AECOM

City of Annapolis
Stormwater Management Inventory and Watershed Improvement Plan

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City of Annapolis
Stormwater Management Inventory and Watershed Improvement Plan

Prepared for
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Department of Neighborhood and Environmental Programs
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Acronyms

BayFAST	The Chesapeake Bay Facility Assessment Scenario Tool
BMP	Best Management Practice
CIP	Capital Improvement Program
EOS	Edge of Stream
EPA	Environmental Protection Agency
ESD	Environmental Site Design
GIS	Geographic Information System
HSG	Hydrologic Soil Group
LDA	Limited Development Area
MDE	Maryland Department of the Environment
MDSPGP	Maryland State Programmatic General Permit
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
WIP	Watershed Implementation Plan

Executive Summary

This Stormwater Management Inventory and Watershed Improvement Plan was initiated by the City of Annapolis' (the City) Department of Neighborhood and Environmental Programs and will support the City in meeting the requirements of the Maryland Department of Environment (MDE) next generation Phase II National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit and the Chesapeake Bay Total Maximum Daily Load (TMDL) goals. This plan will help the City to define and treat 20 percent of the unmanaged impervious area to comply with the upcoming NPDES MS4 permit and the associated Chesapeake Bay TMDL requirements.

The City is located in both the Severn River and the South River Watersheds and is subject to the Chesapeake Bay TMDL reduction goals for total nitrogen (TN), total phosphorus (TP) and total suspended solids (TSS). This report summarizes the progress made by the City and local partners and provides a suite of additional restoration options that can be implemented by the City to meet the water quality goals. As part of this study, design plans and reports provided by the City were reviewed. Plans that included information on existing stormwater management practices throughout the City were scanned, saved digitally, and provided to the City. 741 stormwater best management practices (BMPs) were identified from these plans and were input into a GIS database to document existing stormwater treatment within the City.

As part of the development of this plan, TN, TP, and TSS loads were quantified for the existing conditions specific to the City of Annapolis MS4 area. The pollutant loads were calculated using an Environmental Protection Agency-approved web-based tool called "The Chesapeake Bay Facility Assessment Scenario Tool" (BayFAST). These loads provide a reference point for tracking City progress toward meeting the Chesapeake Bay TMDL.

Potential locations for new and retrofit BMPs were identified via desktop analysis, followed by a field investigation to evaluate restoration strategies. The proposed restoration strategies were ranked using quantitative prioritization criteria, and the City selected 16 high priority restoration strategies for conceptual design. Conceptual designs were developed for the high priority projects and include a description of the recommended strategy, design considerations, a feasibility assessment, pollutant removal, and planning level cost estimates. The concept designs were ranked using a quantitative ranking criteria to assist the City in prioritizing the projects. A list of potential alternative urban BMPs approved by MDE is also provided for the City to consider as part of future pollutant reduction efforts.

The City will need to adopt a multipronged approach that involves working with local partners and implementation of conventional structural, environmental site design (ESD) and alternative urban BMPs including those identified in this plan. The City promotes the implementation of BMPs by requiring stormwater management for all development projects, and by reducing stormwater utility fees for residents who implement BMPs on private property. The City also promotes several alternative urban BMPs and programmatic measures, including tree planting and pet waste management. There are several non-profit organizations located within the City that are identifying and funding restoration measures that are crucial to improving water quality within the City. The City will coordinate with these groups to document projects within the City that can receive credit from MDE. It is through the collective effort of the City, residents and the various non-profit organizations that the City of Annapolis can meet the Phase II NPDES MS4 requirements and the Chesapeake Bay TMDL goals.

1 Introduction

The City of Annapolis Stormwater Management Inventory and Watershed Improvement Plan initiated by the Department of Neighborhood and Environmental Programs will serve as a guide for the City to meet the next generation National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) general permit requirements. The City is currently covered under the Phase II NPDES MS4 General Permit, which expired on April 14, 2008. This permit has been administratively extended until a new permit is reissued. The Maryland Department of Environment (MDE) is expected to issue a new Phase II permit that will require the City to meet the Chesapeake Bay Total Maximum Daily Loads (TMDLs) for total nitrogen (TN), total phosphorus (TP), and total suspended solids (TSS). This permit will likely reference the Maryland Watershed Implementation Plan (WIP) for meeting the Chesapeake Bay TMDL and is expected to require treatment of 20 percent of impervious area in the City that currently has no or limited stormwater management.

1.1 Regulatory Drivers

Stormwater management is required in the City to comply with the City Phase II NPDES MS4 Permit issued by MDE, the Chesapeake Bay TMDL, and local TMDLs.

The City is covered under the Phase II NPDES MS4 General Permit issued by MDE, issued on April 14, 2003. Phase II NPDES MS4 General Permits are required for municipalities with populations between 1,000 and 100,000, and the City is required to meet the six minimum control measures required by MDE:

- Public education and outreach
- Public participation and involvement
- Illicit discharge detection and elimination
- Construction site runoff control
- Post-construction runoff control
- Pollution prevention/good housekeeping

The Phase II MS4 Permits in Maryland have expired; however, they are administratively extended until a new permit is reissued. MDE is developing a new Phase II General Permit and has prepared the "Chesapeake Bay Restoration: Getting Started" preliminary fact sheet to allow municipalities to begin preparing for the new permit (MDE, 2016).

This fact sheet recommends that MS4s:

- Develop an inventory of the impervious areas within the MS4 jurisdiction
- Develop an inventory of best management practices (BMPs) within the MS4 jurisdiction
- Evaluate opportunities for BMP implementation for impervious area restoration
- Develop a BMP database to record inspection and maintenance activities performed on all BMPs

Impervious area restoration will require implementing BMPs for untreated or undertreated urban impervious areas. In 2014, MDE developed the guidance document, *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated*, to support permitted jurisdictions in Maryland in meeting the restoration requirements. This document describes approved structural BMPs, both traditional, environmental site design (ESD), and alternative urban BMPs, with estimated pollutant

removal and impervious acre credits. The treated area requirements for Phase II Permits have not been published yet; however, the Phase I NPDES MS4 Permits (including the Anne Arundel County Permit issued in 2014) and the General Permit for Stormwater Discharges Associated with Industrial Activities (12-SW Permit) both require 20 percent of existing untreated impervious areas to be treated. A similar requirement is anticipated for NPDES MS4 Phase II permits.

The Chesapeake Bay TMDL sets pollution reduction goals for nitrogen, phosphorous, and sediment loads to the Chesapeake Bay from Delaware, Maryland, New York, Pennsylvania, Virginia, West Virginia, and the District of Columbia (EPA, 2010), and includes an area of approximately 64,000 square miles. While the Chesapeake Bay TMDL establishes reductions required to mitigate documented impairments to the health of the Bay as a whole, individual local TMDLs establish reductions required to mitigate impairments at specific streams or stream networks. These impairments include those covered under the Chesapeake Bay TMDL (i.e., nitrogen, phosphorous, and sediment), as well as other impairments monitored by the Environmental Protection Agency (EPA) (e.g., bacteria, metals, and polychlorinated biphenyls). The City of Annapolis is located in Severn River and South River watersheds both of which have TMDLs associated with fecal coliform impairment. The South River watershed also has a TMDL for polychlorinated biphenyls (PCBs) impairment.

The Chesapeake Bay TMDL set watershed limits of 185.9 million pounds of nitrogen, 12.5 million pounds of phosphorus, and 6.45 billion pounds of sediment per year. These limits represent a 25 percent reduction in nitrogen, a 24 percent reduction in phosphorus, and a 20 percent reduction in sediment. These limits are then further divided by jurisdiction and river basin, as discussed in the various WIPs. EPA set a 2017 goal for implementing 60 percent of the needed actions, and a 2025 goal to achieve the final target loads.

WIPs were developed by each of the six states and the District of Columbia that lay out the approach these jurisdictions will adopt to meet the Chesapeake Bay TMDL goals. Maryland has developed Phase I and II WIPs that support the “reasonable assurance of implementation” for Maryland’s part of the TMDL. According to Maryland’s WIP, “reasonable assurance” is a demonstration that achieving the load reductions requirement by the TMDL can reasonably be met. The City of Annapolis’ TMDL requirements will come from the State’s WIP, and will likely be incorporated through the requirements of the Phase II NPDES MS4 permit.

1.2 Goals of this Watershed Improvement Plan

This Stormwater Management Inventory and Watershed Improvement Plan was developed to assess the City’s progress based on previously implemented Stormwater Management plans and to outline a strategy that will help the City comply with the anticipated Phase II NPDES MS4 Permit requirements. The goals of this plan are to:

- Inventory the existing stormwater management BMPs in the City of Annapolis
- Determine the current level of stormwater runoff treatment provided by the existing facilities and estimate the required level of stormwater treatment
- Identify opportunities to expand stormwater management to meet the Chesapeake Bay TMDL and the upcoming Phase II NPDES MS4 Permit requirements
- Provide concept designs and prioritization to identify high priority solutions that can be implemented by the City

2 Local Partners

To meet the next generation Phase II NPDES MS4 General Permit requirements the City must consider a variety of strategies, including coordinating and supporting the efforts of local partners. There are several watershed groups and non-profit organizations within the City that are actively planning and implementing restoration projects. These activities are crucial to improving the water quality within the City, and demonstrate initiative of private citizens to augment the efforts of the City. The City will work with these groups to identify, promote, and document projects within the City to receive credit from MDE.

The Back Creek Conservancy was created by citizen volunteers in 2015 to improve the water quality of Back Creek. The Back Creek watershed is located entirely within the City of Annapolis. Goals of the group include educating the public to mitigate the impacts of over 1,000 recreational vessels stored or moored in the creek, and to promote restoration activities of Back Creek and its tributaries. More information on the Back Creek Conservancy is available at http://backcreekconservancy.org/bcc/.

In 2016, St. Luke's Episcopal Church will begin a Comprehensive Watershed Restoration Project with its implementation partners at the Alliance for the Chesapeake Bay, and Underwood & Associates. The project was funded by grants from the Atlantic Coastal Bays Trust Fund and from various private businesses and churches in the City. This project will include daylighting streams (i.e., replacing storm drain pipe with stream channels), implementing regenerative stormwater conveyance (also known as step pool storm conveyance systems), and living shoreline tidal marsh restoration. More information is available at http://www.stlukeseastport.org/environmental-ministry.

The Severn River Association was founded in 1911, and performs water quality monitoring, education outreach, restoration activities, and phragmites removal. The association holds monthly public outreach meetings to promote best practices for protecting the Severn River Watershed and provide updates on river activities and concerns. There are currently no active projects within the City. More information on the Severn River Association is available at http://severnriver.org/about/history.htm.

The South River Federation has been working to improve the water quality of the South River for over a decade, combining restoration efforts, water quality monitoring, and public education. Restoration efforts include implementing upstream BMPs (e.g., rain gardens), living shorelines, stream restoration projects, and wetland restoration projects. More information on the South River Federation is available at: http://www.southriverfederation.net/. Projects currently planned by South River Federation in the City include:

- Bywater Stream and Wetland Restoration project at Kingsport City Park, a 2,000-linear-foot stream and wetland restoration project
- Church Creek Headwaters Restoration Allen Apartments Branch Project (Church Creek Phase III), a 1,400-linear-foot urban outfall stabilization project, which is a portion of a multi-pronged effort to improve urban habitat in Church Creek

The Spa Creek Conservancy mission is to provide stewardship of the Spa Creek Watershed through education, preservation, mitigation, and restoration. The group has been active for over a decade, and the watershed is located entirely within the City. Restoration efforts include upstream BMPs (e.g., rain gardens, conservation landscaping, and rain barrels), tree planning, riparian forest clean-ups, and stream restoration. More information on the Spa Creek Conservancy is available at http://spacreek.net/. Projects currently planned by Spa Creek Conservancy in the City include:

- Street Ends Project, restoration efforts throughout the Spa Creek Watershed (including restoring one ravine using step pool technology; installing three street-end park biocells; one Department of Public Works stormwater retrofit-fuel station canopy, one pocket park, and stormwater retrofits at two business locations)
- Headwaters of Spa Creek Stream Restoration, a 5,000-linear-foot stream restoration at the headwaters of Spa Creek from the Chinquapin Round Road industrial park to the Chesapeake Children's Museum
- Hawkins Cove Restoration Project, an assessment of the City of Annapolis Housing Authority on Madison Street and surrounding neighborhoods bordering Truxtun Park
- Hawkins Cove Restoration Biocell Showcase – Conservation Landscaping, at the City of Annapolis Housing Authority on Madison Street
- Hawkins Cove Reforestation, an ongoing project with community youth and young adults to plant trees, install stormwater planters, and implement downspout diversion to native plantings

The Annapolis Watershed Network is a collaboration of the City, the Back Creek Conservancy, the Severn River Association, the South River Federation, and the Spa Creek Conservancy to coordinate restoration activities. It was formed to expand communication among the various groups working to improve water quality in the City. This type of collaboration will assist the City in expanding the environmental, social, and atheistic benefits of these projects to tangible credits from MDE.

3 City of Annapolis Characterization

This section summarizes the general conditions of the City of Annapolis. The City and its watersheds were characterized using geographic information system (GIS) data provided by the City and Anne Arundel County.

3.1 Location

The City of Annapolis, the capital of Maryland, is in Anne Arundel County and occupies an area of approximately 4,550 acres. The City is located along the Chesapeake Bay, with the confluence of the South River to the northeast, the confluence of Severn River to the southwest, and Route 50 to the northwest. Figure 3-1 shows the location of the City.

