments shall be applied as required according to soil testing to achieve healthy growth of plants and seed areas to ensure establishment. This includes turf establishment and plant pit amendments.

2. Areas targeted for warm season grass and native meadow establishment should not be amended with fertilization and other amendments.

8.5 Planting Requirements

Tables 2 and 3 on the following pages list all the possible planting zones and requirements for these types of SWM facilities. Figure 11 graphically depicts the various planting zones. The design shall provide planting according to the zones required by the particular facility.

1. Ponds will have aquatic benches that are Emergent & Floating Aquatic Zones; water depths greater than 4 ft. that are submerged aquatic zones and storm elevations for up to the 10-year storm that are frequently fluctuating zones.

2. Wetlands will have micro-pools or deep pools that are submerged aquatic zones, shallow wetland areas that are emergent & floating aquatic zones and water fluctuations up to the 10 year storm that are frequently fluctuating zones.

3. Both SWM ponds and wetlands are required to have the perimeter shade planting, which covers the emergent zone through the frequently fluctuating zone.

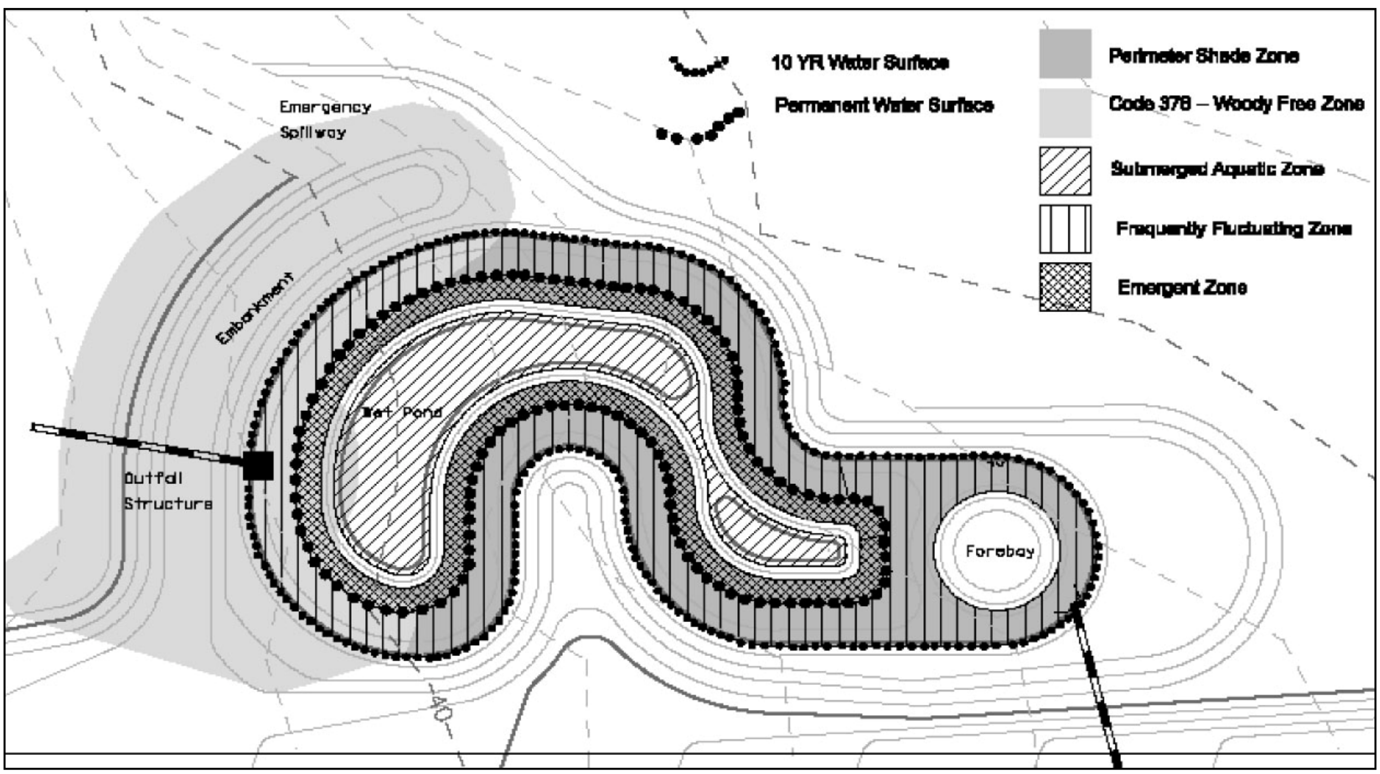


Figure 11 – Stormwater Management Planting Zones

Table 2 – Minimum Planting Requirements at SWM Ponds and Wetland Hydrologic Zones

Min. Quantity/ Placement Considerations	Min. Size/Rate	Root Condition
Submerged Aquatic Zone (4 ft. or greater depth permanent water)		
• 1 plant per 9 cu. ft. of water volume for water depths 4 ft. or deeper. • Min. 2 species with no one species being greater than 60% of the total plants	8 in. ht./length	Bare root
Emergent & Floating Aquatic Zone (up to 18 in. depth permanent water)		
• 24 in. centers max. spacing (2.9 plants per 10 sq. ft.) • Min. 3 species shall be provided with no one species being greater than 50% of the total plants in this zone • Min. 30% of the species shall be broadleaved or floating leaved	24 in. ht.	Container grown
Frequently Fluctuating Zone (permanent water surface to 10 yr. water storm elev.)		
<u>Live Fascines or Wattles</u> • 3 species in each fascine bundle • Place parallel to contours • Min. one layer of fascines at water's edge • Do not use when facility is lined	4 in. diameter by 6 ft. length	Bound bundles
<u>Plug Planting</u> • Min. 3 species of plugs shall be provided with no one species being greater than 50% of the total plants in this zone • Plugs shall be spaced at max. 24 in. centers (2.9 plants per 10 sq. ft.)		
<u>Seed and Mulch</u> • Shall be included to provide permanent stabilization • SWM Seed Mix • SHA Special Purpose Mix • Mulch shall be according to SSCM 2001, Section 705.03.01(f). • No straw mulch shall be used at SWM facilities	16 lbs./ac. 10 lbs/ac.	
Perimeter Shade Planting (emergent & floating aquatic zone to 10 yr. water storm elev.)		
<u>Canopy Trees</u> • 1 tree if areas is ≤ 4,000 SF (measured at 10 YR water surface contour line) • 3 trees if (4,000 SF < area ≤ 8,000 SF) • 5 trees if (8,000 SF < area ≤12,000 SF) • If area > 12,000 SF, add 1 additional tree for each additional 4,000 SF • If facility is lined, no trees or woody shrubs allowed within limits of liner	3 inch cal.	B & B
<u>Understory or Flowering Trees</u> • 2 if area is ≤ 4,000 SF, add 1 additional tree for each additional 1,000 SF • Multiple stemmed trees shall have a min. of 3 trunks.	2 in. cal.	B & B
<u>Woody Shrubs</u> 5 for every understory or flowering tree required	24 in. ht. or spread	Container Grown
<u>Planting Bed Preparation</u> • Mulched beds shall not be used at SWM facilities below the 10 YR water surface elevation. Instead, individual plants shall be installed in plant pits that are not mulched. • Areas between planting pits shall be stabilized with seed and mulch		
<u>Seed and Mulch</u> See Frequently Fluctuating Zone seed and mulch requirements.		

Table 3 – Minimum Planting Requirements for SWM Filtering Practices

Min. Quantity/ Placement Considerations	Min. Size/Rate	Root Condition
<u>Sod</u> • Flow shall be diverted from filter practices until 2 in. ht. of permanent turf stabilization has been established • In cases where flow cannot be diverted, sod shall be applied to the filter surface • Sod shall be applied to all grass weirs except emergency spillways (which shall be established in permanent turf).	Section 708 Section 920 (SSCM 2001)	
<u>Seed and Mulch</u> • SWM Seed Mix • Special Purpose Mix • No straw mulch shall be used at SWM facilities.	 8 lbs / ac. 10 lbs / ac.	
Bioretention		
<u>Trees</u> • min. 0.76 trees per 100 SF (filter surface area measurement) • If the facility has underdrains or is lined, large canopy trees shall not be placed directly in the bioretention facility. Instead, they shall be used adjacent to the facility to provide shade to understory plants. In this case, plant large trees 5 feet away from the perimeter of the filter medium/underdrains or liner.	2 inch cal.	B&B
<u>Shrubs</u> • Min. 2.8 shrubs per 100 SF (filter surface area measurement)	24 in. ht. or spread	Container Grown
<u>Herbaceous layer</u> • 3 perennials or grasses can be substituted for 1 required shrub • No more than 50% of plants shall be perennial or grasses	#1 container	Container Grown
<u>Mulch</u> • 3 in. depth shredded hardwood mulch, evenly distributed and raked smooth	Section 920 (SSCM 2001)	

8.6 General Planting Guidelines

1. Low Maintenance Planting – Avoid the use of planting beds unless appropriate and there is a commitment for maintenance from LOD.

2. The use of woody trees and shrubs shall not be planted where a pond liner is used. Herbaceous species may be allowed depending upon the depth of cover at the liner, but installation procedures should involve hand troweling rather than augers.

3. Sand filters and bioretention facilities have underdrains. Plants should be selected so that their roots do not grow deep enough to clog underdrains. Depth of planting medium will determine appropriate species selected.

4. Mowability should be addressed in the planting zones.

5. The stopping sight distance at ramps and sight distance at intersections should be checked (AASHTO Design Guidelines, Chapter 3).

6. Green Ash is banned by LOD on SHA projects.

7. Temporary seeding and mulching should be provided where appropriate.

8. Benches are an excellent opportunity for landscape plantings.

9. Consider use of the Visual Quality Monitor specification on the project, and discuss this with the HHD task leader. Note that a task will need to be set up for the person to fill this role and this person should attend the pre-construction meeting to introduce themselves to the contractor and construction engineer.

10. Upland plants may require additional watering.

11. Seed mixes should consist of appropriate species. The pounds per acre should be sufficient to establish a good cover.

12. Soil stabilization matting Type A shall be used wherever possible in place of riprap.

8.7 Vegetation Management

1. If an existing facility or site is overgrown and has invasive species, the vegetation management specification should be considered.

2. Crew days should be included in the bid items to cover the vegetation management.

8.8 Additional Watering of Plants

Amounts of additional watering shall be according to Table 4.

Table 4 – Additional Watering of Plants

PLANT	GALLONS PER WATERING	TIMES WATERED	TOTAL GALLONS
Major Deciduous Trees	25	3	75
Evergreen Trees	20	3	60
Flowering/Minor Trees	15	3	45
Reforestation Trees (5 ft. Branched Transplants, 3 ft. Understory)	10	3	30
Shrubs – 18 in. or taller	10	3	30
Shrubs – smaller than 18 in.	5	3	15
Evergreen Seedling (bare root)	2	3	6
Vines	2	3	6
Plugs	0.5	3	1.5
Perennial, Grasses, Annuals per 100 SF planted (not mulched) area	60	3	180
Sod per SF	0.5	3	1.5

9. Details

Various detail components of a stormwater facility should also be checked to ensure they do not create any safety hazards, and to ensure that they are not visually detrimental to the project.

9.1 Cleanouts and Vents

The PPWP used for constructing clean outs and vents at SWM facilities shall be black in color.

9.2 Riprap Aprons, Channel Lining, Check Dams and Outfall Stabilization

Riprap stone used at SWM facilities that are visible from the roadway and/or adjacent properties shall be brown or gray in color. No white riprap shall be used.

9.3 Concrete Structures

Where concrete stormwater management outfall structures are visible from the roadway and/or adjacent properties, the use of integral color pigment in the concrete mix shall be considered. An example specification for pigmented structures is provided in Table 5.