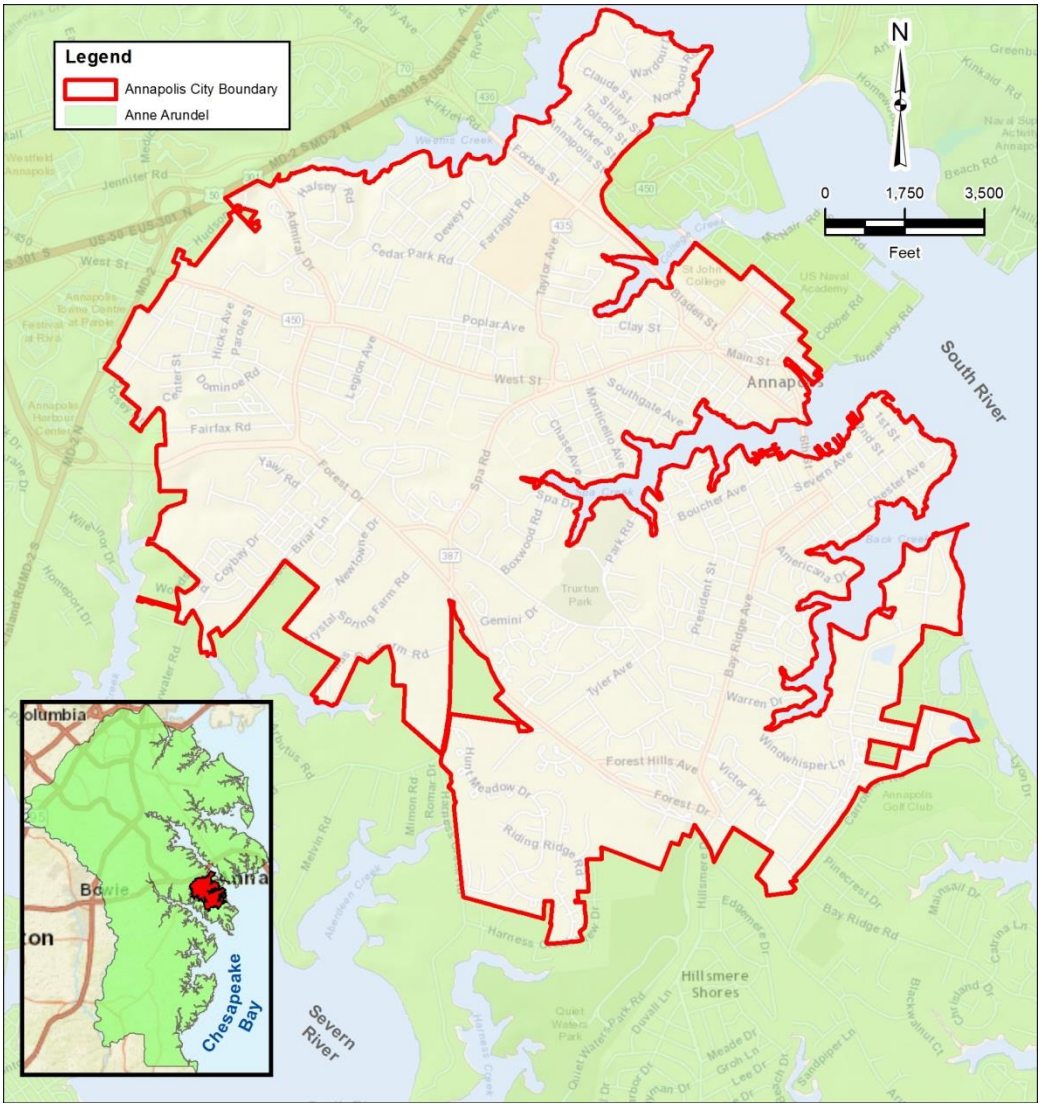


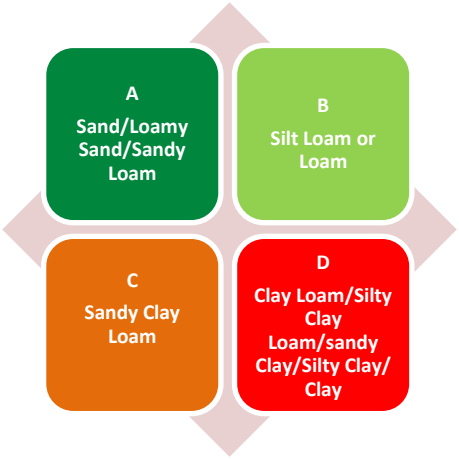
Figure 3-1: City of Annapolis Location Map

3.2 Physiography and Soils

The City is located entirely in the Atlantic Coastal Plain Province, which is composed primarily of gravel, sand, silt, and clay. Streams in coastal zones typically have milder slopes compared to the streams in the piedmont region, and the bedrock in the Atlantic Coastal Plain Province are made of sediment layers, which are easily eroded and can contribute to sediment loads (Maryland DNR, 2005).

The soils data available for the City on the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) website were used to evaluate the soil conditions for the City. NRCS classifies soils into four Hydrologic Soil Groups (HSGs) (A, B, C, and D), depending on factors such as runoff potential, soil texture, and infiltration rates. HSGs A and B generally have sandy, loamy, and silt textures and high infiltration rates. HSGs C and D have clay content, low infiltration rates, and high runoff potential. Erodibility of soils increases with silt and sand content. Soils with clay content are more stable and less susceptible to erosion because of the binding nature of the clay. Clay bonds with organic matter, resulting in a more stable soil structure.

The majority of the soils in the City of Annapolis are hydrologic group C (68 percent) or group D (23 percent), which have low infiltration rates, and therefore are not typically suitable for infiltration practices (Figure 3-2). Figure 3-3 shows the distribution of soil groups in the City.



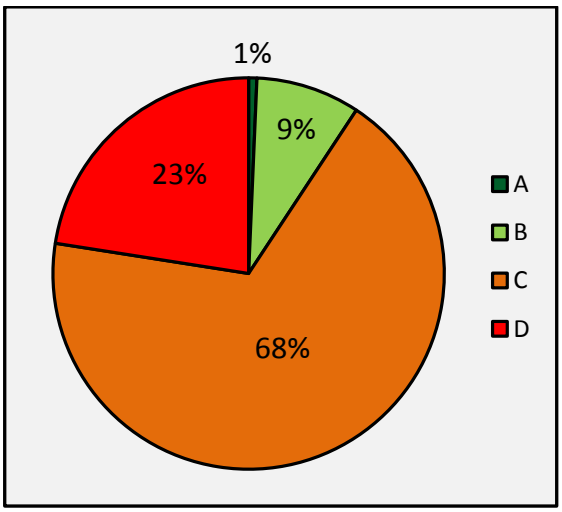


Figure 3-2: Hydrologic Soil Group Distribution in the City of Annapolis

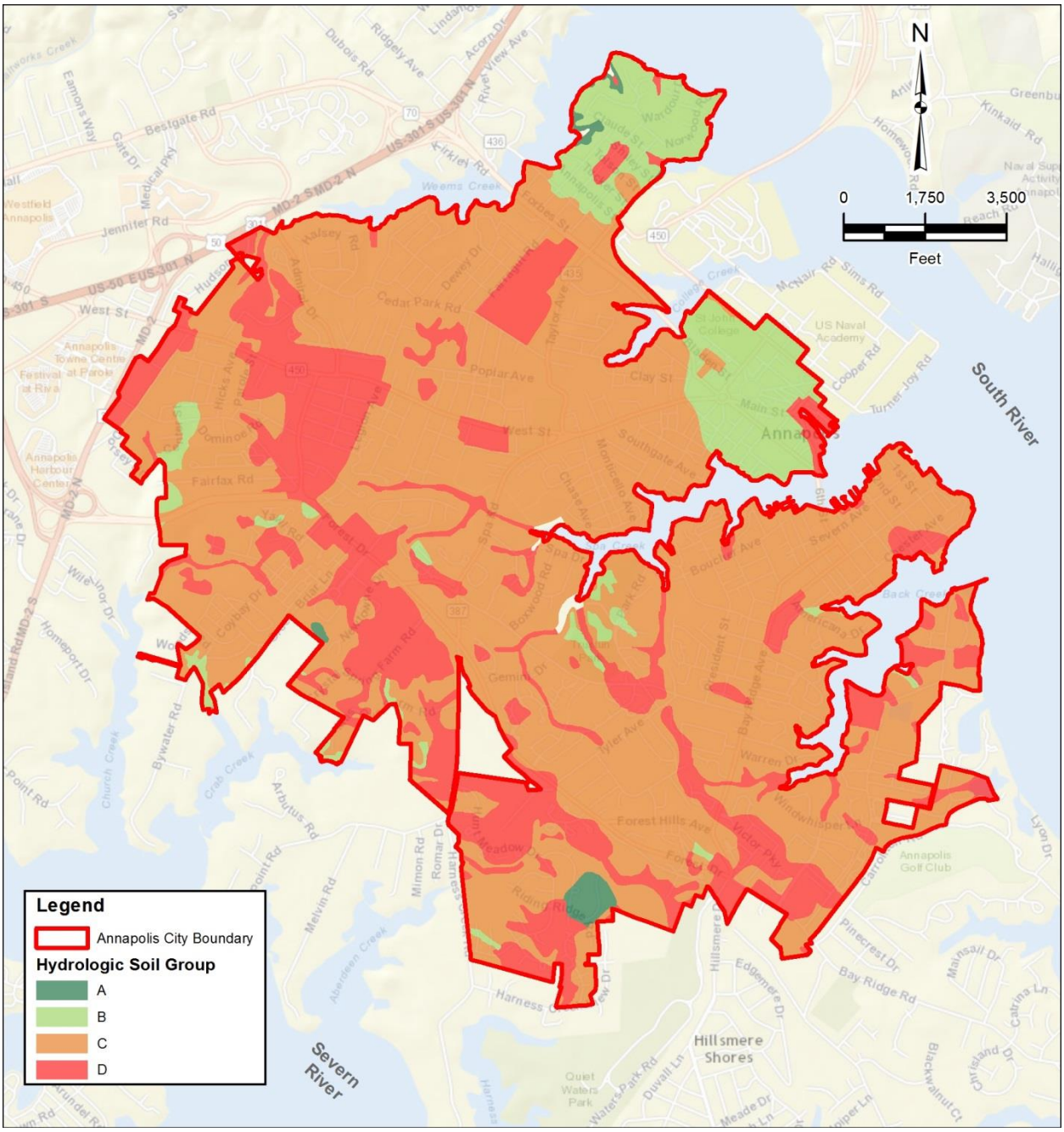


Figure 3-3: Hydrologic Soil Group Distribution in the City of Annapolis

3.3 Land Use

Anne Arundel County updated their land cover GIS dataset in 2011 using aerial imagery collected in Spring 2011 by the state of Maryland. This dataset includes the City and is used for the pollutant modeling performed as part of this plan. The land cover in the City is primarily residential (57 percent), with large commercial (22 percent) and forested areas (12 percent). Figure 3-4 shows the land cover for the City.

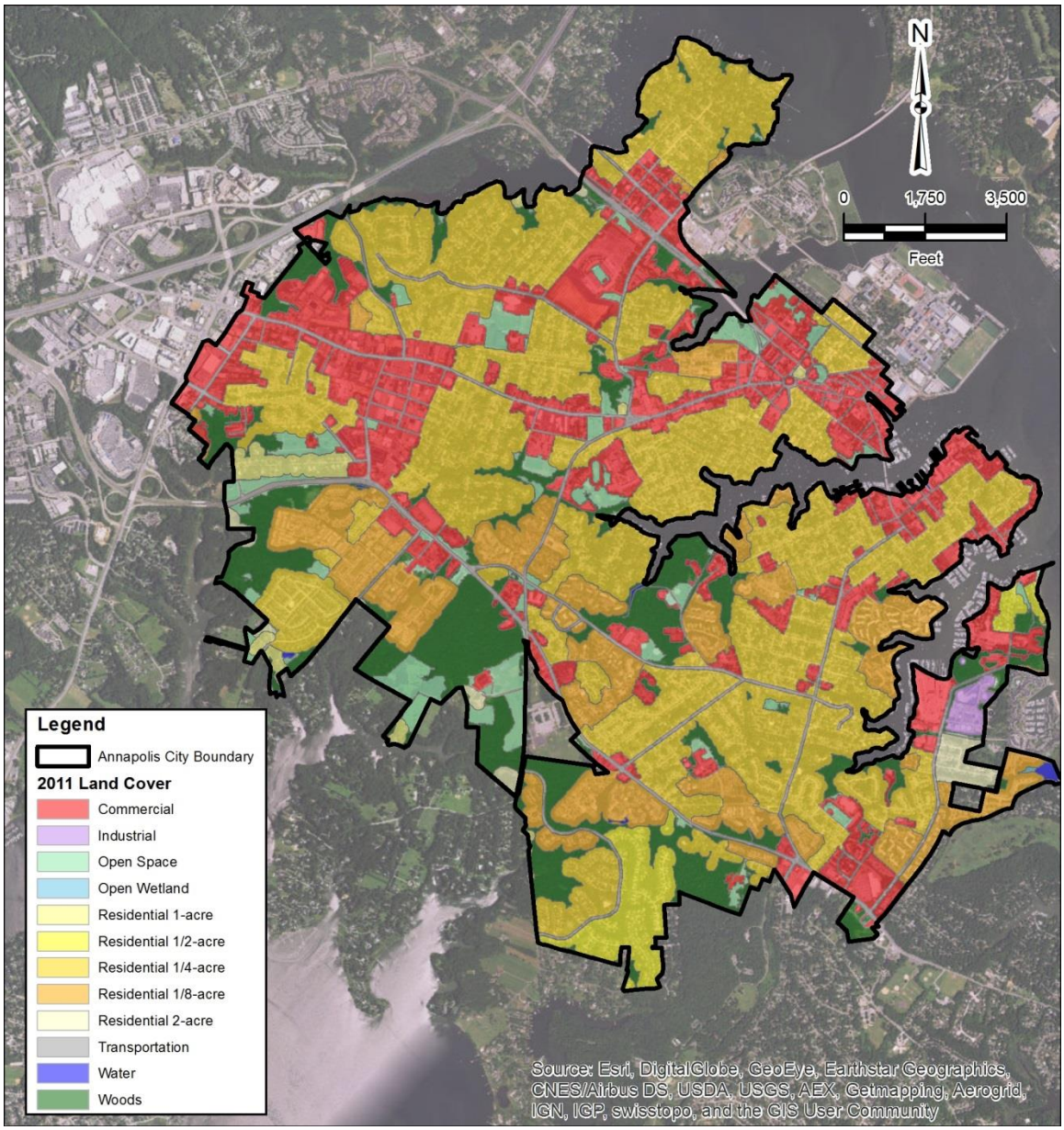


Figure 3-4: City of Annapolis 2011 Land Cover (Source: 2011 Anne Arundel County Land Cover Study)

Parks and recreational areas in the City include the Ellen O. Moyer Nature Park at Back Creek, Truxtun Park, Amos Garrett Park, Annapolis Walk Park, Chamber Park, and the Newman Street Playground. Saint John's College and the U.S. Navy-Marine Memorial Stadium are also located in the City.

3.4 City of Annapolis Watersheds

The City includes portions of the Severn River and the South River Watersheds. Approximately 80 percent of the City is located in the Severn River Watershed, with Forest Drive generally dividing it from the South River Watershed.

The City has 12 sub-watersheds, which are split between the Severn River and South River Watersheds. Spa Creek and Back Creek are the largest sub-watersheds, and the remaining 10 sub-watersheds were grouped into two groups based on their location in the Severn River or South River

Watershed in this plan for identification and evaluation of potential water quality improvement projects. These grouping are shown in Figure 3-5 and are provided in Table 3-1

Table 3-1: Watershed Prioritization Grouping

Group Number	Watershed Name	Sub-watersheds Included
1	Spa Creek Sub-Watershed	Spa Creek
2	Back Creek Sub-Watershed	Back Creek
3	Severn River Sub-Watersheds	College Creek, Weems Creek, Chase Pond, Lake Ogleton, Severn River Tidal
4	South River Sub-Watersheds	Church Creek, Crab Creek, Aberdeen Creek, Duvall Creek, Harness Creek

3.5 Stormwater Management Requirements

Stormwater Management requirements in the City are provided in Chapter 17.10 of the City Code for both new development and redevelopment. All new developments in the City are required to implement stormwater management to the maximum extent practical following the MDE stormwater manual (2000). Environmental site design (ESD) practices described in Chapter 5 of the manual are preferred over structural BMPs discussed in Chapter 3 of the manual. Any redevelopment that disturbs greater than 5,000 square feet (or 2,000 square feet for waterfront sites) must either reduce the existing impervious area on-site by 50 percent or treat runoff from 50 percent of the existing impervious area (or some combination of the two). ESD practices are preferred over structural BMPs, and offsite BMP implementation (treating at least one and one-half times the drainage area and percent imperviousness) is an option where on-site practices are infeasible. The City also requires that private and public BMPs have signed stormwater management maintenance agreements to document that the BMPs are inspected and maintained on a regular basis.

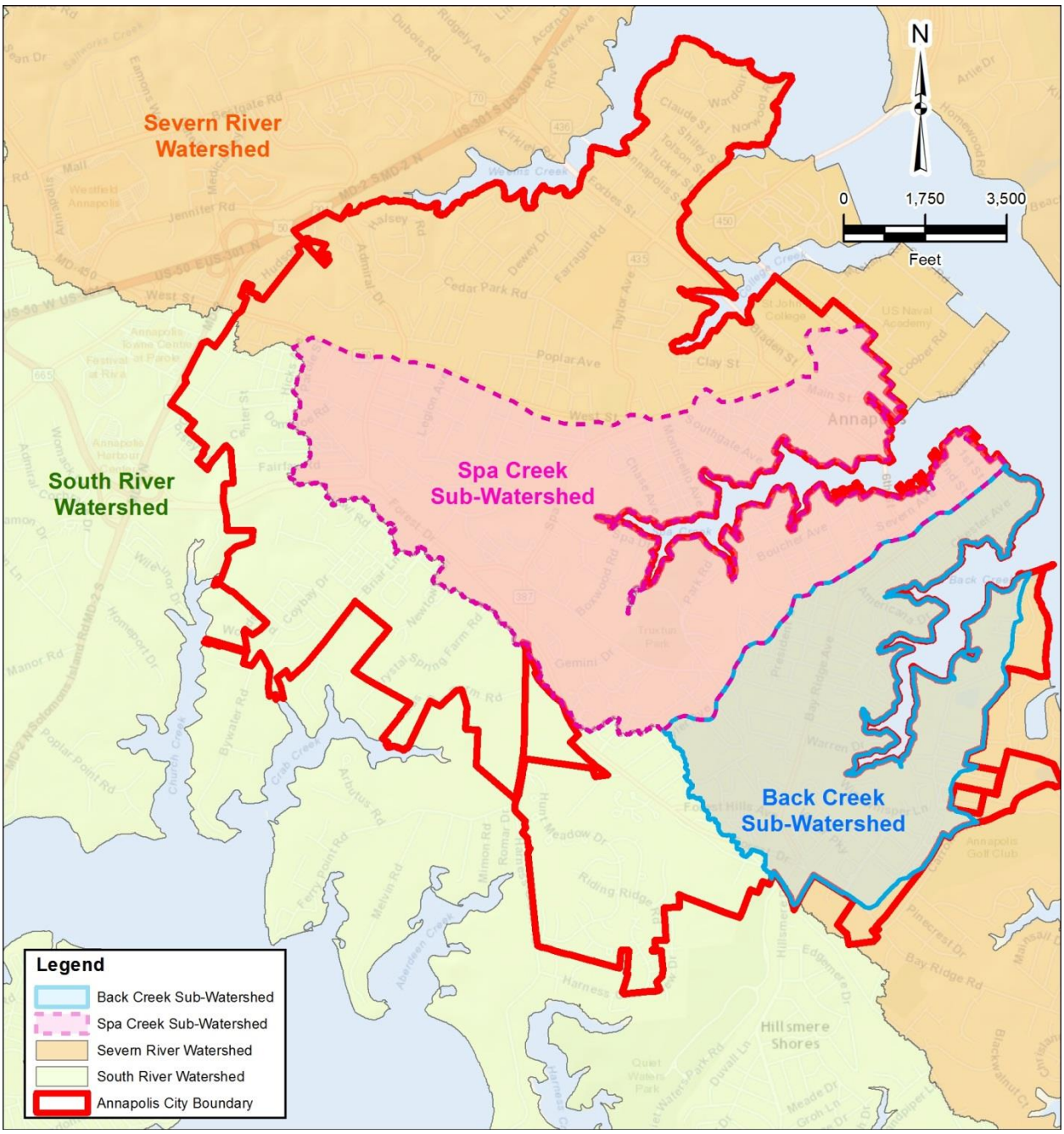


Figure 3-5: City Sub-Watersheds

4 Inventory of Existing Stormwater Management Practices

It is anticipated that the upcoming Phase II NPDES MS4 General Permit will require treating 20 percent of the untreated impervious areas within the City. The preliminary fact sheet provided by MDE recommends that MS4s determine the current level of stormwater runoff treatment provided by the existing facilities to identify the areas that are currently treated. To determine the areas that are currently treated, existing stormwater BMP information was collected into a georeferenced database. Existing development plans from the City were received, in hardcopy and DVD formats, which were scanned, reviewed, and entered into a GIS database. The GIS database, scanned plans, and a summary spreadsheet of BMPs were provided to the City.

4.1 Database Development

AECOM received development plans from several City departments, including the Office of Law, Department of Public Works, and the Department of Neighborhood and Environmental Programs. The Office of Law plans included a summary table that listed whether or not each plan had stormwater management information. All plans from the Office of Law that indicated stormwater management information was included were scanned. The remaining plans received by the City were reviewed and were only scanned if they included stormwater management information. Plans were scanned for 351 sites, consisting of 1,725 scanned plan pages. Of the 351 sites, 273 sites had BMP information. AECOM also reviewed any available reports received from the City, and scanned 42 stormwater management reports. The scanned plans and reports were organized into folders based on the project sites (each site could have multiple plans), along with the digital plans received from the City (whether or not stormwater management information was included). The digital information was provided to the City on July 15, 2015.

Several of the scanned plans and the provided digital plans either did not include information on stormwater management practices or did not include information on BMPs that could be input into the database. Table 4-1 provides a summary of the plans in regard to whether they had BMPs.

Table 4-1: Number of Site Plans With, Without, or Missing BMPs

BMP Status	Number of Plans
Plans with BMPs	273
Plans without BMPs	78
Missing site plans[1]	28

[1]Plans from the Office of Law's list that may have additional BMPs that can be added to the database later if the plans are identified.

From the 273 plans provided by the City with BMPs, a total of 741 BMPs were added to the database. Most of the plans were site drawings from development phases and did not typically include the final as-built drawings, so they may require verification of final implementation and design from the owner, or field verification by the City staff. Additionally, any missing data in BMP attribution may also need to be verified via these sources.

The database's structure follows the NPDES BMP reporting requirements published by MDE in the *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated* (2014) document. BMPs were georeferenced based on locations provided in the development plans, and available BMP

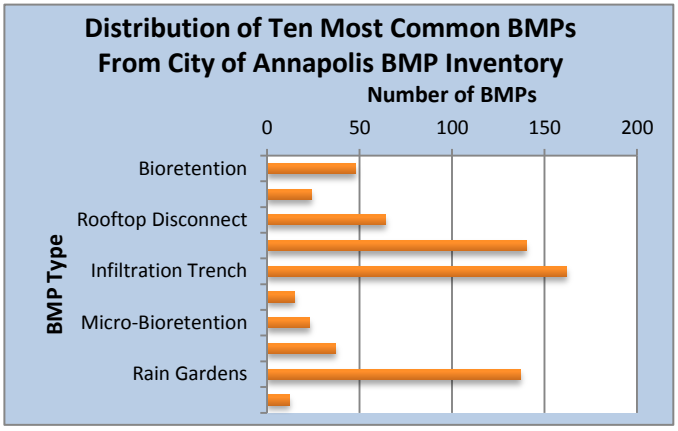
attributes (e.g., BMP type, contributing impervious area, rainfall depth treated, and land use) were entered.

Where the impervious area draining to a BMP was unavailable, and the BMP drainage area was provided, the impervious area was estimated by assuming a percent imperviousness based on the planning zone type. A list of the missing plans from the Office of Law was provided to the City as part of the July 15, 2015 submittal. If any of these plans are identified in the future they can be added to the database and the pollutant models can be updated to capture their effectiveness.

Since most plans provided were not as-builts, records of construction dates may need to be acquired from other sources. Approved dates were entered using the available approval stamp date, plan date, or applicable signatory date. In some cases, BMPs were noted to be part of the final design, but a summary of drainage area or impervious area for an individual BMP was not provided. These BMPs may need to be verified from other sources to determine treatment area. Approximately 28 site locations that were included in the list provided by the Office of Law did not have any associated site/development plans.

4.2 Summary of Existing Stormwater Management

Based on the data inventory of existing plans, there are 741 documented BMPs in the City of Annapolis. MDE assigns a unique three- to four-letter identifier for each BMP type that receives credit for treating runoff (e.g., bioretention facilities are represented as FBIO, and dry wells are represented as MIDW). There are 32 unique BMP types in the City database. The most common BMPs in the inventory were infiltration trenches, followed by dry wells, rain gardens, rooftop disconnections, and bioretention facilities. Appendix A provides a list of MDE-approved BMPs with their four letter BMP codes. Approximately half of these BMPs were implemented as part of new development projects, and the other half were implemented as part of redevelopment projects (less than 1 percent were implemented as part of restoration projects).



Of the documented BMPs, approximately 50 percent were implemented between 2002 and 2009, and approximately 35 percent were implemented between 2010 and 2015 (Table 4-2). The remaining BMPs were implemented between 1985 and 2001. According to MDE, areas developed prior to 1985 often do not have stormwater management, as they were constructed before the adoption of the stormwater management regulations by the State of Maryland. Until 2002, stormwater management in the City, like most of the jurisdictions in the State of Maryland, focused on managing stormwater quantity rather than quality. Most of the quantity control stormwater management practices were designed to collect stormwater runoff from its drainage area and release it at a controlled rate, providing limited water quality management.

Conversely, in the last 10 to 15 years, BMPs that focus on treating water quality have been implemented. These implemented BMPs include traditional stormwater management practices (e.g., wet ponds, and swales) and ESD type practices designed to mimic pre-development runoff characteristics. Stormwater management practices that provide quality treatment are designed to collect and treat rainfall through a combination of organic and inorganic filtering media such as sand, gravel,

and plants. Alternative practices such as stream restoration, shoreline management, and street sweeping also receive credit from MDE. Figure 4-1 shows the locations of BMPs in the City by implementation era, which can be used to evaluate retrofit opportunities for areas. Figure 4-2 shows the locations of BMPs in the City by BMP type.

Table 4-2: Summary of Stormwater Management Inventory in the City of Annapolis by Era

Stormwater Management Implementation Era	Number of Structural BMPs	Number of Environmental Site Design Practices	Number of Alternative BMPs	Total Number of BMPs
1985–2001	20	106	1	127[1]
2002–2009	196	142	8	346
2010–2015	258	10	0	268
Total	**474**	**258**	**9**	**741**

[1]According to MDE, 1985 era and earlier BMPs do not provide adequate water quality treatment of runoff.