Table 5 – Sample Specification
Pigmented Concrete Structures

The admixture shall be a pigmented, water-reducing, admixture that is limeproof and UV resistant containing no calcium chloride or coloring agents. The admixture shall conform to C979, C494 and M194. The color shall meet Federal Standard 595B. The same color shall be used throughout the project. It may be necessary to use white Portland Cement to achieve the color. Compromising the color will not be acceptable in order to avoid using white cement. All pigmented drainage structures shall be textured with a sandblast finish to remove any inflorescence that forms during the casting process. Allow the concrete to cure to sufficient strength so that it will not be damaged by blasting but not less than seven days. The finish shall be Class I (Brush) involving a one pass brush blast that will remove the cement matrix and expose the fine aggregates. No part of the course aggregates shall be exposed. Those stormwater management outfall structures requiring pigment will be determined at the Visual Quality Review meeting. The integral color pigment requirement may be waived by the Administration if staining is proposed in the place of integral color. A sample panel that is 2 ft. x 2. ft. x 4 in. in size shall be cast, sandblasted and made available to the Administration and Visual Quality Monitor at the construction site for color and finish approval. All subsequent structures requiring integral color shall match the sample panel. The sample panel shall remain at the construction site to be used by the Administration as a basis for comparison for the structures.

10. Contract Documents

Contract Documents for the project should be checked for accuracy and thoroughness. The items listed below are representative of the primary items requiring review, to check for compliance with the criteria established in the previous sections of this guideline.

10.1 Plans

1. Stormwater Management Plans
2. Stormwater Management Details
3. Grading Plans
4. Landscape Plans

10.2 Special Provisions

1. Standard special provisions are being developed by Christie Minami for the individual stormwater management facilities types. Current specs available include: Bioretention, dry swale and sand filter.
2. Other facilities should coordinate with Maryland SHA standard specifications.
3. Nutrient management plan from LOD.
4. SWM BMP As-Built Certification SP – ensure the latest version is included.
5. SP for Stabilized Maintenance Access Road.
6. Wildflower seeding, coordinate with LOD, Contractor should be providing any seed.
7. SP for staining or integral color into outfall structure.
8. SP for top rail at chain link.
9. Application of compost blankets (pneumatically or hand placed and tracked).
10. Other special provisions as needed to ensure proper installation.

10.3 Estimate

1. Check quantities on plan and in planting schedules; note errors in comment letter.
2. The master plant schedule quantities should be checked against individual plans.
3. Bid items in Invitation for Bids book should match descriptions and quantities as represented in the plans and special provisions.

VEQ-S Reviewer's Checklist

Contract No.: ____________________ Reviewer Initials: __________

Project Name: ____________________ Reviewer Consultant Firm: __________

Facility ID.: ____________________ Date Received: __________

Review Stage: ____________________ Date of Review: __________

Design meets guidelines?

Yes No Deferred* N/A

* Deferred until later review

Data / Computation Check

Yes	No	Deferred*	N/A		
				1.	Is facility visible from the roadway? Circle one: Yes No
				2.	Type of facility proposed:__________________.
____	____	____	____	3.	Check MD Stormwater Design Manual Ch. 2 and App. A. Is type appropriate?
____	____	____	____	4.	Does facility meet minimum volume required?
____	____	____	____	5.	Are landforms/baffles included when volume has extra capacity available?
____	____	____	____	6.	Does design take advantage of potential volume upstream for WQ?
				7.	Is this an existing facility? No Yes (BMP #__________) obtain latest inspection report, incorporate recommendations into comment letter.
____	____	____	____	8.	Are environmental impacts acounted for? Coordinate with OED.
____	____	____	____	9.	Are environmental impacts avoided to the maximum extent?
				10.	Field Visit was performed on _______________
				11.	Photos uploaded to ProjectWise on ___________________

Form / Grading

Yes	No	Deferred*	N/A		
____	____	____	____	12.	Curvilinear form, or shape appropriate to context?
____	____	____	____	13.	Appropriate baffles included for visual interest and to lengthen flow path?
____	____	____	____	14.	Are all areas requiring routine mowing 4:1 or flatter?
____	____	____	____	15.	Benches provided around permanent pools 2 feet and deeper?
____	____	____	____	16.	Benches are 15' wide, with maximum slope 12:1?
____	____	____	____	17.	If cut slopes are steeper than 4:1, are they forested?
____	____	____	____	18.	If slopes are steeper than 4:1, is fencing proposed?

Outfall Structure

Height of structure _________________ Dimensions ___________________

Yes	No	Deferred*	N/A		
____	____	____	____	19.	If height $\geq$ 30", is 4'-2" provided from manhole edge to riser edge on 2 sides?
____	____	____	____	20.	If distance $\geq$ 48" from riser top to ground surface, is top rail/fence provided?
____	____	____	____	21.	If structure is on a bench, is there 5' clear from structure to water edge?
____	____	____	____	22.	Is structure context-appropriate and visually attractive?
____	____	____	____	23.	Are trash racks visually attractive?
____	____	____	____	24.	Is low flow device appropriate and unobtrusitve? (Submerged is preferred)

VEQ-S Reviewer's Checklist

Contract No.: ____________________ Reviewer Initials: __________

Project Name: ____________________ Reviewer Consultant Firm: __________

Facility ID.: ____________________ Date Received: __________

Review Stage: ____________________ Date of Review: __________

Design meets guidelines?

Yes No Deferred* N/A * Deferred until later review

Safety / Fencing

____ ____ ____ ____ 25. If fencing is proposed, has Consultant obtained design exception from HHD?

____ ____ ____ ____ 26. Are railings provided on structures 48" high or greater (measured from ground)?

____ ____ ____ ____ 27. Does fencing/rail meet top rail requirements?

____ ____ ____ ____ 28. Does fencing/rail meet color requirements?

____ ____ ____ ____ 29. Does fencing/rail meet 42" height requirement?

____ ____ ____ ____ 30. Is placement visually unobtrusive?

____ ____ ____ ____ 31. Is there a 12' wide double gate for access? (Lockable w/2 keys provided to SHA)

Maintenance Access

____ ____ ____ ____ 32. Is access shown to bottom of facility, forebay bottoms, and all structures?

____ ____ ____ ____ 33. Is width of access 12 feet minimum?

____ ____ ____ ____ 34. Does access detail provide 4" topsoil over 6" cellular containment material?

____ ____ ____ ____ 35. Are turnarounds provided where necessary for vehicles?

____ ____ ____ ____ 36. Is longitudinal slope of access 12% or flatter?

____ ____ ____ ____ 37. Is the surface of the access road at least 1' above permanent water surface?

____ ____ ____ ____ 38. Is the entrance free from obstruction by any barriers, parking spaces, etc?

Planting

____ ____ ____ ____ 39. Woody material meets required Code 378 restrictions?

____ ____ ____ ____ 40. Woody material clear of proposed pond liner?

____ ____ ____ ____ 41. Have native species been chosen?

____ ____ ____ ____ 42. Planting configuration in natural, colonization patterns?

____ ____ ____ ____ 43. Proper plantings in submerged aquatic zone?

____ ____ ____ ____ 44. Proper plantings in emergent & floating aquatic zone?

____ ____ ____ ____ 45. Proper plantings in frequently fluctuating zone?

____ ____ ____ ____ 46. Proper perimeter shade plantings?

____ ____ ____ ____ 47. For filtering practices, are Sod and Seed/Mulch applications correct?

____ ____ ____ ____ 48. For Bioretention or Sand Filter, are trees clear of underdrains?

____ ____ ____ ____ 49. For Bioretention, are shrubs and herbaceous layer adequate?

____ ____ ____ ____ 50. For Bioretention, is 3" deep shredded hardwood mulch provided?

____ ____ ____ ____ 51. Site distance: Stopping (@ ramp) Turning (@ intersection) not hindered by plants?

____ ____ ____ ____ 52. For facilities with liners, is hand augering specified in a note?

____ ____ ____ ____ 53. Type A matting used where possible instead of riprap?

VEQ-S Reviewer's Checklist

Contract No.: ______________________ Reviewer Initials: __________

Project Name: ______________________ Reviewer Consultant Firm: __________

Facility ID.: ______________________ Date Received: __________

Review Stage: ______________________ Date of Review: __________

Design meets guidelines?

Yes No Deferred* N/A

* Deferred until later review

Specification/Bid Item Issues for plants:

Yes	No	Deferred*	N/A		
____	____	____	____	54.	Is "additional watering" provided for upland plants?
____	____	____	____	55.	If Visual Quality Monitor seems appropriate, is it provided for?
____	____	____	____	56.	Is Seed mix the proper species?
____	____	____	____	57.	Do plant species meet LOD requirements? (Green Ash is banned)
____	____	____	____	58.	Is Vegetation Management spec appropriate?

Details

Yes	No	Deferred*	N/A		
____	____	____	____	59.	Cleanouts and Vents - aesthetically pleasant if visible?
____	____	____	____	60.	Visible riprap - is it brown or gray?
____	____	____	____	61.	Visible Concrete Structures - is pigmented concrete used where it should be?
____	____	____	____	62.	Is low-flow device either unobtrusive or submerged?

Special Provisions

Yes	No	Deferred*	N/A		
____	____	____	____	63.	Standard Special Provsions for BMP included?
____	____	____	____	64.	Nutrient Management Plan included?
____	____	____	____	65.	SWM As Built Certification included?
____	____	____	____	66.	Stabilized Maintenance Access road included?
____	____	____	____	67.	Wildflower seeding included? (Contact LOD to order)
____	____	____	____	68.	Pigmented Concrete Structures included?
____	____	____	____	69.	Top rail for chain link fence included?
____	____	____	____	70.	Compost blanket application spec included?

Estimate

Yes	No	Deferred*	N/A		
____	____	____	____	71.	Do plan quantities match schedules?
____	____	____	____	72.	Does master plant schedule match individual plan sheets?
____	____	____	____	73.	Do plan quantities match bid item quantities/descriptions?

Reviewer Notes:

APPENDIX G:

SECTION 308 — EROSION & SEDIMENT CONTROL

Quality Assurance Ratings

CATEGORY 300
DRAINAGE

SECTION 308 — EROSION AND SEDIMENT CONTROL

308.01 DESCRIPTION.

242 **DELETE:** The third paragraph, "The Contractor shall…Control Manager (ESCM)."

INSERT: The following.

The Contractor shall assign an employee to the project to serve in the capacity of Erosion and Sediment Control Manager (ESCM). The ESCM and the superintendent shall have successfully completed the Administration's Erosion and Sediment Control Certification Training for Contractors and Inspectors. This certification shall be current at all times. If the certification is expired or revoked for either person, the Contractor shall immediately replace the person with an appropriately certified person acceptable to the Administration.

243 **DELETE:** 308.01.02 Quality Assurance Ratings in its entirety.

INSERT: The following.

308.01.02 Quality Assurance Ratings. All Administration projects requiring Erosion and Sediment Control measures will be inspected by a Quality Assurance Inspector to ensure compliance with the approved Erosion and Sediment Control Plan. The Contractor shall obtain all appropriate permits and approvals; demarcate Limits of Disturbances, wetland and wetland buffers, floodplains and tree protection areas as specified in Section 107; and shall proceed in conformance with the approved Erosion and Sediment Control Plan and schedules. Projects will be inspected at least every 2 weeks and the scores reported on Form No. OOC61, Erosion and Sediment Control Field Investigation report. The Quality Assurance Inspector will use the scores to determine the following ratings:

RATING	SCORE
A	≥ 90
B	80 - 89.9
C	70 - 79.9
D	60 - 69.9
F	< 60

Rating A. The project is in compliance. Minor corrective action may be necessary.

Rating B. Indicates that the project is in compliance; however, corrective action is needed

Rating C. Indicates that the project is in compliance; however, deficiencies noted require correction. Shutdown conditions as described elsewhere herein could arise quickly. Project will be reinspected within 72 hours.