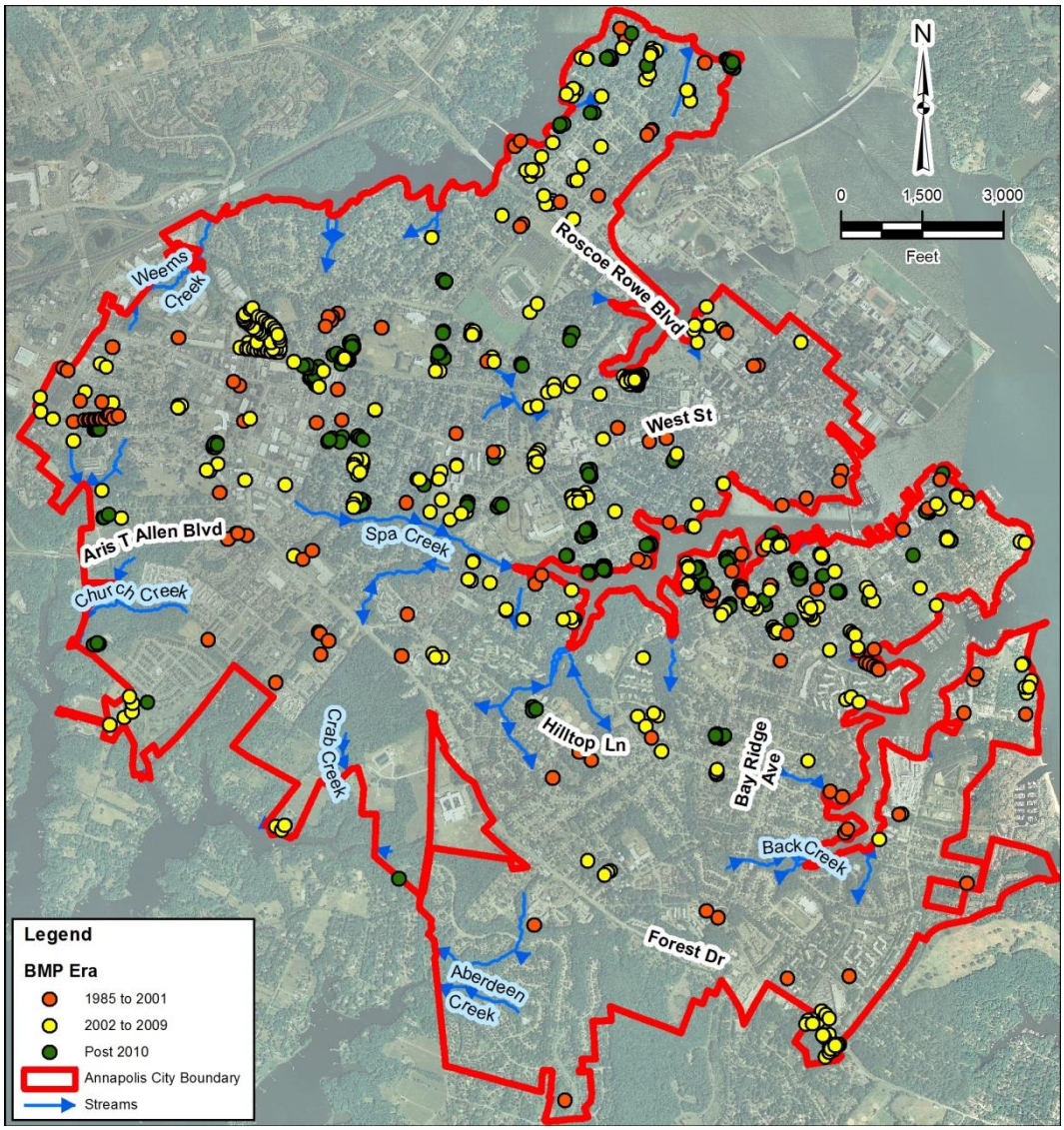


Figure 4-1: City of Annapolis Stormwater Management Inventory by Era

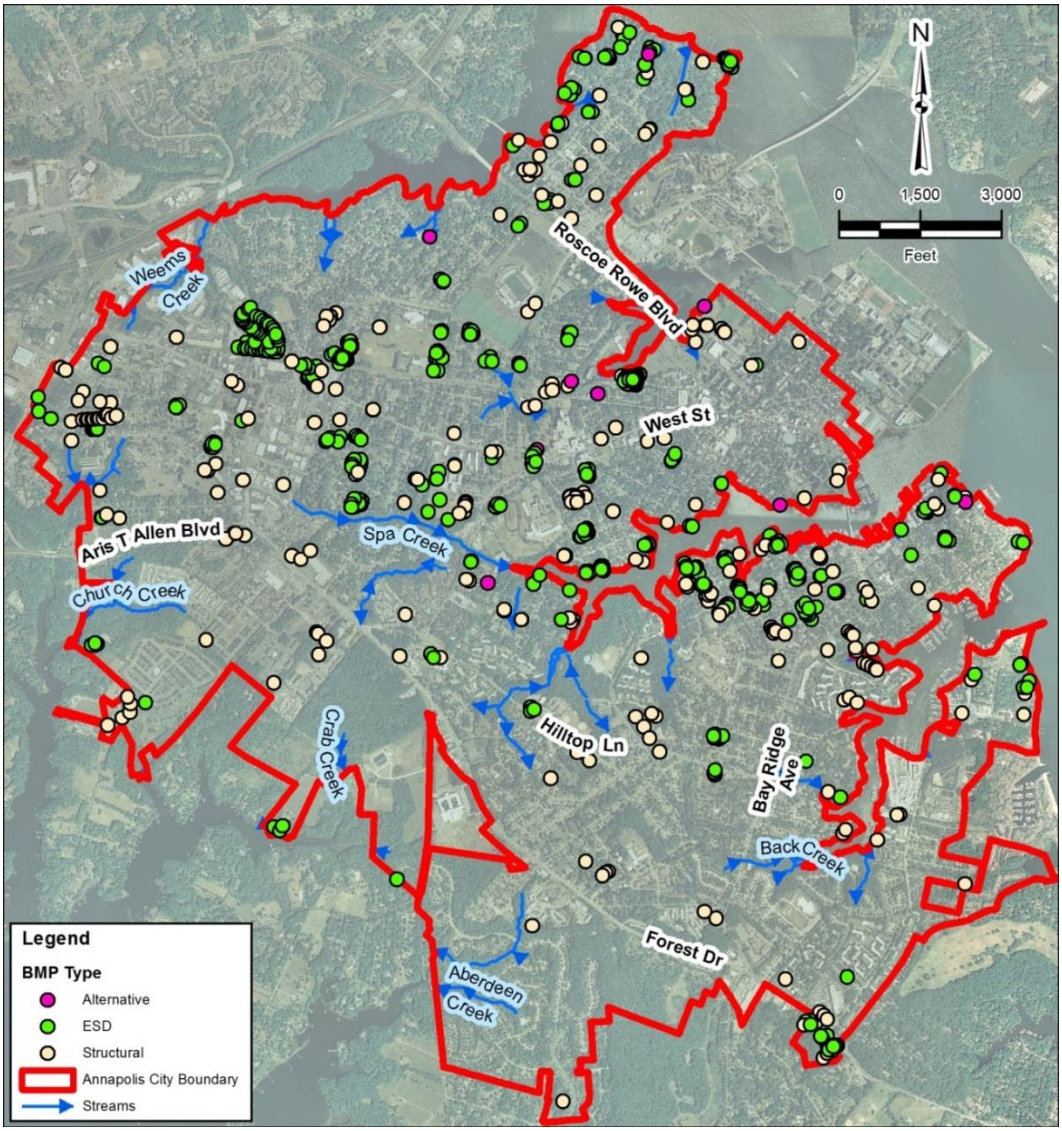


Figure 4-2: City of Annapolis Stormwater Management Inventory by BMP Type

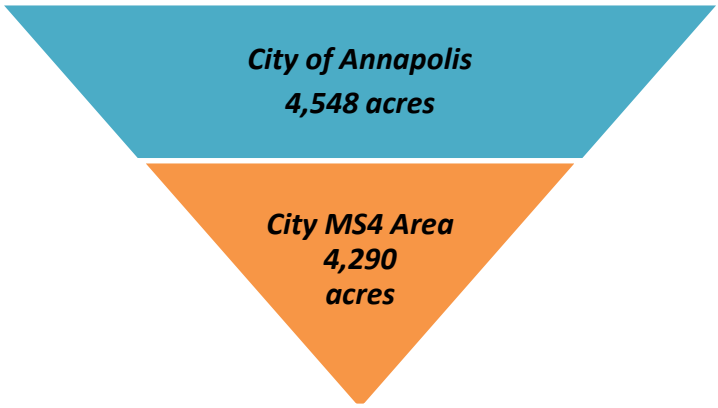
5 Assessment of Nutrient and Sediment Loads

As part of the development of this Watershed Improvement Plan, TN, TP, and TSS were quantified for the existing conditions in the City of Annapolis MS4 area to provide a preliminary understanding of pollutant loads associated with Chesapeake Bay TMDL. The pollutant loads were calculated using an EPA-approved web-based tool called “The Chesapeake Bay Facility Assessment Scenario Tool” (BayFAST). This tool is also recommended by MDE for NPDES MS4 permittees for estimating nutrient and sediment loads for developing restoration plans.

5.1 Defining the City of Annapolis MS4 Area

The City of Annapolis includes properties owned by Anne Arundel County, the Maryland State Highway Administration, and the State. These entities have their own NPDES MS4 permits and are responsible for their respective allocations of the Chesapeake Bay TMDL; therefore, based on guidance by MDE these areas are excluded from this plan. To estimate the nutrient and sediment loads from different scenarios, the City of Annapolis’ area was defined so that the restoration strategies could be focused on areas covered by the City’s Phase II NPDES MS4 permit. The City and County GIS data were used to define the MS4 area for the Watershed Improvement Plan.

According to the MDE’s guidance, facilities with 12-SW permits have their own set of Chesapeake Bay TMDL restoration requirements, and therefore would not be included in the City’s MS4 permit area. However, there are no properties with 12-SW permits within the City of Annapolis boundary.



Based on this analysis, approximately 4,290 acres in the City were defined to be urban, discharging to a MS4 (Figure 5-1). The pollutant load assessment scenario was developed in BayFAST to estimate the nutrient and sediment loads from these portions of the watershed. Similarly, the restoration strategies were also limited to the City of Annapolis MS4 area.

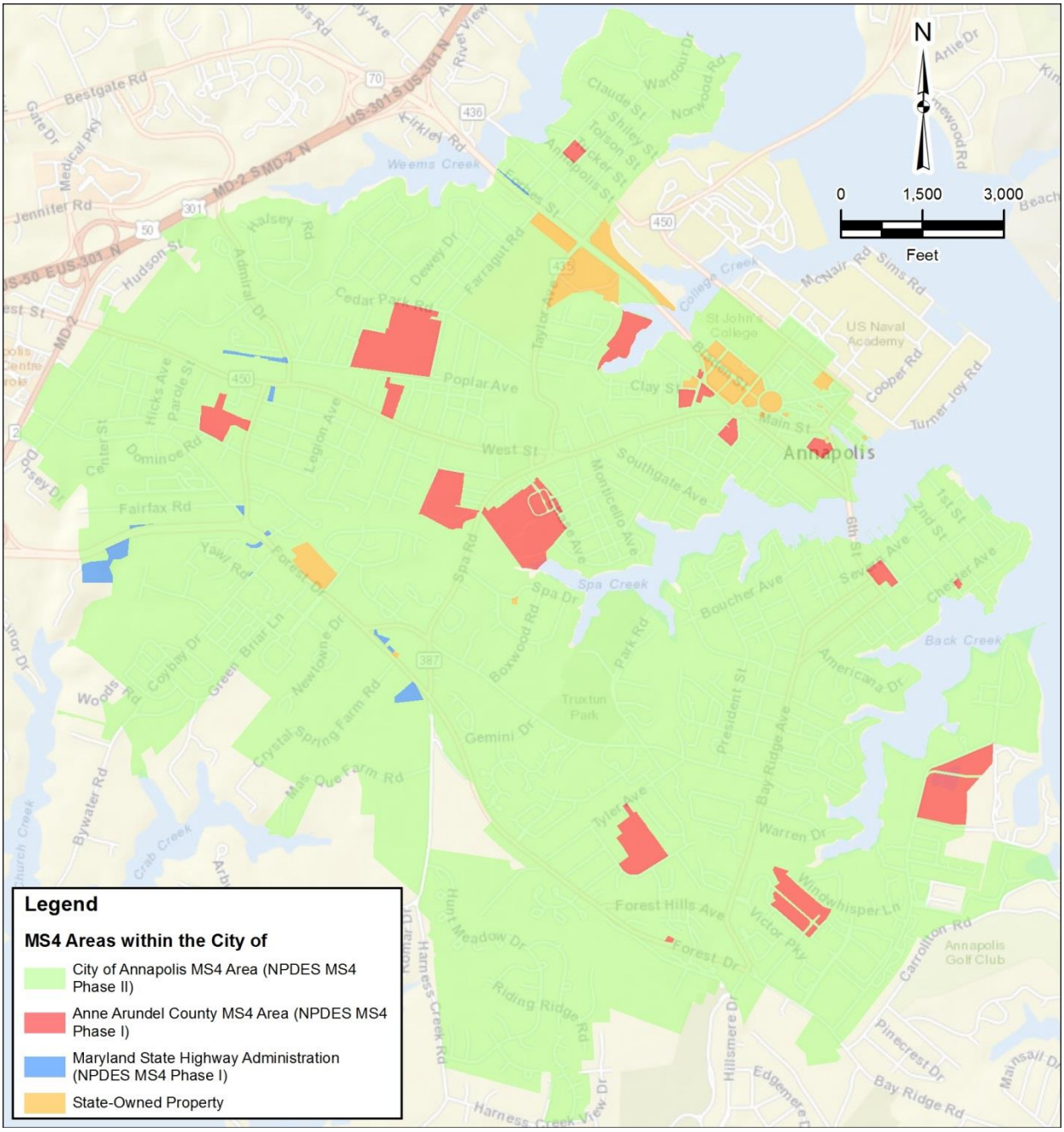


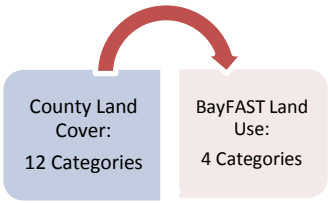
Figure 5-1: MS4 Areas within the City of Annapolis

5.2 Model Input Data

The BayFAST model computes pollutant loading for nitrogen, phosphorous, and sediments based on land use and BMPs. The existing land use data provided by Anne Arundel County and the BMP data gathered as part of the BMP inventory were classified for BayFAST model input.

5.2.1 Land Use

The available land use data from the Anne Arundel County 2011 land cover and impervious cover datasets had to be generalized for input into BayFAST. The four land use categories in the City of Annapolis BayFAST model are:



- Regulated impervious
- Regulated pervious
- Forest
- Water

The regulated impervious area was extracted from the County 2011 impervious cover GIS dataset, while the forest and water land use areas were extracted from the County land cover GIS dataset. The remaining areas in the City of Annapolis were classified as regulated pervious. Table 5-1 and Figure 5-2 show the land use for the City of Annapolis MS4 Area input into BayFAST to calculate pollutant loads.