Rating D. Indicates that the project is in noncompliance. The Administration will shut down all earthwork operations. All work efforts shall focus on correcting erosion and sediment control deficiencies. The project will be reinspected within 72 hours. All required corrective actions shall be completed within the 72 hour period for the project to be upgraded to a 'B' rating. Failure to upgrade the project to a 'B' rating will result in the project being rated an 'F'. Liquidated damages will be imposed for each day the project has a 'D' rating. Refer to Shutdowns elsewhere in this Specification for additional requirements.

Rating F. Indicates a score less than 60 or the appropriate permits and approvals have not been obtained; demarcated limits of disturbances, wetland and wetland buffers, floodplains, and tree protection areas as specified in Section 107; or is not proceeding in conformance with the approved Erosion and Sediment Control Plan and schedules. An 'F' rating indicates that the project is in noncompliance. The Administration will shut down the entire project until the project receives a 'B' rating. All work efforts shall focus on correcting erosion and sediment control deficiencies. Liquidated damages will be imposed for each day the project has an 'F' rating.

Shutdowns. When a 'C' rating is given to a project, the Contractor shall have all deficiencies corrected within 72 hours. The project will be reinspected at the end of this period. If it is found that the deficiencies have not been satisfactorily corrected, a 'D' rating will be given and all earthwork operations will be shut down until the project receives a 'B' rating.

When a consecutive 'C' rating is given for other deficiencies and the original deficiencies were corrected, the Contractor will be alerted that their overall effort is marginal and a shut down of all earthwork operations is imminent if erosion and sediment control efforts do not substantially improve within 72 hours. The project will be reinspected at the end of this period. If it is found that the deficiencies have not been satisfactorily corrected or other deficiencies are identified by the Quality Assurance Inspector that results in a score of less than 80 on Form No. OOC61, a 'D' rating will be given and all earthwork operations will be shut down until the project receives a 'B' rating.

When a disregard for correcting these deficiencies is evident, an 'F' rating will be given and the entire project will be shut down until the project receives a 'B' rating. When degradation to a resource could occur, or if the Contractor is unresponsive to direction to take corrective action, the Administration may elect to have these corrective actions performed by another contractor or by Administration maintenance staff. All costs associated with this work will be billed to the original Contractor in addition to liquidated damages.

Incentive Payment/Liquidated Damages. The Administration has included an incentive payment to the Contractor. When an average score equal to or greater than 85 for the entire rating quarter is given to the project by the Quality Assurance Inspector the quarterly incentive payment will be made to the Contractor within 60 days after the end of the rating quarter. No incentive will be paid for partial quarters or for quarters with less than four inspections. No incentives will be paid for any quarter that liquidated damages are imposed. A rating quarter consists of three months. The first quarter begins with the month the Notice to Proceed is issued for the project. When a project does not receive a 'D' or 'F' rating and the overall average score given to the project by the

Quality Assurance Inspector is equal to or greater than 85 the final incentive payment will be made to the Contractor at final project close-out. If a time extension is granted to the Contract, additional quarterly incentive payments will be drawn from the final incentive payment.

When a ‘D’ or ‘F’ rating is given to the project by the Quality Assurance Inspector for any inspections; the Administration will impose liquidated damages on the Contractor. Payment of the liquidated damages shall be made within thirty days from imposition of the liquidated damages and shall not be allowed to accrue for consideration at final project close-out.

When the project receives two ‘F’ ratings the erosion and sediment control certification issued by the Administration shall be revoked from the project superintendent and the Erosion and Sediment Control Manager for a period of not less than six months and until successful completion of the Administration’s Erosion and Sediment Control Certification Program. Neither the project superintendent nor the Erosion and Sediment Control Manager shall be allowed to oversee the installation and maintenance of erosion and sediment controls during the period the certification is revoked on any project of the Administration. The Contractor shall immediately provide certified personnel to replace the project superintendent and the Erosion and Sediment Control Manager. Work may not commence until the certified personnel are in place.

308.01.03 Incentive/Liquidated Damages Payments. The total incentive awarded for this Contract will not exceed $3,340.00 (Payment A). The quarterly incentive payment for this contract is $890.00 (Payment B). A final incentive payment for this contract is $1,680.00 (1/2 Payment A) less the total quarterly incentives paid during a contract extension.

For each day that the project has a ‘D’ rating the Contractor and/or his surety shall be liable for liquidated damages in the amount of $3,000.00 (Payment D) per day. Failure to upgrade the project to the minimum of a ‘B’ rating within 72 hours will result in the project being rated ‘F’.

For each day that the project has an ‘F’ rating the Contractor and/or his surety shall be liable for liquidated damages in the amount of $3,990.00 (Payment F) per day.

308.03 CONSTRUCTION.

DELETE: 308.03.01 Contractor Responsibilities its entirety.

INSERT: The following.

308.03.01 Contractor Responsibilities. The Contractor shall demarcate all wetlands, wetland buffers, floodplains, tree protection areas, and the Limit of Disturbance (LOD) as specified in Section 107. Prior to beginning any earth disturbing activity, the Contractor shall have all demarcated wetlands, wetland buffers, floodplains, tree protection areas, and LOD inspected and approved by the Engineer. The Contractor shall construct all erosion and sediment control measures in conformance with 308.01.01. The Contractor shall have all control measures inspected and approved by the Engineer prior to beginning any other earth disturbing activity. The Contractor shall ensure that all runoff from disturbed areas is directed to the sediment control measures. The Contractor shall not remove any erosion or sediment control measure without the approval of the Engineer and MDE. Refer to GP-7.12 for unforeseen conditions.

246 **DELETE:** 308.03.04 Schedule in its entirety.

INSERT: The following.

308.03.04 Schedule. Within 14 days after the Notice of Award, the Contractor shall submit an Erosion and Sediment Control Schedule to implement the E & S Plan to the Administration and the MDE. The schedule shall indicate the sequence of construction, implementation and maintenance of controls, temporary and permanent stabilization, and the various stages of earth disturbance. After the schedule is approved by the Administration, it will be forwarded to MDE for approval. The schedule shall, at least include the following:

(a) Demarcation of all wetlands, wetland buffers, floodplains, tree protection areas, and the LOD prior to any earth disturbing activity.

(b) Clearing and grubbing of areas necessary for installation of perimeter controls specified in the Contract Documents.

(c) Construction of perimeter controls specified in the Contract Documents.

(d) Remaining clearing and grubbing.

(e) Roadway grading (including off-site work).

(f) If applicable, utility installation and whether storm drains shall be used or blocked after construction.

(g) Final grading, landscaping, and stabilization.

(h) Removal of perimeter controls.

No work shall be started on-site or off-site until the Erosion and Sediment Control schedules and methods of operation have been accepted by the Administration and MDE.

308.03.35 Maintenance of Stream Flow.

253 **ADD:** The following after the second paragraph “Upon completion of...to the Engineer.”

The Contract Documents may include stream diversion details for maintenance of stream flow. These details show the locations of the stream diversion system and a system that is approved by the Maryland Department of the Environment.

The Contractor is alerted that the stream diversion system as shown may not be capable of blocking the flow of water through the soil beneath the stream diversion system. The Contractor shall be responsible for designing and providing an effective means of diverting the water away from the designated areas, even though it may require more elaborate diversion systems. The Contractor shall also ensure that all excavation performed within the stream diverted area shall be maintained in a dewatered condition, which may require additional pumps, sheeting, shoring, cofferdams, etc. Should the proposed system not perform satisfactorily or additional material and equipment be required to dewater the site and excavated areas, the Contractor shall remedy the stream diversion system at no additional cost to the Administration.

The Contractor shall securely anchor the stream diversion system in place to prevent movement during high water events. Prior to placing the stream diversion system, the Contractor shall submit the proposed method of anchoring to the Engineer and the MDE field inspector for approval. Anchors shall not go beyond the limits of disturbance shown on the Plans or infringe on the channel area available for stream flow. Placing the stream diversion system in the stream without the approval of both the Engineer and the MDE inspector is prohibited. All cost associated with the anchoring of the stream diversion system shall be incidental to the Maintenance of Stream Flow item.

The Contractor shall have the option of proposing an alternate stream diversion system. All conditions stated in the Contract Documents shall apply to the alternate stream diversion system. Any alternate stream diversion system shall be submitted to the Maryland Department of the Environment through the Administration for approval prior to implementation.

308.04 MEASUREMENT AND PAYMENT.

257 **DELETE:** 308.04.26 in its entirety.

INSERT: The following.

308.04.26 Maintenance of Stream Flow will not be measured but will be paid for at the Contract lump sum price. The payment will also include designing and providing diversion structures regardless of the type required to satisfactorily divert the stream flow, excavation, backfill, dewater the site and excavated areas within the stream diversion area, maintenance of the diversion system, sandbags, polyethylene sheeting, diversion pipes, pumps, hoses, connections, and portable sediment tanks. This price will not be adjusted when consideration is given to an alternative stream diversion system regardless of any changes in quantities from that shown in the Contract Documents. The provisions of GP-4.05 will not apply to this work.

APPENDIX H:

Stormwater Management Facility As-Built Certification

Special Provision

CATEGORY 300
DRAINAGE

STORMWATER MANAGEMENT FACILITY AS-BUILT CERTIFICATION

DESCRIPTION. This work shall consist of inspecting stormwater management (SWM) facilities during various stages of construction and providing documentation to the Administration to certify that the SWM facilities have been constructed as specified in the Contract Documents, including certification that the constructed SWM facilities meet the functionality as designed.

As-Built (AB) Inspector. The AB Inspector shall be a licensed Professional Engineer or Land Surveyor in the State of Maryland with experience in stormwater management design and construction.

Inspections of planting installations, survival and final turf establishment shall be performed by a Landscape Architect, licensed in the State of Maryland, or an Administration approved Environmental Specialist/Analyst. The inspector shall have experience in stormwater management planting design and construction.

As-Built Certification Package. The as-built certification package, to be provided by the Contractor, shall consist of photographs, completed as-built checklists for each SWM facility, completed as-built certification forms for each SWM facility, material testing reports for any soil, a copy of green-line revision plans for SWM facilities that include as-built survey information, a copy of completed planting checklists, and turf inspection data for SWM facilities and drainage conveyances areas (such as ditches and swales). The as-built survey information shall be superimposed on the final design (including addendums or redlines) contours and a separate plan shall be prepared depicting the as-built information alone.

Information about the person(s) that will perform the plant and turf inspections shall be part of the as-built certification package and shall include, but not be limited to name of the person(s), employer name, brief description of related work history, contact information, and anticipated dates for plant and turf establishment inspections.

The Contractor shall provide to the Administration two hard-copies and one digital copy in PDF format of the as-built certification package.

Plant and Turf Establishment Certification Package. The plant and turf establishment certification package, to be provided by the Contractor, shall consist of field photos, completed turf inspection checklists, completed planting checklists and the contract planting plans and details with green-line revisions. If survivability percentages are not achieved, notation shall be made on the plans and a report designating the plants or areas that are dead or do not meet turf coverage expectations. A description of efforts taken to bring the plantings or turf up to the required survivability shall be included in the report. A schedule for implementing the remediation efforts and documentation of completion of the remediation efforts shall also be included.

The plant and turf establishment certification process must be completed and approved prior to the Administration accepting the establishment phase for maintenance (see Section 710.03.06).

MATERIALS. Not applicable.

CONSTRUCTION.

Stages for As-Built Inspections. The AB Inspector shall perform minimum inspections for SWM facilities as follows:

(a) Stormwater Ponds and Wetlands.

(1) Upon completion of excavation to sub-foundation and when required, installation of structural supports or reinforcement for structures, including, but not limited to:

(i) Core trenches for structural embankments.

(ii) Inlet and outlet structures, anti-seep collars or diaphragms, and watertight connections on pipes.

(iii) Trenches for enclosed storm drainage facilities.

(2) During placement of structural fill, concrete, and installation of piping and catchbasins.

(3) During backfill of foundations and trenches.

(4) During embankment construction.

(5) Upon completion of final grading and establishment of permanent stabilization.

(b) Infiltration Trenches.

(1) During excavation to subgrade.

(2) During placement and backfill of underdrain systems and observation wells.

(3) During placement of geotextiles and all filter media.

(4) During construction of appurtenant conveyance systems such as diversion structures, pre-filters and filters, inlets, outlets, and flow distribution structures.

(5) Upon completion of final grading and establishment of permanent stabilization.

(c) Infiltration Basins. Refer to stages specified for pond construction and add:

(1) During placement and backfill of underdrain systems.

(d) Filtering Systems. Filtering systems include bioretention, sand filters, organic filters, bio-filters, and dry swales.

(1) During excavation to subgrade.

(2) During placement and backfill of underdrain systems.

(3) During placement of geotextiles and all filter media.

(4) During construction of appurtenant conveyance systems such as flow diversion structures, pre-filters and filters, inlets, outlets, orifices, and flow distribution structures.

(5) Upon completion of final grading and establishment of permanent stabilization.

(e) Open Channel Systems. Open channel systems include wet swales and grass channels.

(1) During excavation to subgrade.

(2) During installation of diaphragms, check dams, or weirs.

(3) Upon completion of final grading and establishment of permanent stabilization.

(f) Non-Structural Practices. Upon completion of final grading and after the establishment of permanent stabilization.

The checklist for each SWM facility shall be completed by the AB Inspector in its entirety at the appropriate stages of construction as specified in the Contract Documents. The as-built certification shall be signed and dated by the AB Inspector upon completion of all SWM facility checklists.

Stages for Plant and Turf Establishment Inspections. At the plant establishment phase (710.03.06) inspection, the plant and turf establishment inspection shall also be conducted and documented by the Contractor's plant inspection representative. Turf establishment inspection shall be conducted according to the Administration's Turf Coverage Specifications (705.03.07). Plants shall be inspected for species, size, quantity, health and location. Plants that measure smaller than the installed size are considered to be dead. Dead plants shall be replaced according to the design specifications. Plant and turf establishment inspections shall be conducted from June 15 to November 15.

The following planting and turf shall be inspected and documented:

(a) Ponds and Wetlands

(1) During and after wetland area planting.

(2) SWM embankment (including roadway embankment if applicable) and clear zone 15 feet beyond toe of embankment cleared of woody vegetation and established with turf or native meadow.

(3) During second growing (plant establishment phase inspection) season to verify a vegetation survival rate at submerged benches and wetlands of 50 percent.

(b) Infiltration Trenches

Turf establishment in conveyances, filter strips and other features draining to the trench that are within the Administration right-of-way and within the project site shall meet Turf Coverage Specifications (705.03.07). Off-site areas shall be visually observed and the location of off-site eroded or bare areas included in the report and photographed.

(c) Infiltration Basins

(1) Woody plant clear zones listed for Ponds above.

(2) Plant, turf or native meadow establishment inspected at basin bottom and side slopes.

(3) Turf establishment in conveyances, filter strips and other features draining to the trench that are within the Administration right-of-way and within the project site shall meet Turf Coverage Specifications (705.03.07). Off-site areas shall be visually observed and the location of off-site eroded or bare areas included in the report and photographed.

(d) Filtering Systems

(1) Turf establishment on weir, bottom and sides of facility, and all conveyances draining to the facility shall meet Turf Coverage Specifications (705.03.07).

(2) At Bioretention Facilities, to verify a plant survival rate of at least 90 percent. The mulch bed shall be inspected and replenished to constructed depth and condition.

(e) Open Channel Systems.

(1) For Dry Swales, turf establishment on weir, bottom, side slopes and conveyances draining to the facility meets Turf Coverage Specifications (705.03.07).

(2) For Wet Swales, turf establishment on weirs, sides and all conveyances draining to the facility shall meet Turf Coverage Specifications (705.03.07). Planting at the bottom of the facility shall meet 50 percent survival rate.

As-Built Survey, Computations and Green-Line Drawings. Upon completion of the final grade and stabilization at each SWM facility, the Contractor shall survey each SWM facility, including contours, inflow and outflow ditches, limits of riprap, emergency spillway(s), outfall structure(s) (including elevations and dimensions at top, all orifices, weirs and openings), and all other pertinent features in and around the facility.

Elevation variances greater than ± 3 in. for earthwork and ± 1.2 in. (0.1 ft.) for emergency and principal spillways, pipe inverts, orifice and weir elevations shall be corrected by the Contractor to meet the acceptable tolerance limits. Constructed dimension for the required freeboard shall be equal to or greater than designed. If meeting the required tolerances is not possible, the Contractor shall provide computations for the volumes, discharges, stage-storages and detention times that demonstrate that the SWM facility meets the designed parameters. The Contractor shall resurvey any corrected areas.

The Administration will provide to the Contractor a copy of the final approved design Stormwater Management Report and copies of the plan CADD files that shall be used in producing the green-line revision plans. The AB Inspector shall follow SHA CADD standards in producing the green-line documents.

Submission to and Approval by the Administration. The Contractor shall submit the completed as-built certification package to:

Maryland State Highway Administration
Highway Hydraulics Division Chief
707 North Calvert Street, Mailstop C-201
Baltimore, MD 21202

MEASUREMENT AND PAYMENT. Stormwater Management Facility As-Built Certification will not be measured but will be paid for at the Contract lump sum price. The payment will be full compensation for the completion and submission of the as-built certification package, plant and turf establishment certification package, and for all material, labor, equipment, tools, and incidentals necessary to complete the work.

Re-inspection of corrections to stormwater management facilities and re-certification of any deficiencies to be corrected by the Contractor shall be at no additional cost to the Administration.

Engineering and analysis for Contractor-modified SWM facilities shall be at no additional cost to the Administration.

Deficiencies to the as-built certification package shall be corrected by the Contractor at no additional cost to the Administration.

Additional construction, planting and stabilization necessary to meet the certification standards shall be completed at no additional cost to the Administration.

Payment Schedule. Payment will conform to the following:

No greater than thirty-five percent (35%) of the total payment will be paid upon completion and submission of the As-Built Certification Package.

No greater than thirty-five percent (35%) of the total payment will be paid upon approval from the Administration for the As-Built Certification Package.

Final payment will be paid upon approval from the Administration for the Plant and Turf Inspection Certification Package.

APPENDIX I:

Pollution Prevention BMP Summary & Capital Improvement Summary

Industrial NPDES

Pollution Prevention BMP 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				
		OWS Upgrade					O		
		Material Storage Bin Structure - New					O		
		Berm/Swale to Divert Site Runoff						O	
	Princess Anne	OWS Upgrade					O		
		AST - Removal and Remediation					O		
		Berm/Swale to Divert Site Runoff						O	
	Salisbury	Wash Bay - Retrofit				U			
	Snow Hill	OWS - Connection to Public Sewer System			X				
2	Centreville	OWS Upgrade			X				
	Chestertown	Wash Bay - Retrofit				U			
		OWS Upgrade					O		
	Denton	OWS Upgrade			X				
		Material Storage Bin Structure - New					O		
		Fuel Canopy Downspout/Outfall - 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			
3	Fairland	Stabilize Discharge Point and Improve Drainage						O	
		SWM Infiltration Trench Retrofit							O
	Gaithersburg	OWS Repair		X					
		Material Storage Bin Structure - New					O		
		Fuel Canopy Downspout/Outfall - Retrofit					O	O	
		Berm/Swale to Divert Site Runoff						O	
		Brine Operations - Retrofit/Repair							O

NOTE: X - Completed, U - Underway, O - Pending
OWS - Oil Water Separator

Pollution Prevention BMP Summary (continued)

DISTRICT	FACILITY	ITEM	FY04	FY05	FY06	FY07	FY08	FY09	FY10
3 (cont)	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 Basin Retrofit							O
	Metro/Landover	Material Storage Bin Structure - New					O		
		Fuel Canopy & Drainage - New						O	
		Berm/Swale to Divert Site Runoff						O	
4	Churchville	OWS Upgrade			X				
		Plumbing - Connect to OWS			X				
		Fuel Canopy Downspout/Outfall - Retrofit						O	
	Golden Ring	Riprap Channel Construction for Erosion Control						O	
	Hereford	OWS Upgrade	X						
		Material Storage Bin Structure - New					O		
		Berm/Swale to Divert Site Runoff						O	
	Owings Mills	OWS - Connection to Public Sewer System			X				
		Material Storage Bin Structure - New					O		
5	Annapolis	Erosion Stabilization				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/Outfall - Retrofit		X					
		Bioretention Retrofit			U				
		Material Storage Bin Structure - New					O		
	Hanover Complex	OWS Upgrade			X				
	LaPlata	OWS - Connection to Public Sewer System			X				
		Material Storage Bin Structure - New					O		
	Leonardtown	OWS Upgrade	X						
		Material Storage Bin Structure - New					O		
		Berm/Swale to Divert Site Runoff						O	
	Prince Frederick	OWS - Connection to Public Sewer System		X					
		Fuel Canopy Downspout/Outfall - Retrofit		X					
		Wash Bay - Retrofit				U			
		Inlet Sediment Trap						O	
		Riprap Channel for Erosion and Sediment Control						O	
		Water Quality BMP							O

Pollution Prevention BMP Summary (continued)

DISTRICT	FACILITY	ITEM	FY04	FY05	FY06	FY08	FY09	FY10	FY11
6	Frostburg	Material Storage Bin Structure - New					O		
		Water Quality BMP							O
	Hagerstown	Wash Bay - Retrofit				U			
		Fuel Canopy Downspout/Outfall - Retrofit						O	
	Hancock	Fuel Canopy & Drainage - New						O	
		Storm Drain System - New Construction						O	
		Water Quality BMP							O
	Keysers Ridge	OWS Upgrade			X				
		Wash Bay - Retrofit				U			
		OWS - Connection to Public Sewer System						O	
		Fuel Canopy Downspout/Outfall - Retrofit						O	
	LaVale	Wash Bay - Retrofit				U			
		Fuel Canopy Downspout/Outfall - Retrofit						O	
	Oakland	Fuel Canopy Downspout/Outfall - 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	OWS Upgrade					O		
		Water Quality BMP							O
	Westminster	N/A							

Capital Improvement Summary

The following table lists industrial pollution prevention capital improvements, their cumulative design and construction costs and their completion status.