Table 5-1: City of Annapolis Existing Land Use required for BayFAST

Urban Land Use	Area, acres
Regulated Impervious	1,660
Regulated Pervious	2,130
Forest	490
Water	10
Total	**4,290**

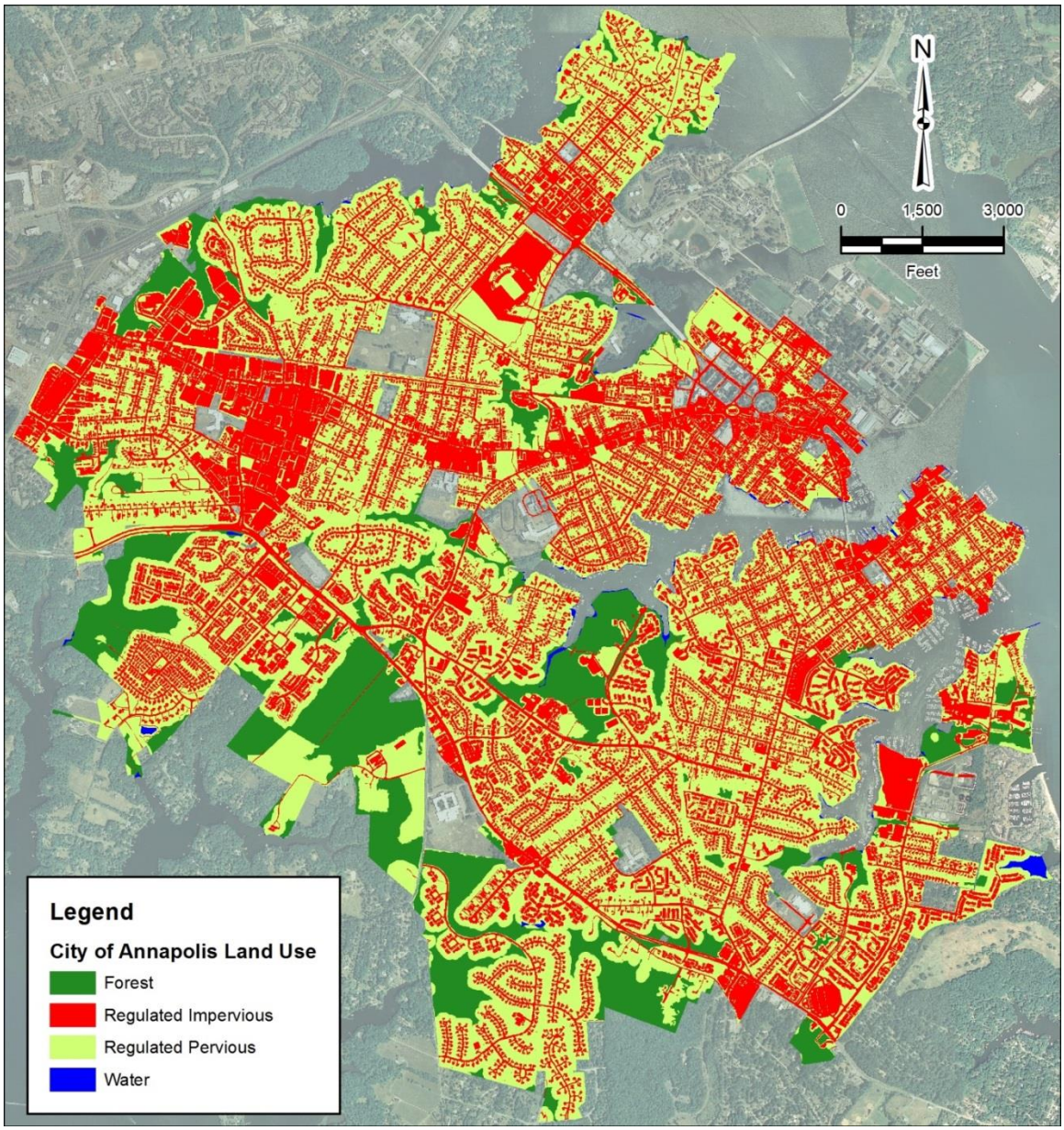
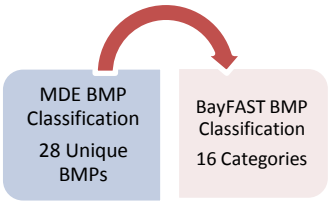


Figure 5-2: Land Use for City of Annapolis MS4 Area Required for BayFAST

5.2.2 BMP Reclassification and Treated Drainage Areas

The BMP classifications from the BMP inventory task were organized for input into the BayFAST BMP classifications. There are approximately 50 MDE-approved BMP classifications, and there are 32 different practices in the City BMP inventory. The MDE classifications are more specific than the BayFAST classifications. For example, BayFAST has only a single category for wet ponds and wetlands, whereas MDE identifies 9 different BMPs in this category (e.g., wet extended detention structures, pocket ponds, shallow marshes, and pocket wetlands). Another key difference between the two classifications is that some of the BayFAST categories (e.g., bioretention facilities, vegetated channels, and pervious pavements) are differentiated based on soil type (i.e., A/B or C/D), whereas the MDE classifications do not differentiate based on soils. The hydrologic soil group was extracted for each BMP using the NRCS soil group, and these soil data were used during reclassification. A total of 16 BayFAST categories were used for modeling pollutant loading.



According to MDE, urban land is considered treated if the water quality volume is contained within a BMP (MDE, 2000; MDE, 2014). Since BMPs implemented before 2002 were not typically designed according to this manual, they are not included in this analysis. For the majority of Maryland (including the City), the water quality volume is defined as 1 inch of rainfall over the facility drainage area. When less than 1 inch of rainfall is treated by a BMP, a proportional credit is granted by MDE (e.g., treatment of 0.5 inch for 4 acres results in 2 acres of credit). When more than 1 inch of rainfall is treated, full credit for the drainage area is granted along with an additional 25 percent for each additional inch above 1 inch that is treated by a facility (e.g., treatment of 2 inches for 4 acres results in 5 acres of credit). The treated impervious area and treated pervious drainage areas were calculated for each BMP with this methodology using the impervious drainage area, total drainage area, and rainfall depth populated in the BMP database.

5.3 Existing Nutrient and Sediment Loads

The City existing condition scenario in BayFAST includes the BMPs implemented from January 1, 2002 to June 2015. Table 5-2 lists BMPs and restoration projects with their drainage areas and impervious areas. There are also 710 feet of stream restoration and 750 feet of shoreline restoration, which corresponds to approximately 7.1 and 30 equivalent impervious acres, respectively.

Table 5-2: BMPs Included in 2015 Existing Conditions Assessment BayFAST Scenario

BMP Type	Treated Pervious Area (acres)	Treated Impervious Area (acres)	Number of BMPs
Bioretention/Rain Garden A/B Soils, no underdrain	5.6	5.2	11
Bioretention/Rain Garden C/D Soils, underdrain	28.3	31.5	195
Bioswale	0.8	1.2	4
Dry Ponds and Hydrodynamic Structures	1.7	1.0	3
Impervious Surface Reduction	0.05	0.8	14
Permeable Pavement w/o Sand - A/B Soils, no underdrain	0.05	0.3	4
Permeable Pavement w/o Sand - C/D Soils, underdrain	1.6	3.8	33
Urban Filtering Practices	1.1	2.5	8
Urban Infiltration	15.7	10.6	235
Urban Tree Planting	0.0	0.1	4
Urban Filter Strip Storm Water Treatment	0.1	1.0	86
Vegetated Open Channels - A/B Soils, no underdrain	3.0	0.3	2
Vegetated Open Channels - C/D Soils, no underdrain	1.5	1.2	10
Wet Ponds and Wetlands	15.8	12.1	2
Total	**75.3**	**71.6**	**611**[1]

[1] There are 614 total BMPs when including the 1 shoreline restoration project and 2 stream restoration projects that provide an additional 37.1 equivalent impervious acre credits.

The BayFAST program provided two output pollutant loads at different levels of hydrologic system for the existing conditions scenario:

- Edge of Stream (EOS) loads: This is the amount of pollutant load transported from different land uses to the stream.
- Delivered loads: This is the amount of pollutant loads transported to Chesapeake Bay through the stream. These loads are generally lower than EOS loads because they tend to be reduced by various in-stream biological processes.

MDE usually uses the EOS load to develop TMDLs. Table 5-3 shows the EOS loads for nitrogen, phosphorus, and sediment for the existing conditions scenario.

Table 5-3: Existing Conditions Edge of Stream loads from BayFAST for the City of Annapolis

Pollutant	Existing Load
EOS Nitrogen Loads	34,280 lbs/year
EOS Phosphorous Loads	3,270 lbs/year
EOS Sediment Loads	580 tons/year

Based on the existing database the City can currently take credit for treating 78.7 impervious acres (71.6 impervious acres, and for 7.1 equivalent impervious acres) from BMPs installed since 2002. There are 1,660 impervious acres regulated by the City (Table 5-2) with approximately 1,581 acres currently either untreated or undertreated. To treat 20 percent of the untreated impervious acres approximately 316 impervious acres would need to be treated. Based on the MDE's published factsheet for Phase II General Permit, "Chesapeake Bay Restoration: Getting Started" (MDE, 2016), impervious area treated by the restoration BMP projects implemented since 2006 can be counted towards the 20 percent Chesapeake Bay Restoration requirements. Therefore, 30 acres of equivalent impervious area credits from the shoreline management project implemented in 2006 can be credited towards the 316 impervious acres treatment requirement. This would reduce the amount of impervious area to be treated by the City to meet the Chesapeake Bay Restoration requirements to 286 acres.

The Chesapeake Bay TMDL requires reductions based on the 2010 "baseline" conditions. This allows for credit to be taken for BMPs implemented from 2010 to the present toward meeting the TMDL; however, it also accounts for anticipated increases in pollutant loading due to urbanization. This study provides the existing conditions based on 2011 land use data, and can be updated once the Phase II NPDES MS4 General Permit is released with specific requirements.

6 Identification of Stormwater Management Opportunities

Preliminary restoration strategies proposed to meet the nitrogen, phosphorous, and sediment TMDL load reduction requirements and improve the water quality in the streams in the City are outlined in this section. These strategies were evaluated using existing City and County GIS data, the City's Capital Improvement Program (CIP), and other relevant data. The approach for identifying potential BMPs involved:

- Conducting an initial desktop analysis to identify potential sites using GIS data including the existing BMP inventory
- Assessing the feasibility of the identified sites based on field reconnaissance
- Developing preliminary rankings to identify high priority sites for concept development
- Selecting high priority sites based on prioritization, engineering judgement, and community input

6.1 Desktop Analysis

The existing data provided by the City of Annapolis was reviewed prior to the field assessment. These data included GIS data for stormwater systems, sanitary sewer lines, water lines, City-owned property, park locations, and 2-foot contour data. Additional GIS information, such as impervious cover and sub-watershed boundaries, was downloaded from Anne Arundel County's GIS website. The existing stormwater management facilities that were digitized as a part of the stormwater management inventory were also used as part of the desktop analysis.

A desktop analysis was conducted to identify potential new and retrofit opportunities for stormwater management facilities. The City also requested an evaluation of three sites that reported drainage problems that are being considered for acquisition by the City.

Sixty-five sites, including the City-requested sites, were selected for field assessment:

- 20 existing stormwater management facilities
- 45 potential new stormwater management facility sites

These sites were then evaluated in the field to assess the feasibility for potential improvements.

6.2 Identification of Stormwater Management Opportunities

Site assessments were conducted at 65 locations in the City to assess stormwater management deficits and identify potential alternatives. This information was documented on field data sheets and photographs, which are provided digitally as Appendix B. Figure 6-1 provides an overview of evaluated site locations.

63 of the 65 sites could be accessed, while two sites were inaccessible because of grading, fencing, or other site constraints. These two sites were not considered feasible locations for stormwater management projects.

For the 63 accessible sites the following information was collected:

- Land-use type of the surrounding drainage area
- Access constraints

- Utilities present
- Potential permits / regulatory approvals required
- Site visibility to public
- Flooding concerns
- Recommendations for the site
- Sketch of the site and potential improvements

Appendix C provides a table summarizing the data from the site assessments. Based on the field investigation, 46 sites were considered to have potential for stormwater management improvements. The remaining 17 sites were not considered appropriate for potential improvements because of significant site constraints (e.g., utilities, major accessibility concerns, small drainage areas). Reforestation or stream restoration is recommended for some sites as an alternative to stormwater management projects. Multiple facilities were proposed at four sites, resulting in 53 potential stormwater improvement opportunities.

The City also requested an evaluation of two properties offered to the City as a donation: one north of Lincoln Drive (owned by the Baldwin Family) and the other potential donation near the intersection of Ridgewood Street and Brewer Avenue (owned by the Schubert Family). The potential water quality benefits for accepting the donation of each site were evaluated. Flooding concerns were also evaluated at Harness Creek View Court and west of McKendree Avenue. Flood mitigations options were proposed at both these sites and are discussed in Section 6.3.

Several restoration projects initiated by the watershed groups and non-profit organizations (Section 2) are currently planned to improve natural resources within the City. Prior to the site assessment the City indicated the following projects in the implementation phase:

- Bywater Stream and Wetland Restoration project at Kingsport City Park (South River Federation)
- Church Creek Headwaters Restoration Allen Apartments Branch Project (South River Federation)
- Street Ends Project (Spa Creek Conservancy)
- Headwaters of Spa Creek Stream Restoration (Spa Creek Conservancy)
- Hawkins Cove Restoration Project (Spa Creek Conservancy)
- Hawkins Cove Restoration Biocell Showcase – Conservation Landscaping (Spa Creek Conservancy)
- Hawkins Cove Reforestation (Spa Creek Conservancy)

To avoid duplication of efforts, areas that overlapped with these projects were not included in this study. The City will work with the Spa Creek Conservancy and the South River Federation to document these projects with MDE to receive water quality credit.