Fiscal Year	Facility	Capital Improvement	Total Cost (Design + Construction)	Status
FY05	Centreville Hanover Churchville Keyser's Ridge	Oil/Water Separator Upgrade	$277,337 $209,578	complete complete
	Snow Hill La Plata Owings Mills	Sanitary Sewer Connection		
	Glen Burnie Shop	Dewatering Structure		
FY06	Denton	Maintenance Bay Floor Drain Connection to Sanitary Sewer		
FY07	Prince Frederick	Wash Bay Retrofit		

APPENDIX J:

NPDES Individual Industrial Permit Stormwater Pollution Prevention Plan

District 2 - Centreville Maintenance Facility

Maryland State Highway Administration
District 2 - Centreville Maintenance Facility

NPDES Individual Industrial Permit - Stormwater Pollution Prevention Plan

Prepared for:

Maryland State Highway Administration
Highway Hydraulics Division
Baltimore, Maryland

Prepared by:
Greenman-Pedersen, Inc.
10620 Guilford Road, Suite 100
Jessup, Maryland 20794
(410) 880-3055
(301) 470-2772

January 2001

Revised November 2002

Revised June 2005

CERTIFICATION

As the responsible official, I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

District Engineer, District 2
Maryland State Highway Administration

____
Print Name

__________________________________ ___________________
Signature Date

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PPP_Centreville.doc

LIST OF ACRONYMS AND ABBREVIATIONS

AST	Above-ground Storage Tank
BMP	Best Management Practice
D/S	Downstream
EPA	U.S. Environmental Protection Agency
GPI	Greenman - Pedersen, Inc. – SHA’s consultant
MDE	Maryland Department of the Environment
NPDES	National Pollutant Discharge Elimination System
PPP	Pollution Prevention Plan
RME	Resident Maintenance Engineer
SHA	Maryland State Highway Administration
SWM	Stormwater Management
U/S	Upstream
UST	Under-ground Storage Tank

1.0 INTRODUCTION

The development of this Stormwater Pollution Prevention Plan (PPP) is pursuant to the Individual Discharge Permit for Storm Water Associated with Industrial Activities, State Discharge Permit No. 03-DP-3438 and NPDES Permit MD0069043 as part of the National Pollutant Discharge Elimination System (NPDES) Program. This permit was issued to the Maryland State Highway Administration (SHA) on February 18, 2005. This plan intends to identify potential sources of pollution, which may reasonably be expected to affect the quality of stormwater discharges associated with industrial activity from the facility. In addition, this plan shall describe and ensure the implementation of Best Management Practices (BMPs) used to reduce the pollutants in stormwater discharges associated with industrial activity at the facility and to assure compliance with terms and conditions of this permit. SHA's Maintenance Facilities will implement the provisions of the Stormwater Pollution Prevention Plan required as a condition of the Permit.

The Centreville Maintenance Facility is located at 111 Safety Drive in Queen Anne's County. The facility hosts several buildings including a maintenance building, which contains offices and a shop, a inventory storage building with a vehicle wash bay connected, a vehicle storage building, a pesticide storage building, and covered storage sheds. Also on-site is a salt barn, brine tank, and fueling area. The majority of the facility is covered with asphalt, with grass areas along the west and south sides of the property.

The facility is primarily used to service SHA roadway maintenance equipment and vehicles, store equipment and materials, fuel state vehicles, and serve as a staging area for daily maintenance activities associated with State highways within the County.

2.0 PLANNING AND ORGANIZATION

2.1 Pollution Prevention Team:

Leader: Greg Holsey
Title: Resident Maintenance Engineer (RME)
Responsibilities:

- Responsible for the overall operations of the Maintenance Facility
- Manages and supervises all activities of the Pollution Prevention Team

Members: Troy Sisco
Title: Assistant Resident Maintenance Engineer (ARME)
Responsibilities:

- Assists with overall operations of Facility
- Assists with managing and supervising all activities of the Pollution Prevention Team

Member: Ryan White (1st Contact) Phil Whitlock (Secondary Contact)
Title: TET
Responsibilities: Inspects all features of the Yard area including the Stormwater Management facilities.

Members: Gary Moran
Title: Shop Chief
Responsibilities:

- Maintains the vehicle shop and maintains records for all hazardous material disposal
- Trains shop personnel in proper materials handling and disposal

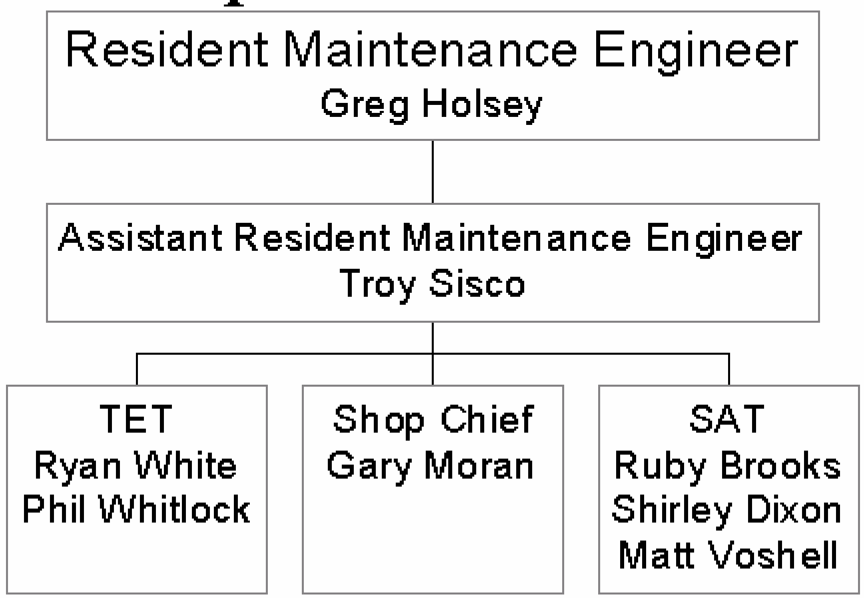
Members: Ruby Brooks (1st Contact) Shirley Dixon/Matt Voshell (Secondary Contacts)
Title: SAT
Responsibilities:

- Maintains all materials manifests and maintains waste and waste management records.

The team organization is summarized in Figure 1.

Figure 1

Maryland State Highway Administration
Centreville Shop Pollution Prevention Team



2.2 Record Keeping

Management of site records and reporting of onsite events will be performed to maintain history and track progress of pollution prevention practices and waste minimization. The typical records to be maintained are routine site inspections, maintenance records, and scheduled housekeeping reviews. Other records include the reporting of significant spills and major repairs of Best Management Practices (BMPs) associated with Pollution Prevention.

Recordkeeping for Spills, Leaks, and Other Discharges: A system has been developed for documenting spills, leaks, and other discharges, including discharges of hazardous substances/wastes in significant quantities. The documentation is contained in the Spill Prevention Control and Countermeasures Plan (SPCCP) in the Appendix of this document.

Recordkeeping for Site Inspections and Maintenance Activities: Maintain records for all activities associated with Stormwater Pollution Prevention. Document all inspections to ensure good housekeeping/maintenance and to promote detection of any potential problems. Suggested techniques to accurately document and report inspection results include:

- Field notebooks
- Photographs with date stamps
- Video tapes
- Up-to-date Design Plans/Site Maps

Recordkeeping for Materials/Wastes Management: Maintain current inventory of materials stored at the facility and the off-site disposal of wastes.

Recordkeeping Retention: Records of spills, leaks, and other discharges, must be retained for at least one (1) year beyond the permit expiration. Records of inspections and maintenance activities should be retained for a period of three (3) years.

2.3 Annual Reporting

Annually in December the Shop will provide SHA's Highway Hydraulics Division with documentation to be used in preparing the Annual NPDES Report. Items to be included are:

- Most-Current Site Inspection Check-list
- Spill Reports from the preceding year
- Signed Shop Improvements Summary

2.4 Monitoring

In accordance with the permit, Daily Monitoring Report (DMR) must be completed for each quarterly reporting period and submitted to MDE. On a monthly basis sampling will be conducted and documented.

3.0 ASSESSMENT

GPI performed an on-site visit of the Centreville Shop to inspect the storage structures, review operating procedures, document existing pollution prevention measures, interview site operating staff and document potential sources of contaminated stormwater runoff. A survey outside the grounds was conducted to identify site flow patterns, storm drain conveyance structures, impervious areas, infiltration areas, and non-stormwater activities with the potential to come into contact with stormwater. The following presents a summary of the findings of this visual inspection.

3.1. Site Assessment Inspection

1. Date: January 7, 2005
2. Time: 10:00 a.m.
3. Personnel: Linda Kelbaugh, GPI
   David Young, GPI
4. Weather: Sunny, 40 degrees F
5. Site Condition: Normal
6. Potential Pollutant Sources:
   a. Waste water of oil-water separator coming from wash bay discharges to surface water off-site.
   b. Waste water of oil-water separator from maintenance shop floor drains discharge to stormwater management pond on-site
   c. Canopy downspouts and upslope hydrology discharge across concrete fueling area where there is a potential for contaminated runoff
   d. Abrasive stockpile is discharging through a curb opening into a riprap ditch that outlets to the stormwater management pond.

3.2. Vicinity Map and Site Map

1. The Vicinity Map is show in Figure 2.
2. A Site Map was prepared and is an attached exhibit. Maps were prepared in accordance with the regulatory requirements published in the EPA guidance manual, "Storm Water Management for Industrial Activities-Developing Pollution Prevention Plans and Best Management Practices" (EPA 832-R-92-0006, Office of Water).

   Information contained on the Site Map includes:

   a. Location of structures and buildings
   b. Locations of impervious and pervious Areas
   c. Drainage area delineations from which runoff flows to discharge points
   d. Point Source Discharges of stormwater that outfall off the property
   e. Potential pollutant sources

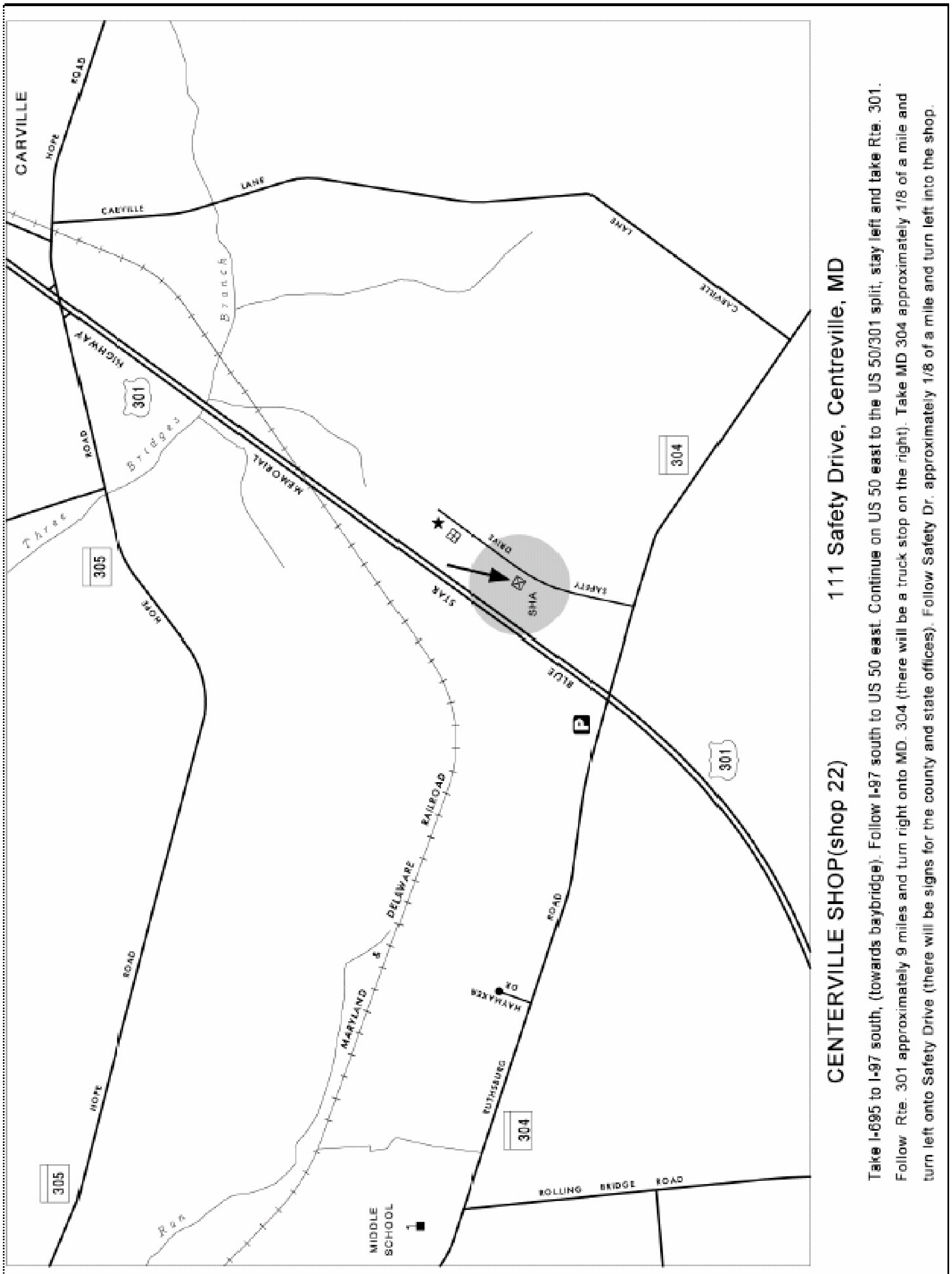


Figure 2 – Vicinity Map

3.3. Storm Water Flow Patterns

This facility has three (3) point sources that discharge off the site. Point source discharge 1 is located at the outfall of a stormwater management pond located on the southwest end of the site. This pond receives stormwater run-off from approximately 80% of the site.

Point source discharge 2 is located at a pipe discharging wastewater from the wash bay's oil-water separator to a roadside swale along US 301.

Point source discharge 3 is located in the northeast portion of the facility. This discharge receives runoff via a grass swale from a storm drain system that collects runoff from in front of the vehicle storage building.

3.4. Inventory of Significant Materials

1. Roadway Salt stored in dome
2. Brine AST
3. Motor Oil
4. Fuel Oil
5. Pesticides
6. Paint Drums
7. Oil Drums
8. 2-Propane AST
9. Septic UST
10. 500 gal. Waste Oil AST
11. Heating Oil AST
12. 3,000 gal. Heating Oil UST
13. Sand in storage bins and in stockpile
14. 10,000 gal. Diesel UST
15. 10,000 gal. Unleaded UST

3.5 List of Significant Spill and Leaks

No significant spills have occurred at the site within the past two year.

4.0. BEST MANAGEMENT PRACTICES

Best Management Practices (BMPs) are measures or practices used to reduce the amount of pollution entering surface water. BMPs may take the form of a process, activity, or physical structure. Some BMPs are simple and can be put into place immediately, while others are more complicated and require extensive planning or space. They may be inexpensive or costly to implement. Regardless of the situation, a coordinated effort and strategy must be developed in order to find a solution to any pollution concern and maintain compliance with the permit. Coordination, education, implementation, and enforcement at all levels of Maintenance Facility Operations are the optimum goal in achieving compliance with the permit.

4.1. Existing BMPs

1. The vehicle wash bay drains to a grit separator that discharges to an oil-water separator. The grit is contained in the drains inside the wash bay. The wastewater from the oil-water separator then is discharged to surface water. Both oil and grit tanks are maintained by the Maryland Environmental Service on a monthly basis.
2. The maintenance shop floor drains to a grit separator that discharges to an oil-water separator. The wastewater from the oil-water separator then is discharged to a stormwater management pond. Both oil and grit tanks maintained by the Maryland Environmental Service on a monthly basis.
3. A stormwater management pond receives drainage from approximately 80% of the site. This pond has a forebay to allow for some water quality treatment before discharging it off-site.
4. All roadway salt is stored in the salt barns.
5. Most stockpiled materials are stored in covered storage bins. One sand stockpile was surrounded by jersey barrier in proximity to the salt barn for mixing. Unfortunately, the stockpile was placed over a curb opening that discharges stormwater to a riprap ditch and ultimately discharges to the stormwater management facility. Inspection of the SWM outfall showed no signs of sand discharged from the facility. Stormwater run-on deposited sand and salt in the ditch. The stockpile needs to be relocated or the area needs to be redesigned to eliminate further deposition into the SWM facility.

4.2. Best Management Practices for Pollution Prevention

This Stormwater Pollution Prevention Plan consists of a series of steps and activities to first, identify sources of pollution or contamination at a site, and second, select and carry out actions which prevent or control the pollution of stormwater discharges. The following is a list of possible BMPs for specific areas on the site.

4.2.1. Fueling Area

- Keep absorbent material readily available and clearly marked in the fueling area to cleanup any small spills. Dispose of used material properly.
- If cleaning of the fuel area is necessary, do not clean area with a hose. Use a mop and dispose of wastewater into the oil-water/grit separator.

- Construct a diversion swale or berm upslope of the concrete fueling pad to divert hydrology from the concrete pad and/or redesign the downspout system from the canopy.
- Avoid topping off vehicles to prevent discharge onto fueling surface area.
- Educate and train personnel on clean up procedures.

4.2.2. Vehicle Maintenance Area

- Separate hazardous wastes from non-hazardous wastes (i.e. oily rags) and dispose of properly.
- Contaminated wastes should be stored in a location that prevents contact with rain or stormwater run-on until disposed of properly. Storage of contaminated wastes should be placed in a plastic bag and temporarily stored in a covered dumpster.
- Do not pour liquid wastes (i.e. used oil, degreasers) into floor drains, sinks, storm drain inlets, or other storm drain or sewer connections. These materials should be stored and disposed of properly by a licensed contractor.
- Use appropriate absorbent material to clean up spills. Dispose of contaminated clean up material in plastic bag and place into covered dumpster for disposal at an approved site.
- Store used batteries in a manner that prevents contact with rain and stormwater run-on. Store material inside or in roofed storage bins to eliminate contact with stormwater. If storing material inside or under roof is not possible, then place on a pallet and cover with a tarp.
- Educate and train personnel on clean up procedures.

4.2.3. Vehicle Washing

- All vehicles should be washed inside of vehicle wash bay. If vehicles are unable to fit entirely within the wash bay then only wash half of the vehicle, then reverse the vehicle to complete washing operations.
- Minimize or eliminate the use of detergents.
- Educate and train personnel on wash bay cleaning procedures.

4.2.4. Above Ground Storage Tanks (AST)

- Tanks must comply with applicable state and federal laws.
- Implement and document routine visual inspection of all tanks. Inspect foundation, connections, coatings, walls, and piping system for leaks, strains of tank support structures, cracks, scratches in protective coating, and other physical damage.
- Once leaks are identified, immediately control the leak with a drip pan or absorbent material, until maintenance can be performed on the tank. Maintenance should be scheduled immediately after leak has been identified.
- Spills that occur on the top and sides of tanks during filling operations should be cleaned up immediately and all caps and lids properly sealed.
- Educate and train personnel on spill prevention procedures and materials stored onsite.

4.2.5. Storage of Materials

- Anything that may contain or consist of residual hazardous material or could cause sedimentation must be stored in a manner that prevents contact with rain and stormwater run on. Store material inside or in roofed storage bins to eliminate contact with stormwater. If storing material inside or under roof is not possible, place on a pallet and cover with a tarp. Segregate materials and store in a designated location when possible.
- All salt is stored in the salt barn. Maintain existing procedures for keeping salt barn area clean and salt properly stored. If it is necessary to have an exposed pile in periods of heavy salt use, keep exposed salt piles to a minimum.
- Educate and train personnel on good house keeping procedures.

4.2.6. Waste Storage/Disposal

- Any waste that may contain or consist of residual hazardous material must be stored in a manner that prevents contact with stormwater until a licensed contractor can dispose it. Storing material inside, putting in it storage bins with a roof to prevent run-on, or placing on a pallet and covering with a tarp can achieve this.
- Waste that is collected on a regular basis should have a scheduled pick-up that eliminates the stockpiling of materials (i.e. used tires, roadside trash).
- A licensed contractor should remove all wastes (i.e. old fuel tanks, air conditioners, refrigerators, or containers with unknown material) that could be potentially hazardous and serve no purpose as soon as possible.
- Educate and train personnel on good housekeeping procedures.
- Hazardous or special waste disposal should be coordinated with SHA's Office of Maintenance at (410) 582-5568.

4.2.7. Leaks

- If a vehicle parked outside has a leak, place a drip pan under the leak until it is fixed. Clean up with absorbent material.
- Absorbent booms should be put around any storm drain inlet that may come in contact with oil/fuel spills.
- Maintenance should be performed immediately on all tanks and lines to prevent continual leaking. Place drip pan under the leak or absorbent material or use absorbent booms to contain the leak until maintenance is performed.
- Educate and train personnel on good house keeping procedures.

4.2.8. Maintenance of Inlet/Grit Separator and Oil-Water Separator

- Clean out inlet with grit separator and oil-water separator on a regular basis.
- Inspect and document oil-water separator for oil accumulation. If oil has accumulated to 80% of capacity, remove by a licensed contractor.
- Inspect and document accumulation of sediment in grit chamber. If grit has filled 80% of the chamber storage volume, remove accumulation and dispose of properly.

- Educate and train personnel on spill prevention procedures.

4.2.9. Spills

- Contain spill by blocking off flow paths to inlets, swales, etc.
- Notify appropriate authorities if a spill occurs. A Spill Control and Countermeasure Plan is contained in the Appendix of this document.

4.2.10 Stockpiles

- Wherever possible, stockpiles should be in covered storage areas.
- When it is not possible to have stockpiles under cover, perimeter control should be established in a manner to contain any material movement while allowing access. Silt fence, non-outletting ditches, curb stops wrapped in filter cloth are examples of perimeter control.
- Topsoil stockpiles should be seeded to provide vegetative cover. When material is removed from the stockpile, the stockpile should be reseeded. Annual rye is a seed that germinates quickly to provide vegetative stabilization.

4.2.11. SWM Facilities Maintenance

- Maintain annually the on-site SWM facilities. Remove debris and trash, stabilize exposed areas, and maintain conveyance area by removing invasive vegetation.

4.3. Shop Improvements Summary

The following summary includes the Action List for both Structural and Operational Improvements to aid in pollution prevention.

District 2 - Centreville Shop

Shop Summary

Location: 111 Safety Drive, Centreville
Permit: Individual

RME: Greg Holsey | OOM: Ms. Lauren Baker, PE
ADE: Terry Wright | OCE: Ms. Sonal Sanghavi, PE

Assessment Date: 1/1/2001;4/18/2005 | Report Date: 6/1/2004;4/18/05
Report Contact: Ms. Sonal Sanghavi, PE | Contact Phone No.: 410-582-5585

Priority Action List	Responsible Party	Completion Date	Comments
Structural Improvement Action List			
☐ Add new Oil-Water Separator to Wash Bay floor drain system	Office of Maintenance	FY-06	complete
Operational Improvement Action List			
☐ Spill Prevention Control & Countermeasures Plan & Shop Staff Training	Office of Highway Development	Dec-04	4/18/05 trained 31 employees; draft provided
☐ Pollution Prevention Plan Updates & Shop Re-Assessment for Pollution Prevention	Office of Highway Development	Jun-05	4/18/05 Reassessment; draft plan updates
☐ Pollution Prevention Training for Shop Staff	Office of Highway Development	Annual	4/18/05 trained 31 employees; draft provided
☐ Perform Monthly Sampling at OWS Outfall per Individual Permit Requirements	Shop	Monthly	MES - On-going
☐ Prepare MDE Quarterly Discharge Monitoring Reports (DMR) for Sampling at OWS Outfall per Permit Requirements	Shop	Quarterly	MES - On-going
☐ Perform & Track Routine Oil-Water Separator (OWS) Servicing	Shop	Monthly	MES performs monthly
☐ On-Site Stormwater Management Devices: Monitor & Perform Maintenance Activities	Shop	Minimum Annual	On-going by Shop personnel
☐ Perform Annual Pollution Prevention Site Inspection in Accordance with General Permit Req.	Shop	Minimum Annual	

ADE Signature

Date

APPENDIX:

Pollution Prevention Checklist

Pollution Prevention Checklist

Inspector Name:
Date/Time:

Fueling Area						
Observed Spills?	YES	___	NO	___	NA	___
Absorbent material readily available?	YES	___	NO	___	NA	___
Absorbent material used in clean-up?	YES	___	NO	___	NA	___
Automotive Shop						
Absorbent material readily available?	YES	___	NO	___	NA	___
Oily waste separated and stored in appropriate containers?	YES	___	NO	___	NA	___
All floor drains functioning properly and maintained?	YES	___	NO	___	NA	___
Wash Bay						
All vehicles washed in wash bay?	YES	___	NO	___	NA	___
All floor drains functional?	YES	___	NO	___	NA	___
Oil/Grit Separator						
Waste oil tank greater than 80% full?	YES	___	NO	___	NA	___
Grit in separator greater than 80% full?	YES	___	NO	___	NA	___
Separator functioning properly?	YES	___	NO	___	NA	___
Excess oil accumulation in separator?	YES	___	NO	___	NA	___
Above Ground Storage Tanks (AST)						
Tank free of damage, corrosion, cracks?	YES	___	NO	___	NA	___
Spills or leaks present around area?	YES	___	NO	___	NA	___
All necessary caps fitted?	YES	___	NO	___	NA	___
Valves turned off when not in use?	YES	___	NO	___	NA	___
Storage of Material						
Salt stored in covered area?	YES	___	NO	___	NA	___
Salt staging area is clean?	YES	___	NO	___	NA	___
Unused oil barrels, crack sealant, solvents, batteries stored properly?	YES	___	NO	___	NA	___
Roadside garbage bins free of potentially hazardous materials?	YES	___	NO	___	NA	___
Material stockpiles with soil or sand covered or runoff controlled?	YES	___	NO	___	NA	___
Unused tanks/drums stored under cover until disposed of properly?	YES	___	NO	___	NA	___
Waste Storage/Disposal						
Oily waste or contaminated material stored separately?	YES	___	NO	___	NA	___
Used barrels, crack sealant, solvent, batteries stored properly?	YES	___	NO	___	NA	___
Leaks						
Pans or absorbent material used to control vehicle leaks?	YES	___	NO	___	NA	___

Maintenance/Comments

APPENDIX:

Daily Monitoring Report Form

PERMITTEE NAME/ADDRESS (Include Facility Name/Location if Different)

NAME ______

ADDRESS ______

FACILITY ______
LOCATION ______

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)

DISCHARGE MONITORING REPORT (DMR)

(2-16) PERMIT NUMBER | (17-19) DISCHARGE NUMBER

	MONITORING PERIOD						
FROM	YEAR	MO	DAY	TO	YEAR	MO	DAY
	(20-21)	(22-23)	(24-25)		(26-27)	(28-29)	(30-31)

Form Approved.
OMB No. 2040-0004
Approval expires 05-31-98

☐ Check here if No Discharge

NOTE: Read Instructions before completing this form

PARAMETER (32-37)		QUANTITY OR LOADING (3 Card Only) AVERAGE (46-53)	QUANTITY OR LOADING MAXIMUM (54-61)	UNITS	QUALITY OR CONCENTRATION (4 Card Only) MINIMUM (38-45)	QUALITY OR CONCENTRATION AVERAGE (46-53)	QUALITY OR CONCENTRATION MAXIMUM (54-61)	UNITS	NO. EX (62-63)	FREQUENCY OF ANALYSIS (64-68)	SAMPLE TYPE (69-70)
	SAMPLE MEASUREMENT										
	PERMIT REQUIREMENT										
	SAMPLE MEASUREMENT										
	PERMIT REQUIREMENT										
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	PERMIT REQUIREMENT										

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER	I CERTIFY UNDER PENALTY OF LAW THAT THIS DOCUMENT AND ALL ATTACHMENTS WERE PREPARED UNDER MY DIRECTION OR SUPERVISION IN ACCORDANCE WITH A SYSTEM DESIGNED TO ASSURE THAT QUALIFIED PERSONNEL PROPERLY GATHER AND EVALUATE THE INFORMATION SUBMITTED. BASED ON MY INQUIRY OF THE PERSON OR PERSONS WHO MANAGE THE SYSTEM, OR THOSE PERSONS DIRECTLY RESPONSIBLE FOR GATHERING THE INFORMATION, THE INFORMATION SUBMITTED IS, TO THE BEST OF MY KNOWLEDGE AND BELIEF, TRUE, ACCURATE, AND COMPLETE. I AM AWARE THAT THERE ARE SIGNIFICANT PENALTIES FOR SUBMITTING FALSE INFORMATION, INCLUDING THE POSSIBILITY OF FINE AND IMPRISONMENT FOR KNOWING VIOLATIONS. SEE 18 U.S.C. § 1001 AND 33 U.S.C. § 1319. (Penalties under these statutes may include fines up to $10,000 and or maximum imprisonment of between 6 months and 5 years.)		TELEPHONE		DATE		
TYPED OR PRINTED		SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	AREA CODE	NUMBER	YEAR	MO	DAY

COMMENTS AND EXPLANATION OF ANY VIOLATIONS (Reference all attachments here)

EPA Form 3320-1 (10-96) (REPLACES EPA FORM T-40 WHICH MAY NOT BE USED.) PAGE OF

APPENDIX:

Spill Prevention Control and Countermeasures Plan

Spill Prevention Control and Countermeasures Plan

For

Maryland State Highway Administration
District 2 – Centreville Maintenance Shop

Prepared by
Maryland State Highway Administration
And
Greenman-Pedersen, Inc.
10620 Guilford Road, Suite 100
Jessup, MD 20794

June 2005

GUIDELINES TO FOLLOW IN THE EMERGENCY OPERATION OF MAINTENANCE FACILITIES.

INTRODUCTION:

The purpose of this Spill Prevention Control and Countermeasures Plan (SPCCP) is to insure that proper containment and precautions are provided to prevent the discharge of non-hazardous products which include**,** but not limited to**,** Unleaded Gasoline, Diesel Fuel, Kerosene, Heating Oil, Waste Oil, chemical products and herbicides/pesticides. The plan purpose is also to prevent and control spilled product or product leaks into public water and wastewater facilities, soil, or water, above or below ground.

This plan compiles with the requirements of the Code of Federal and State regulations, as listed below.

REFERENCES: See Appendix A

PROCEDURES:

This plan will be updated when any significant change is made by the Maryland Department of Environment (MDE), local government or Federal government. We will forward updated revisions or changes to all facilities as soon as possible.

1. Any spill in excess of 2 gallons, shall be reported immediately to the MDE and the Md State Highway Administration's (SHA) Office of Maintenance (OOM). Copies of records and reports regarding spills and cleanup shall be maintained at the facility and copies forwarded to the Office of Maintenance (OOM). Spills must be reported to the MDE within two (2 hours after the spill is discovered. The emergency number for MDE is 1-(866) 633-4686 and OOM / Facilities Maintenance Division (FMD) is 410-582-5580/ 5512.

2. The following information shall be provided to alert MDE and OOM / FMD that a spill incident has occurred:

    a. Caller's Name, Address, Telephone number and time of discharge
    b. Location of and type of material spilled
    c. Estimated quantity of materials spilled
    d. Action taken and/or initiated
    e. The need for assistance (if any)
    f. Injures caused by spill (if any)
    g. Agencies notified
    h. Agencies on the scene
    i. Extent of contamination (surface/subsurface water, soil, oil/water separator, etc.)

3. If underground storage tank (UST)/above ground storage tank (AST) is leaking, when ever possible, transfer the remaining product from the leaking to tank to another container. The main objective is to limit material loss. Notify MDE and OOM as soon as possible. MDE is to be notified within 2 hours. If the material reaches plumbing drains or the oil/water separator, notify Anne Arundel County at 410-222-8400

4. Determine/estimate the amount of product lost and how much was recovered. Report this information to MDE and OOM. Keep OOM informed about of the progress of the recovery operations.

5. MDE will designate the type investigation that must be done and the technique e.g. boring, hydropunch, or monitoring wells to be used to test soil and/or water for the presence of petroleum products.

6. The Facility where the spill occurs is responsible for spill cleanup. Work can be performed by either a commercial firm or self help using SHA resources. In either case actions must be in accordance with MDE specifications. OOM / FMD will provide assistance.

7. If a tank is found leaking during construction under the Department of General Services (DGS) contracts, work on the tank(s) should cease immediately. MDE and OOM are to be notified at once. Other scheduled work under the contract may continue as long as it is not related to the tanks.

8. A report must be sent to the MDE within ten (10) working days after the removal and cleanup work is completed. (Code of Maryland Regulations 26.10.01.03. Report of Oil Spill or Discharge). A copy of the report should be sent to OOM/ FMD.

9. If a large spill (10 gallons or more) occurs contact the District Safety Officer to determine if a fire hazard exists. If the District Safety Officer determines that the fire hazard is minimal, attempt to contain the spread of the spill by placing absorbent materials on spill and use sand or other material to make a dike around the spill area. This will protect oil/water separators, internal plumbing drains, storm drains, surface water or streams from contamination. If fire hazard exists evacuate the area in the vicinity of the spill and contact the fire department. Contact MDE and OOM. When MDE arrives follow their directions. Keep OOM / FMD informed.

10. If water is found in tanks, OOM should be informed. Assistance will be provided to assist in the removal of water and checking for possible tank or piping problems.

11. In the event that dirt or foreign materials are discovered in the tank (s) contact OOM / FMD. Assistance will be provided to properly remove the substances from the tank(s).

12. When refilling a UST /AST that is not on the Department of General Services Fuel Management System, amount of fuel remaining in the tank should be measured manually to avoid over filling. Results should be entered in appropriate inventory management forms. These tanks are to be monitored every day of operation. Records are to be retained for at least one year.

13. A permanent sign is to be posted near the tank field. The sign must be at least 8”x10” and properly color-coded to indicate product types. Contact OOM/ FMS for information for obtaining signage.

TANK COLOR CODING

Colors of Tank fill lids are to be Painted:

Diesel-Low Sulfur - Yellow Hexagon.
Diesel-High Sulfur - Blue Stripes.
Diesel-Heating Oil - Green Hexagon.
Unleaded Gas- Regular - White Circle with Black X.
Unleaded Gas- Medium Grade - Blue Circle with White X.
Unleaded Gas-Supper - Red Circle with White X.
Waste Oil- All Black.
Kerosene- Brown Hexagon.
Vapor recovery vents- Orange Circle.
Monitoring well cover- White with Black triangle.

EMERGENCY RESPONSE FOR HAZARDOUS MATERIAL SPILLS:

Material Release Lost or Spilled Underground.

Once a loss or spill is detected, notify the Facility Manager (Supervisor) and the Office of Maintenance at 410-582-5580. Report the type of material released, location of release and estimated amount of product lost.

Notify MDE - Compliance/ Remediation Division Oil Control Program at 1-(866) 633-4686 with information contained on the Fuel Spill Report within two (2) hours of after the spill or lost is discovered.

If a UST is leaking, transfer the product to another tank or truck as quickly as possible to reduce the amount of spillage. Record the number of gallons transferred.

MDE will visit the site and conduct an inspection. They may write a citation. They will review inventory records and will request an estimate of gallons lost.
The MDE citation will describe work that must be performed, and establish a completion date. The work description in the citation will assist in the preparation of a scope of work. Bid procedures specified in the SHA Procurement Procedures Manual are to be followed.

MDE may require several Hydropunch penetrations in the area to determine the amount of underground contamination.

If free product is found, MDE may then require installation of monitoring wells to recover the product. The recovered amount will be properly handled and noted in the recovery reports.

The recovery efforts will be continued until MDE determines that monitoring is no longer necessary.

EMERGENCY RESPONSE FOR HAZARDOUS MATERIAL SPILL:

Material Release/Spill Above Ground - 2 gallons or more.

The following measures should be taken:

1. If employees are injured contact EMS immediately (911). If the safety of personnel is threatened evacuate the area and restrict traffic in the general vicinity. If the fire department is called, alert them to the type of material that has spilled.