6.3 Flood Mitigation

The goal for the stormwater BMPs proposed as part of this study is to improve water quality to meet the Phase II NPDES MS4 General Permit requirements; however, the City is prioritizing opportunities where stormwater improvements may also address frequent flooding issues. Flood mitigation was taken into

account in the preliminary and concept prioritizations, and the City requested an investigation of specific areas of flooding concerns, including:

- Stormwater management alternatives that improve water quality and may improve flooding were identified during the inspection of the existing Harness Creek View Court wet pond (BMP_14); this retrofit was selected for concept design and is discussed in Section 7.

- The areas west of McKendree Avenue (e.g., S. Cherry Avenue) convey runoff via sheet flow on the road or via roadside swales. Even though this site was not selected for concept design, potential improvements were identified to address flooding concerns include regrading roads where flooding is occurring, installing new swales, upgrading existing swales (e.g., at Corey Lane), or installing a storm drain pipe system. It may be possible to improve water quality by designing any new or upgraded swales to meet MDE guidelines, or by installing offline BMPs (e.g., sand filters or bioretention areas).

The City will continue to identify and prioritize stormwater management options that can mitigate flooding concerns in the City.

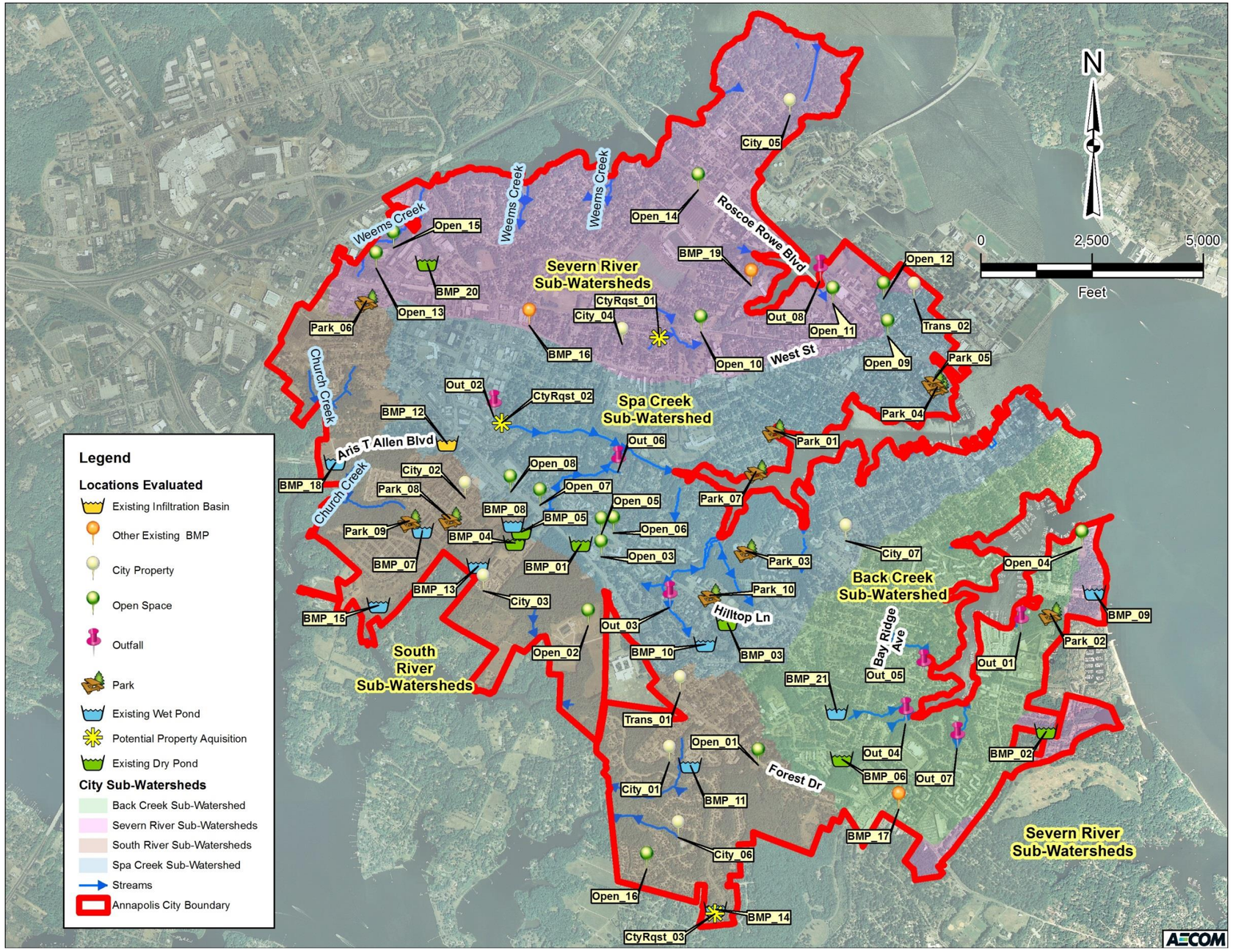


Figure 6-1: City of Annapolis Locations Evaluated during the Fall 2015 Field Investigation

6.4 Preliminary Priority Ranking Matrix

The potential BMPs were prioritized using weighted numeric criteria to support the selection of projects to move forward with the concept design development. The 53 potential improvements were ranked as part of this analysis.

The City requested that the projects be divided for ranking based on their location in the watershed. The groupings are provided in Figure 3-5 and Table 3-1. The preliminary priority ranking matrix with the score for each criterion was provided as part of the Interim Submittal submitted on September 10, 2015 and is not included in this plan.

The summary table for field-assessed sites is shown in Appendix C and includes existing site summary information, proposed restoration measures, and a feasibility assessment. This evaluation was also provided to the City as an Interim Submittal on September 10, 2015 and was presented to the Mayor and City Council on September 17, 2015.

6.5 Community Input

The City selected high priority sites based on the engineering evaluation and feedback from residents. The preliminary results were presented at a public meeting on October 19, 2015, with approximately 40 attendees. The Interim Submittal report was posted on the City's website, and City staff created a web ArcGIS application with information on the sites evaluated in the field including photographs taken during the field reconnaissance.

A web survey was created that allowed residents to identify sites of interest and provide other comments on the Watershed Improvement Plan. Residents chose sites identified during this study as well as other potential projects they thought would provide water quality benefits. When selecting the high priority projects the City considered the potential improvement priority ranking matrix, engineering judgement, and the survey responses from residents.

6.6 Selection of Projects for Conceptual Design

The City selected projects for conceptual design based on the preliminary project prioritization, community input, and engineering judgement. Sixteen sites were selected by the City for concept development and they are discussed in Section 7.

7 Proposed Strategies for NPDES MS4 and TMDL Compliance

To prepare for MDE Phase II NPDES MS4 Permit and TMDL compliance, the City is considering implementation of structural, ESD and alternative urban BMPs. Concept level designs were completed for 16 structural and ESD BMPs and information on alternative urban BMPs that the City may consider in the future are also described below.

7.1 High Priority Structural Practices

The high priority structural practices include retrofits and new BMPs designed to current MDE standards to collect and treat stormwater runoff to remove pollutants through processes such as filtration and infiltration.

7.1.1 Concept Designs

Concept designs were developed for the 16 high priority structural practices selected by the City using the preliminary priority ranking of the potential projects identified in the field, engineering judgment, and community input. These projects included 14 projects identified during the field reconnaissance and 2 projects identified by residents in the web survey. One of the resident identified projects was an existing dry pond without stormwater management plans, and the other was a retrofit to a bioretention that was implemented in 2002. Figure 7-1 shows the locations of the high priority structural practices selected by the City. An additional field investigation was performed for the 2 new projects identified by residents to verify the sites were suitable for a stormwater BMP.

The concept design development package for each high priority site includes:

- A description of the existing site
- A description of the proposed project
- Existing and proposed site condition graphics
- Site photographs
- Water quality volume and pollutant removal estimates
- A feasibility assessment of the solutions
- A description of required plans and permits
- Cost estimates

The feasibility of each proposed solution was assessed by considering:

- **Property Ownership:** Identification of the owner of the property and assessment of potential easements that would be necessary for project construction.
- **Construction Access**: Construction access to the proposed improvement site was identified. The proximity to roads, private property, and potential heavy equipment parking were noted.
- **Utility Conflicts:** Potential utility conflicts, such as water, sewer, electric, cable, and power lines, were identified based on field observations and GIS data.
- **Environmental Impact:** Potential impacts to trees and wetlands were noted.
- **Design/Construction:** Site-specific design/construction considerations.

The conceptual construction costs were developed based on engineering judgment. Typical unit costs are based on contractors' estimates and on unit price data for Anne Arundel County, Maryland and other areas. Costs reflect current rates and geographic conditions. The concept design packages for each high priority site are provided in Appendix D.

7.1.2 Ranking of High Priority BMPs

The 16 concept designs were prioritized using weighted numeric criteria to identify the highest ranked projects. This evaluation was based on the preliminary project ranking criteria but considers the detailed pollutant removal and costs calculated as part of the concept design packages. The details of the evaluation criteria are provided in Appendix E.

The priority ranking matrix with the score for each criterion is provided in Appendix F, with the projects organized by rank. Table 7-1 summarizes the priority rankings. The City may consider including any of these 16 high priority projects for implementation as a part of its CIP.

7.1.3 Estimated Pollutant Reductions and Equivalent Impervious Acres

The *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated* guidance provides MDE-approved pollutant reductions for TN, TP, and TSS based on the runoff depth treated. The documentation also provides loading rates that can be used to estimate the loading to urban areas. Pollutant removal volume was estimated for each of the concept designs using these methods. The total reductions calculated for TN, TP, and TSS are 3,000 pounds, 230 pounds, and 70 tons, respectively. An equivalent impervious area treatment credits of 253 acres are anticipated from the proposed concept designs.

The proposed concept designs were also input into BayFAST, and the pollutant loading and nutrient removal resulting from BayFAST were considerably different from those indicated by MDE. The BayFAST results indicate that the total reductions for TN, TP, and TSS are 1,120 pounds, 220 pounds, and 60 tons, respectively.

For consistency with the Phase II NPDES MS4 permit, only the MDE loading reductions are provided in the concept design report; however, it should be noted that the estimated reductions are lower when using BayFAST when compared to the estimates following the MDE guidance. This discrepancy is based on differences in assumed BMP pollutant reductions. The City will need to meet the requirements specified in the Phase II NPDES MS4 Permit as well continue to track the progress toward meeting the Chesapeake Bay TMDL goals using MDE approved models such as BayFAST.