2. If safety of personal and/or loss of property is not probable, attempt to contain the released product with sand or other absorbent materials.

3. If product is leaking from a fuel storage tank and conditions are safe, transfer the material to another container. If possible and reasonably safe, attempt to contain the lost or spread of the product.

4. Notify Facility Manager (supervisor) as soon as possible. Identify type of material, location of spill, estimated quantity lost, and notify MDE as soon as possible but within 2 hours, at 1-(866) 633-4686.

5. Notify Office of Maintenance as soon as possible at (410) 582-5580 / 5512.

Note: Follow directions of emergency response units for all safety conditions.

PETROLEUM SERVICES:

Fuel Dispensing System, Storage Tanks, Waste Oil Equipment, and Oil Separators are maintenance / service contract items.

Maintenance and service shall be accomplished by qualified vendors. All vendors are to comply with all pertinent safety, health, hygiene, and environmental codes and regulations.

Use Regional Buyers Guide - Yellow pages:

List your own local vendors in the space provided:

Name & Address	Phone Number	County-Location
Commercial Fuel System Inc.	301-829-0875	Statewide

QUICK REFERENCE
EMERGENCY CONTRACTS FOR SPILL RESPONSE
SHA District 2 – Centreville Maintenance Shop

AGENCY	Phone Number	Responsibilities
Fire Department	911	Fire and Rescue
Police	911	Public Safety
MDE Spill Response	1 (866) 633-4686	Spill Response
Office of Maintenance	(410) 582-5580/5512	SHA Office responsible for state-wide maintenance and facility issues

APPENDIX K:

Long Draught Branch Stream Restoration Project

NPDES Monitoring Plan

NPDES Monitoring Plan

for

Long Draught Branch

Stream Restoration Project

AT387A21

October 13, 2006

Prepared for:

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1.0 Project Objective

Chemical, physical and biological monitoring will be performed over a period of three years in order to determine the effectiveness of the restoration efforts through the Long Draught Branch Stream Restoration Project.

2.1 Phases of Chemical Water Quality Monitoring

Chemical water quality monitoring will occur in two phases:

Phase CHEM 1 will include chemical monitoring prior to stream bank restoration. The goal of this effort will be to conduct pre-restoration, baseline characterization of the stream reach. Pre-restoration monitoring will occur from November 2006 to February 2008.
While construction is underway monitoring will stop and begin again once construction is complete. 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 an assessment of controls and 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 to October 2010.

During both ***Phases CHEM 1*** and ***CHEM 2***, continuous flow monitoring will also be conducted on Long Draught Branch. Collection of flow data will allow for the calculation of event mean concentrations (EMCs) as required by the permit. Chemical monitoring during storm events will occur over the course of SHA's permit cycle (through October 2010).

It is important to note that all dates given in this monitoring plan are anticipated start and end times. Construction project schedules may shift during this project. Any deviations to the schedule given above will be communicated to the Maryland Department of the Environment (MDE).

2.2 Phases of Physical Monitoring

Phase PHYS 1 will include pre-construction measurements of the planform, cross section and longitudinal geometry at three sites within the construction area and one site downstream of the construction area. The goal of the measurements is to establish Rosgen classification of the stream channel for the 3 distinct reaches within the construction area. Two riffles and one pool cross section will be performed for each of the three longitudinal profiles. Wolman pebble counts will be taken at each of the three study reaches to complete the Rosgen Level I and II assessment.

The fourth site coincides with the downstream chemical monitoring site to monitor any changes in the stream channel for that reach with one cross section and one longitudinal profile. Local benchmarks will be established for accurate duplication of efforts if needed with good horizontal and vertical control.

Phase PHYS 2 will include a continuation of the three onsite study reaches as well as the downstream location. Local benchmarks will be established again for duplication of cross sections, profile and planform.

2.3 Phases of Biological Monitoring

The Biological Monitoring will be conducted by the University of Maryland as a separate task. An annual report will be submitted to SHA with the monitoring results.

Phase BIO 1 will include pre-construction monitoring of benthic invertebrates (spring and fall index period fall index period), fish, and physical habitat will be conducted at one control reach and at three restoration reaches.

Monitoring will be conducted using the 2001 MBSS protocols (with the exception of fall collection of benthic invertebrates). IBI scores will be calculated from these data. The 2006 data will also provide a current baseline for comparison with post-construction data.

Phase BIO 2 will include post-construction monitoring conducted annually for two years. Benthic invertebrates (spring and fall index period), fish, and physical habitat will be monitored at the three reaches established during pre-construction monitoring and using the 2001 MBSS protocols. IBI scores will be calculated for these data.

3.1 Water Quality Sampling Locations

For both pre-restoration and for post-restoration event efforts, chemical monitoring will be conducted at two sites within the stream reach: one above and one below the restoration site. The upstream site will be located directly downstream of where Clopper Road crosses Long Draught Branch at Firstfield Road. The downstream site will be located at the foot bridge crossing upstream of the City of Gaithersburg stormwater management facility (on Rabbitt Road west of Quince Orchard Road).

The position for each of the sampling locations is presented in Figure 1.

3.2 Physical Monitoring Locations

For both pre and post restoration efforts, physical monitoring locations will be in 3 locations within the construction area; the first at the upstream end of the Mainstem (near MD 117); the second is just upstream of the proposed confluence; the third is on the tributary

3.3 Biological Monitoring Locations

Biological Monitoring locations will coincide with the physical monitoring reaches for both pre and post construction efforts.

4.0 Continuous Flow Measurements

As mentioned earlier, flow will be measured to allow for calculations of EMCs on Long Draught Branch. Continuous flow measurements will be recorded at the upstream monitoring site. The flow meter will be attached to the downstream side of the culvert at the Clopper Road crossing (MD 107 culvert). Under this approach, we assume that the difference in flow between the upstream and downstream monitoring points is not significant in calculating EMCs.

A final decision on the flow monitoring equipment used for this project has not been made. It is anticipated that continuous flow measurements will be obtained using equipment equal to the Teledyne Isco 4110 Ultrasonic Flow Logger. Data from the flow meter will be downloaded on a monthly basis and flow meter batteries will be replaced. Data from the flow meter will be recorded on a data sheet following the database formats specified by MDE in Appendix A of the permit.

5.0 Chemical Water Quality Monitoring

Chemical water quality monitoring will be performed by teams of two individuals and will occur monthly. At least three sampling events will occur in a quarter with quarters based on the calendar year. Chemical water quality monitoring will occur in conjunction with 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 rainfall within 72 hours.

To allow for the collection of sufficient data to determine impacts of stormwater discharges, base flow will be collected during dry weather once per quarter (as weather conditions permit) in lieu of a wet weather event. Collection of dry weather samples will also allow SHA to more readily evaluate any illicit discharges or connections that may be found in the stream reach and distinguish these sources from those found during wet weather. Dry weather is defined as less than 0.1 inch having fallen within the previous 72-hour period.

If dry weather water quality data show consistency for the above parameters after a year of data collection (through the beginning of permit year 3), chemical monitoring during storm events can be increased to 12 events per year, weather permitting. If extended dry periods occur, baseflow samples will be taken at least once per month at the monitoring stations if flow is observed.

Data collected through this effort will be used to estimate annual and seasonal pollutant loads as well as for the calibration of watershed assessment models. Samples will be collected per the procedures in the Sampling and QA/QC Plans. Samples will be submitted to a laboratory for analysis according to the methods identified in 40 CFR Part 136.

Discrete samples will be collected at the identified monitoring stations using manual sampling methods. The samples will be collected within one foot of the surface and two monitoring locations will be used. Measurements of pH and water temperature will be taken in situ with a portable meter. Parameters to be sampled will be the same for both wet and dry weather samples. These 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 (TPH)*
- *Oil and Grease*
- *E. coli*

These parameters will be analyzed by GPL Laboratories in Fredrick, Maryland and e coli will be analyzed by Fredricktown Labs in Middletown, Maryland.
EMCs will be calculated for the parameters listed above and all results will be supplied to MDE following the database style specified in Appendix A in the permit.

5.1 Wet Weather Sampling

Wet weather sampling will commence when it is anticipated that the rainfall total will be greater than 0.1 inches and it has not rained significantly (greater than 0.1 inch) in the past 72 hours. Sampling will begin within two hours of mobilization with the first sample being taken at the upstream site. The time at which the initial sample is taken is considered time zero. The sampling team will then leave this site and drive to the downstream site where the first sample at this site will be taken. For each sampling site, a total of three samples will be taken per wet weather event (six samples in total per wet weather event).

5.2 Dry Weather Sampling

Dry weather sampling will occur when a sampling event is preceded by 72 hours without precipitation. One sample will be taken at both sites for each dry weather sampling event. A total of two dry weather samples will be taken per dry weather event.

6.0 Field Documentation

6.1 Field Data Collection Forms

Field logbooks will be maintained, serving as a record of observations during sampling activities. Pages will be numbered sequentially and entries will include:

· *Names of the field crew*
· *Sampling location*
· *Date and time of sample collection*
· *Number and volume of samples collected*
· *Sample identification numbers*
· *Preservatives used*
· *Weather Conditions*
· *Physical Conditions*

6.2 Sample Custody and Documentation

Completed chain of custody forms will be required for all samples to be analyzed. Chain of custody forms will be initiated by the sampling crew in the field and will remain with the samples at all times. The chain of custody form will contain the sample identification number, sample date and time, sample description, sample type, sample preservation, and analyses required. The original change of custody form will accompany the samples to the laboratory with copies made prior to delivery for field documentation.

7.0 Sample Collection, Handling, and Shipping

All samples will be collected as grab samples. A dip sampler will be placed below the surface of the water and sample will be transferred to the lab provided sample container. All samples will be stored in coolers, maintained at a temperature at or below 4°C and preserved according to EPA protocol. All employees will be trained in techniques for the proper handling of samples of analysis.

8.0 Data Quality Objectives and Requirements

A comprehensive and integrated QA program includes planning, control, assessment, reporting, and correction activities to ensure the quality of the data collected. The RKK/LTI team is committed to collecting scientifically valid data that are of the highest quality.

The overall goal of the QA/QC procedures it ensure that the data collected are complete, representative, comparable, and of known quality. A major component of the field QA/QC process will be collection and analysis of field duplicates.
Laboratory QA/QC will be performed according to established laboratory procedures and protocols.

Field duplicates will be used to assess the consistency and precision of field sampling and analytical procedures. The duplicate will be collected by simultaneously filling a second sample container from the same source as the first, using identical procedures. The duplicate will be returned from the field in a cooler with the regular samples. The field duplicate will be collected at a frequency of one in every 10 samples and will be done in a random fashion.

9.0 Schedule for Monitoring Program Implementation

A summary of tasks and a schedule for chemical, physical and biological monitoring and analysis is given in the table below:

	Task Description	***Anticipated Begin Date***	***Anticipated Completion Date***
1	Submit monitoring plan to MDE	-	10/31/06
2	Install flow meter	10/15/06	-
3A	Perform **CHEM 1** Phase of Chemical Water Quality Monitoring	10/15/06	1/31/08
3B	Perform **PHYS 1** Phase of Physical Monitoring	10/15/06	1/31/08
3C	Perform **BIO 1** of Biological Monitoring	10/15/06	1/31/08
4	Construction period/remove flow meter	2/1/08	9/31/08
5	Reinstall flow meter	10/1/08	-
6A	Perform **CHEM 2** Phase of Chemical Water Quality Monitoring	10/1/08	10/31/10
6B	Perform **PHYS 1** Phase of Physical Monitoring	10/1/08	10/31/10
6C	Perform **BIO 1** of Biological Monitoring	10/1/08	10/31/10
7	Remove flow meter	11/1/10	-

Karen: Please verify the highlighted portion with MDU

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