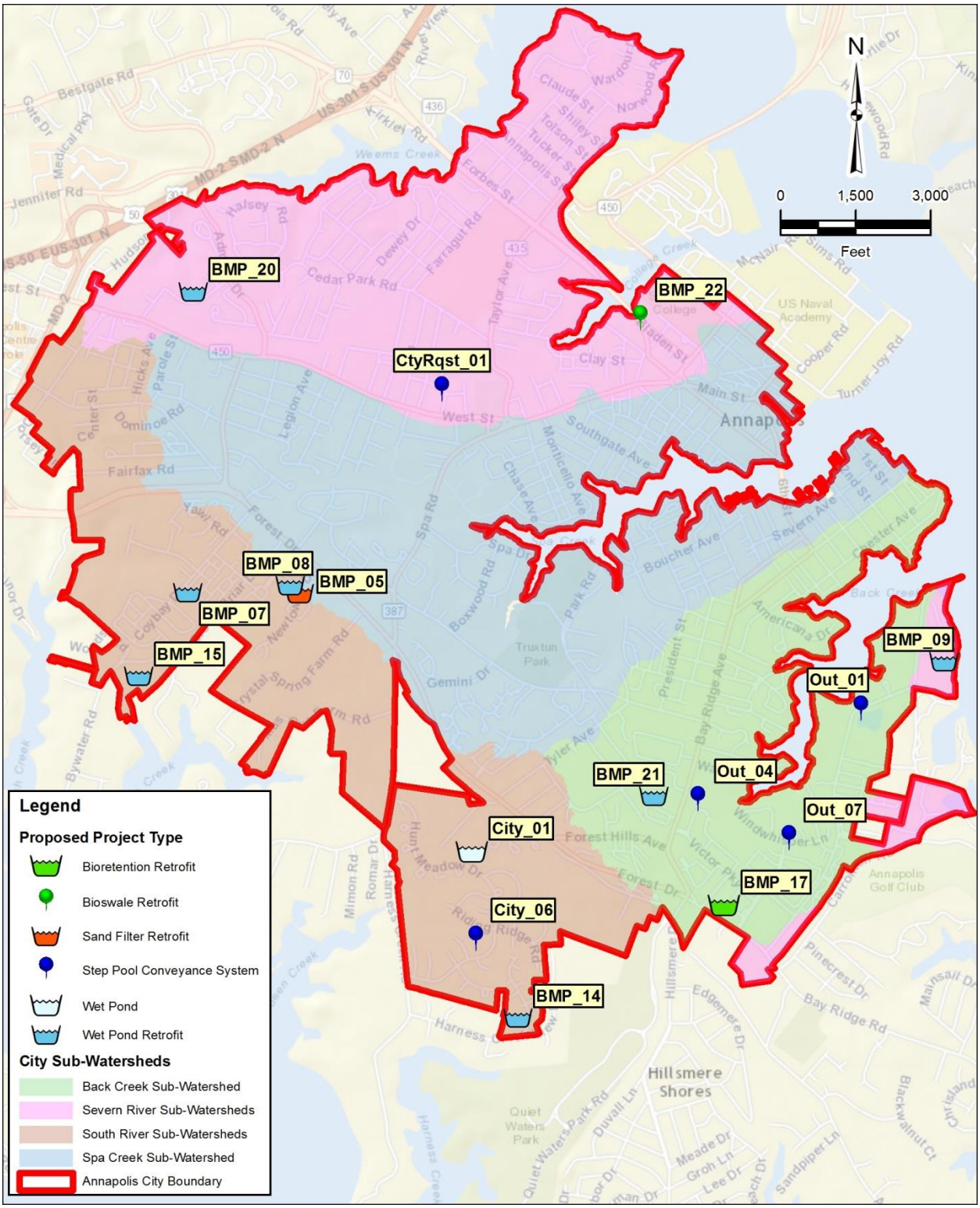


Figure 7-1: Locations of High Priority Sites Selected by the City of Annapolis

Table 7-1: Ranking and Summary of Concept Design Projects

BMP ID	Location	Proposed Project Type	Treated Area (acres)		Pollutant Removal[1]			Construction Cost[2]	Rank
			Total	Impervious	TN (lbs)	TP (lbs)	TSS (tons)		
BMP_15	Southwest of the intersection of Child's Point Road and Woods Road	Wet Pond Retrofit	37.4	14.5	144.4	13.2	4.4	$276,767	1
Out_01	North of Edgewood Road (Osprey Nature Center)	Step Pool Conveyance System	34.6	15.1	230.9	15.5	4.4	$254,084	2
BMP_14	Northwest of the intersection of Harness Creek View Court and Harness Creek View Drive	Wet Pond Retrofit	19.5	5.0	75.3	6.9	2.3	$183,175	3
CtyRqst_01	Northwest of the intersection of Ridgewood Street and Woodlawn Avenue.	Step Pool Conveyance System	82.1	40.0	547.5	36.8	10.3	$918,621	4
BMP_20	North of Moreland Parkway	Wet Pond Retrofit	56.8	39.8	219.0	20.1	6.7	$286,531	5
Out_04	Southeast of the intersection of Timber Creek Drive and Bay Ridge Avenue.	Step Pool Conveyance System	120.7	54.6	805.1	54.2	15.2	$744,906	6
BMP_21	Northwest of the intersection of Langdon Court and Berwick Drive.	Wet Pond Retrofit	55.6	19.2	215.0	20.0	6.6	$119,528	7
Out_07	Northeast of the intersection of Windwhisper Lane and Georgetown Road	Step Pool Conveyance System	55	30.2	367.1	24.7	6.9	$567,470	8
BMP_07	Southeast of the intersection of Coybay Drive and Annapolitan Lane (Annapolis Walk)	Wet Pond Retrofit	19.6	9.5	75.7	6.9	2.3	$234,842	9
City_06	Northwest of the Hunt Meadow Drive Pool Parking Lot	Step Pool Conveyance System	25.3	7.1	232.3	15.6	4.4	$574,665	10

BMP ID	Location	Proposed Project Type	Treated Area (acres)		Pollutant Removal[1]			Construction Cost[2]	Rank
			Total	Impervious	TN (lbs)	TP (lbs)	TSS (tons)		
City_01	Between Tyler Avenue, Hunt Meadow Drive, and Ironstone Court	Wet Pond	16.7	7.4	64.5	5.9	2.0	$248,530	11
BMP_08	5 Cherry Grove Avenue (The Village Greens)	Wet Pond Retrofit	9.1	5.2	35.1	3.2	1.1	$230,027	12
BMP_05	Northeast of the intersection of Juliana Circle East and Newtowne Drive (Riders Glen)	Dry Pond Retrofit to Sand Filter	3.1	1.6	12.0	1.1	0.4	$84,905	13
BMP_22	Between Bloomsbury Square and Rowe Boulevard.	Grass Swale to Bio Swale Retrofit	0.5	0.1	0.4	0.04	0.01	$35,365	14
BMP_09	7101 Bay Front Drive (BayWoods of Annapolis)	Wet Pond Retrofit	4.6	2.9	17.6	1.6	0.5	$93,759	15
BMP_17	914 Bay Ridge Road (Georgetown Plaza)	Bioretention Retrofit	0.7	0.5	2.7	0.2	0.1	$98,757	16
Total	**-**	**-**	**541**	**253**	**3045**	**226**	**68**	**$4,951,900**	**-**

[1] Pollutant calculated using MDE guidance: *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated* (MDE, 2014).
[2] Additional cost of approximately $100,000 for design, environmental services, geotechnical investigation, survey, and permitting is assumed.

TN = total nitrogen
TP = total phosphorus
TSS = total suspended solids
lbs = pounds

8 Alternative Urban BMPs

In addition to the structural BMPs, MDE-approved alternative urban BMPs are important tools for the City to achieve nutrient, sediment, and impervious surface reductions (MDE, 2014). Alternative urban strategies generally do not require detailed design like the structural BMPs and often focus on conservation of natural areas. These strategies are approved by MDE and provide flexibility for jurisdictions in meeting their NPDES MS4 and TMDL goals. The City is already implementing several alternative strategies; however, there are many potential alternative urban BMPs that can be considered for implementation by the City in the future.

8.1 Strategies Currently Adopted by the City

To promote the installation of BMPs on residential and commercial properties, the City offers a reduction of up to a 50 percent of the stormwater utility fee for on-site stormwater management facilities. The facilities must be inspected by City staff to receive the reduction, and commercial properties must have signed maintenance agreements in place.

The City is also working to include stormwater BMPs as part of the Complete Streets program (Anne Arundel County, 2013). The primary goals of the Complete Streets program are to provide bicycle lanes, safe pedestrian access, and vegetated buffers within roadways. The City was awarded a Bronze-level Bicycle Friendly Community award in 2011, and is working toward earning a Silver-level Community award as indicated in its Bicycle Master Plan (Annapolis, 2011). As part of these projects, the City is considering rain gardens, bioretention facilities, and permeable pavements to provide stormwater management. The Complete Streets program can therefore benefit the environment and community by reducing vehicle traffic while also providing BMPs that improve water quality.

The City is also implementing alternative urban BMPs and programmatic measures such as:

- Pet Waste Education: The City currently maintains over 20 biodegradable pet bag units in popular dog walking areas.
- Tree Planting and Giveaways: Since 2007 the City has taken part in tree plantings and has provided trees for residents to plant.
- Erosion and Sediment Control Program: The City requires anyone with a building permit to sign an Erosion and Sediment Control Plan form to promote practices that reduce sedimentation, with fines in place if mud/dirt are found to escape a site.

Public education, outreach, participation, and involvement are all required under the current Phase II NPDES MS4 General Permits and will be included in the next generation permits. The City has engaged the public through the Pet Waste Education and Tree Planting initiatives described above, and through the public meeting conducted as part of this plan.

The City can receive impervious acre credit from MDE for any new BMPs that treat existing impervious area as part of the utility fee reduction program, Complete Streets program (e.g., bioretentions), or tree planting program. Remaining strategies are recognized by MDE and are currently being for their potential water quality benefits.

8.2 Potential Alternative BMPs and Programmatic Strategies

Examples of potential alternative urban BMPs are as follows:

- **Street Sweeping:** There are approximately 130 miles of roadway in the City, so street sweeping may be a feasible alternative urban BMP. The City already conducts street sweeping periodically. However, the current street sweeping program will not receive credits as it does not follow the MDE requirements to be accepted as an alternative urban BMP. According to MDE, both mechanical street sweepers (with mechanical brooms) and regenerative/vacuum sweepers (with vacuum/suction) receive credits from MDE, although sweeping must occur at least twice a month. Mechanical street sweeping results in 0.07 equivalent impervious acre credit per acre swept, while regenerative street sweeping results in 0.13 equivalent impervious acre credits per acre swept. Street sweeping is most effective at removing total suspended solids and can decrease the accumulation of sediments in City streams. Assuming that City road widths are approximately 30 feet on average, the City may be able to receive up to 65 equivalent impervious acre credits for regenerative street sweeping. The cost of conducting street sweeping twice a month and potential parking difficulties for City residents should be considered before implementing this strategy.

- **Urban Tree Planting:** The City is already promoting tree planting as part of its stormwater management program. To receive credits from MDE for tree planting, a survival rate of at least 100 trees per acre is necessary, and 50 percent of the trees must be at least 2 inches in diameter and have a 4.5-foot-tall trunk. Tree planting on pervious urban land results in 0.38 equivalent impervious acre credit per acre of tree planting, while tree planting on impervious urban land results in 1 equivalent impervious acre per acre planted. There likely are not enough tree planting opportunities to earn significant impervious area credits; however, the added benefits of tree planting (e.g., aesthetics, shade, and public awareness) are substantial, and the City is committed to promoting tree planting in the future.

- **Catch Basin Cleaning and Storm Drain Vacuuming:** There are more than 2,000 storm drain inlets in the City and over 50 miles of storm drain pipe. Both catch basin cleaning and storm drain vacuuming physically remove sediment from urban storm drain systems. Credits for catch basin cleaning and storm drain vacuuming are based on the weight of material that is collected and result in 0.04 equivalent impervious acre credit per ton of material removed. In addition to the water quality benefits of removing sediment from the storm drain system, this practice can also increase the conveyance of storm drain pipes that have been clogged by sediment, and can reduce the frequency of nuisance flooding that may be exacerbated by sedimentation. Unlike street sweeping, these two practices do not have to occur at a specific frequency and can be performed as needed. It could be beneficial to perform catch basin cleaning and storm drain vacuuming once throughout the City to evaluate how many equivalent impervious acre credits could be achieved. This strategy may improve conveyance in storm drain pipes and mitigate any local flooding caused by blocked storm drains while providing impervious area treatment credits.

- **Stream Restoration and Outfall Stabilization:** The City and private owners have been engaged in both stream restoration and outfall stabilization projects. Both stream restoration and outfall stabilization improve the stability and ecologic function of streams affected by urban development. During outfall stabilization, localized areas of erosion below storm drain outfalls are repaired, while stream restoration is implemented along a stream reach disturbed by urbanization. Both practices receive 1 impervious acre equivalent credit for every 100 feet of restoration/stabilization, although the maximum credit for outfall stabilization projects is 2 acres. Stream restoration and outfall stabilization can reduce erosion within channels and mitigate

flooding caused by blocked culverts. Stream restoration is also typically well received by the public.

- **Shoreline Management:** The City has several miles of shoreline and may have opportunities for shoreline management (e.g., Living Shorelines). Shoreline management can improve water quality by preventing erosion while also filtering nutrients, and can improve shallow water habitat. Shoreline management can also promote flood mitigation, thereby providing drainage, water quality, and aesthetic benefits. Living shorelines typically use organic materials (e.g., natural vegetation, oyster reefs, and fiber logs) whereas traditional shoreline management typically use stone revetments, bulkhead, and concrete seawalls. Additional information on shoreline management is available from the Chesapeake Bay Foundation at http://www.cbf.org/Document.Doc?id=60. Shoreline management receives 4 impervious acre equivalent credits for every 100 feet of shoreline management.

- **Impervious Urban Surface to Pervious Surface:** The City can receive credit for converting impervious surfaces to vegetated areas. To receive credits from MDE vegetated cover of 95 percent must be established, and 0.75 equivalent impervious acre credits are provided for each acre converted. There are likely limited opportunities within the City for conversion of impervious areas to pervious areas; however, it should be prioritized for impervious areas that are no longer in use.

Table 8-1 summarizes the efficiencies and equivalent impervious acre credits provided by MDE for the alternative urban BMPs discussed.

Table 8-1: Pollutant Removal and Impervious Acre Equivalent Credit from MDE for Alternative Urban BMPs

Alternative Urban BMP	Efficiency per Acre			Impervious Acre Equivalent
	Total Nitrogen	Total Phosphorus	Total Suspended Solids	
Mechanical Street Sweeping	4%	4%	10%	0.07
Regenerative/Vacuum Street Sweeping	5%	6%	25%	0.13
Impervious Urban to Pervious	13%	72%	84%	0.75
Reforestation on Pervious Urban	66%	77%	57%	0.38
Reforestation on Impervious Urban	71%	94%	93%	1.00
Alternative Urban BMP	**Pounds Reduced / Ton**			**Impervious Acre Equivalent**
	Total Nitrogen	**Total Phosphorus**	**Total Suspended Solids**	
Catch Basin Cleaning	3.5	1.4	4	0.40
Storm Drain Vacuuming	3.5	1.4	4	0.40
Alternative Urban BMP	**Ponds Reduced / Linear Feet**			**Impervious Acre Equivalent**
	Total Nitrogen	**Total Phosphorus**	**Total Suspended Solids**	
Stream Restoration	0.075	0.068	15/45	0.01
Outfall Stabilization	Not Applicable	Not Applicable	Not Applicable	0.01
Shoreline Management	0.075	0.068	137	0.04

Source: The values are from Table 7 of *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated* (MDE, 2014).

The document was downloaded in January 2016, and some values have been updated by MDE since the document issuance in August 2014; values may also be subject to change in the future.

- **Incentives for Private Property Owners:** The City already provides incentives to private property owners who install stormwater management structures on their property by providing a discount of 50-percent on their stormwater utility fee. The City can continue to encourage residential and commercial property owners by expanding the incentive programs for implementation of stormwater management features like rain gardens and cisterns. The City could conduct outreach and education programs that would provide instructions for implementing stormwater management BMPs on their properties.

Several alternative urban BMPs do not currently receive credit from MDE but do receive credit from the Chesapeake Bay Program (applicable to BayFAST), including nutrient management plans and urban forest buffers. To receive credit from the Chesapeake Bay Program for nutrient management plans, site-specific nutrient management plans are required that describe how major nutrients are managed to protect water quality. These plans must be updated every 3 years to continue to receive credit. To receive credit from the Chesapeake Bay Program for urban forest buffers, riparian areas must be at least 35 feet wide on one side of a stream and must be managed to promote filtering of runoff. The City is highly urbanized, so the opportunities for new forest buffers are likely limited; however, it may be possible to enhance existing buffers. Both of these practices could be used to meet the TMDLs, although they do not earn equivalent impervious acre credits from MDE.

9 Implementation Plan

The new Phase II NPDES MS4 General Permit is expected to be released shortly, and is anticipated to have rigorous restoration requirements including treatment of 20 percent of existing untreated impervious areas. The City has already taken the first step to meet the upcoming permit requirements by conducting an inventory of existing stormwater management treatment and identifying potential stormwater management projects through this plan. With the challenging NPDES MS4 permit and the Chesapeake Bay TMDL goals, a multi-faceted approach will be required to be adopted by the City that will include implementing structural, ESD and alternative urban BMPs, coordinating with partners and adoption of a flexible approach.

The proposed 16 conceptual designs are anticipated to treat approximately 253 impervious acres and can be added to the City's list of CIP projects. The City's MS4 area includes approximately 1,660 impervious acres with 78.7 impervious acres currently treated; therefore, approximately 316 untreated impervious acres require treatment (20 percent of 1,581 acres). Equivalent impervious area credits of 30 acres from a shoreline management restoration project implemented in 2006 can be counted towards the 316 acres treatment requirement, thereby reducing the amount of impervious area to be treated by the City to 286 acres. Based on these calculations implementing all of the conceptual designs would provide approximately 88.5 percent of the required impervious area treatment; this corresponds with reductions in TN, TP, and TSS that are between 15 percent and 50 percent of the reductions required by the Chesapeake Bay TMDL. The City can also choose the additional projects that are recommended as a part of this plan but not selected for concept design development to be included as a part of their CIP.

Practices implemented in coordination with partners, alternative urban BMPs, and the proposed structural BMPs can be used to meet the NPDES MS4 and the Chesapeake Bay TMDL goals. The increase in the stormwater management facilities will require the City to develop an effective maintenance program to track the functioning of the implemented stormwater management projects and to retain impervious area treatment credits. The City needs to execute a flexible approach that will adjust based on improvements in technology, and from improved scientific understanding of pollutant removal to meet the water quality goals.

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Appendix A
MDE BMP Definitions

Table A-1: MDE Approved BMP Classifications

BMP Code	BMP Category	BMP Code Description	BMP Code	BMP Category	BMP Code Description
AGRE	Environmental Site Design (Alternative Surfaces)	Green Roof – Extensive	IBAS	Structural Practice (Infiltration)	Infiltration Basin
AGRI	Environmental Site Design (Alternative Surfaces)	Green Roof – Intensive	ITRN	Structural Practice (Infiltration)	Infiltration Trench
APRP	Environmental Site Design (Alternative Surfaces)	Permeable Pavements	FBIO	Structural Practice (Filtering Systems)	Bioretention
ARTF	Environmental Site Design (Alternative Surfaces)	Reinforced Turf	FSND	Structural Practice (Filtering Systems)	Sand Filter
NDRR	Environmental Site Design (Nonstructural Technique)	Disconnection of Rooftop Runoff	FUND	Structural Practice (Filtering Systems)	Underground Filter
NDNR	Environmental Site Design (Nonstructural Technique)	Disconnection of Non-Rooftop Runoff	FPER	Structural Practice (Filtering Systems)	Perimeter Sand Filter
NSCA	Environmental Site Design (Nonstructural Technique)	Sheetflow to Conservation Areas	FORG	Structural Practice (Filtering Systems)	Organic Filter (Peat Filter)
MRWH	Environmental Site Design (Micro-Scale Practice)	Rainwater Harvesting	ODSW	Structural Practice (Open Channels)	Dry Swale
MSGW	Environmental Site Design (Micro-Scale Practice)	Submerged Gravel Wetlands	OWSW	Structural Practice (Open Channels)	Wet Swale
MILS	Environmental Site Design (Micro-Scale Practice)	Landscape Infiltration	XDPD	Structural Practice (Other Practices)	Detention Structure/Dry Pond

BMP Code	BMP Category	BMP Code Description	BMP Code	BMP Category	BMP Code Description
MIBR	Environmental Site Design (Micro-Scale Practice)	Infiltration Berms	XDED	Structural Practice (Other Practices)	Extended Detention Structure, Dry
MIDW	Environmental Site Design (Micro-Scale Practice)	Dry Wells	XFLD	Structural Practice (Other Practices)	Flood Management Area
MMBR	Environmental Site Design (Micro-Scale Practice)	Micro-Bioretention	XOGS	Structural Practice (Other Practices)	Oil Grit Separator
MRNG	Environmental Site Design (Micro-Scale Practice)	Rain Gardens	XOTH	Structural Practice (Other Practices)	Other
MSWG	Environmental Site Design (Micro-Scale Practice)	Grass Swale	MSS	Alternative Urban BMPs	Mechanical Street Sweeping
MSWW	Environmental Site Design (Micro-Scale Practice)	Wet Swale	VSS	Alternative Urban BMPs	Regenerative/Vacuum Street Sweeping
MSWB	Environmental Site Design (Micro-Scale Practice)	Bio-Swale	IMPP	Alternative Urban BMPs	Impervious Surface Elimination to Pervious
MENF	Environmental Site Design (Micro-Scale Practice)	Enhanced Filters	IMPF	Alternative Urban BMPs	Impervious Surface Elimination to Forest
PWED	Structural Practice (Ponds)	Extended Detention Structure, Wet	FPU	Alternative Urban BMPs	Planting Trees or Forest on Pervious Urban
PWET	Structural Practice (Ponds)	Retention Pond	CBC	Alternative Urban BMPs	Catch Basin Cleaning
PMPS	Structural Practice (Ponds)	Multiple Pond System	SDV	Alternative Urban BMPs	Storm Drain Vacuuming
PPKT	Structural Practice (Ponds)	Pocket Pond	STRE	Alternative Urban BMPs	Stream Restoration

BMP Code	BMP Category	BMP Code Description	BMP Code	BMP Category	BMP Code Description
PMED	Structural Practice (Ponds)	Micropool Extended Detention Pond	OUT	Alternative Urban BMPs	Outfall Stabilization
WSHW	Structural Practice (Wetlands)	Shallow Marsh	SPSC	Alternative Urban BMPs	Regenerative Step Pool Storm Conveyance
WEDW	Structural Practice (Wetlands)	Extended Detention Wetland	SHST	Alternative Urban BMPs	Shoreline Management
WPWS	Structural Practice (Wetlands)	Wet Pond – Wetland	SEPP	Alternative Urban BMPs	Septic Pumping
WPKT	Structural Practice (Wetlands)	Pocket Wetland	SEPD	Alternative Urban BMPs	Septic Denitrification

Appendix B

Digital Submission - Site Photographs and Field Data Sheets

Appendix C

Preliminary Field Investigation Summary

Table B-1: Back Creek Sub-Watershed Field Investigation Summary

Project ID	Location	Existing Site Conditions	Potential Improvement Project Type	Project Description	Owner	Approximate Drainage Area (Acres)	Approximate Impervious Area (Acres)
BMP_06	Mt. Moriah Church (2204 Bay Ridge Ave)	The church addition and dry pond designed in 1999 were never constructed. A grass area adjacent to the south entrance of the church that currently receiving runoff from a roof drain. No utilities were observed in this grass area.	Rain Garden	Potential improvements at this site include converting the grass area into a rain garden to treat roof runoff. This Environmental Site Design (ESD) practice would reduce runoff while creating an aesthetically pleasing garden that could provide an educational opportunity.	Community (Church, Mosque, etc.)	0.1	0.1
BMP_17	914 Bay Ridge Road (Georgetown Plaza)	This site is an existing infiltration area (riprap area) at the northwest corner of the Georgetown Plaza. Runoff enters the facility from an inlet that captures runoff from a catch basin at the corner of the parking lot. The parking lot is sloped toward the catch basin, and a concrete channel conveys runoff from the east side of an existing mulch island to the west. No utilities were observed in the infiltration area, although one tree was observed southeast of the facility. The infiltration area is surrounded by fence on the east and west sides and a trash enclosure on south. The site is not easily visible from the parking area.	Infiltration Trench or Bioretention Retrofit	Retrofit alternatives at this site include upgrading the existing infiltration area to either an infiltration trench or bioretention. A stilling basin would need to be constructed near the inlet, possibly using existing riprap. The majority of the riprap will need to be removed from the infiltration area, although it could be used to stabilize the slope. Several parking spaces could be used as construction staging areas. The tree adjacent to the existing practice would most likely need to be removed.	Private	0.9	0.6
Out_01	North of Edgewood Road (Osprey Nature Center).	This site is at the outfall on the Osprey Nature Center property, adjacent to the Bert Jabin Yacht Yard. A 36-inch elliptical pipe that conveys runoff from the Annapolis Water Reclamation Facility, and a 24-28-inch elliptical pipe outfall are at this location. Only the larger pipe was identified in the City GIS data. A concrete block and riprap strip are downstream of the larger outfall pipe, and a footbridge is downstream of both outfalls. Approximately 10 trees are in proximity to the stream, and wetland areas may be upstream of the confluence with Back Creek. There is approximately a 4-foot of drop between the outfall and the confluence with Back Creek.	Step Pool Conveyance System	Potential improvements include implementing a step pool conveyance system at this outfall. The existing bridge would need to be temporarily removed during construction, and up to 10 trees could be impacted.	City	33.4	12.2
Out_04	Northwest of Windwhisper Lane	The site is at the northern end of Windwhisper Lane. Due to the existing fencing, steep slopes, and thick vegetation the outfall was inaccessible.	None - Inaccessible	The site was inaccessible; no potential improvements are provided at this site.	Private	Not Applicable	Not Applicable

Table B-1: Back Creek Sub-Watershed Field Investigation Summary

Project ID	Location	Existing Site Conditions	Potential Improvement Project Type	Project Description	Owner	Approximate Drainage Area (Acres)	Approximate Impervious Area (Acres)
Out_05A	Northeast of Tyler Avenue and Janice Drive	The site is in the recreation area of Greenacres north of Janice Drive and leads to an existing dock. Runoff from Janice Drive and nearby properties flow to an 18-inch storm drain pipe under the recreation area that outfalls to Back Creek. There is an existing storm drain manhole in the recreation area, and the open space is bounded to the north and south by residential structures. The entire space has a mild slope, and parts are within 100 feet of the Bay. It appears that vehicles occasionally drive to the existing dock from Janice Drive.	Bioretention	Potential improvements include implementing a bioretention along the southern boundary of the open space by diverting a portion of the flow from the existing storm drain pipe. A flow splitter could be installed at the manholes, and there appears to be approximately 50 linear feet available with an approximate width of 20 feet to implement a bioretention cell. Excavation would be required to set the practice below existing grade, and low vegetation would be recommended to avoid impacting the view from properties to the south. The elevations of the existing manhole and pipe are not available at this time, and the proposed design may not be possible if the invert elevation of the manhole is more than 2 feet below ground surface elevation without additional expense.	Home Owners Association (HOA)	2	0.7
Out_05B	Northeast of Tylder Avenue and Janice Drive	The site is in the recreation area of Greenacres north of Janice Drive that leads to an existing dock. Runoff from Janice Drive flows into an existing inlet, that enters an 18-inch storm drain pipe that outfalls to Back Creek. There is a mulch area with several plants that is surrounded by grass areas near the existing inlet, with a utility pole and a tree nearby. It appears that vehicles occasionally drive to the existing dock from Janice Drive.	Micro-Bioretention	Potential improvements include implementing a micro-bioretention in the existing mulch area and nearby grass areas. A curb cut could be installed adjacent to the existing inlet on Janice Drive, and a weir could be placed at the existing inlet to promote flow into the curb cut. The curb cut would cross under the existing sidewalk allow runoff to enter the micro-bioretention facility. The soils in the area are hydrologic group C so an underdrain may be required that connects to the existing storm drain system. The elevations of the existing manhole and pipe are not available at this time, and the proposed design may not be possible if the invert elevation of the manhole is less than 2 feet below the ground surface elevation.	HOA	0.3	0.3
Out_07	Windwhisper Lane and Georgetown Road	The site is northeast of the intersection of Windwhisper Lane and Georgetown Road at the outfall of a 48-inch RCP pipe. Runoff from nearby residential structures and roadways drain from the outfall to a tributary of Back Creek. A scour pool has developed downstream of the outfall. Gabion baskets are placed along the edges of the stream, with gabion baskets in the stream functioning like a weir. Several trees are in the area, although the stream is wide near the outfall. According to the National Hydrography Dataset (NHD) this stream is not Perennial. The outfall is approximately 500 feet upstream of the existing FEMA 100 year floodplain.	Step Pool Conveyance System	Potential improvements include implementing a step pool conveyance system at this outfall. Approximately 20 to 30 trees could be impacted and sediment and debris would need to be removed from the channel bottom. Permitting for stream and/or wetland impacts would be required.	Private	50	26.7

Table B-1: Back Creek Sub-Watershed Field Investigation Summary

Project ID	Location	Existing Site Conditions	Potential Improvement Project Type	Project Description	Owner	Approximate Drainage Area (Acres)	Approximate Impervious Area (Acres)
Park_02	Ellen O. Moyer Nature Park at Back Creek (Bembe Beach Road and Edgwood Road)	The site is northwest of the intersection of Edgewood Road and Bembe Beach Road in the grass island in the visitor parking lot. The parking area drains to the grass island, and a grass swale flows to an 18-inch culvert that leads to another swale that eventually flows into Back Creek. The existing culvert is covered with riprap, most likely impeding flow. A sewer line crosses the grass island towards the northeast, and a single tree is in the island.	Dry Swale Retrofit to Bioswale	Potential stormwater improvements at this site include upgrading the existing swale to a bioswale to meet current MDE standards or implementing a linear micro-bioretention cell. Curb cuts with pea gravel flow dissipaters would be provided as needed. One tree may need to be removed to construct the facility.	City	0.6	0.3

Table B-2: Severn River Sub-Watersheds Field Investigation Summary

Project ID	Location	Existing Site Conditions	Potential Improvement Project Type	Project Description	Owner	Approximate Drainage Area (Acres)	Approximate Impervious Area (Acres)
BMP_02	1013-1075 Blackwell Road	This site is at an existing extended detention dry pond at the end of Blackwell Road. According to the site plans the pond collects runoff from Blackwell Road and adjacent houses via a curb cut and storm drain pipe. The pond has significant vegetation growth, including several trees, and is surrounded by a fence. No utilities were observed in the pond, and hydrologic group C soils are in the area. It had rained the day before the field work and there was no evidence of ponding water; therefore, the infiltration rate of the pond may be higher than is typical for hydrologic group C soils.	Dry Pond Retrofit to Infiltration Basin	Retrofit alternatives at this site include implementing an infiltration basin if soil tests provide evidence that the soil is permeable enough for infiltration practices. A berm is proposed near the inlet to create a sediment forebay, and the entire pond area would need to be cleared of vegetation. The riser would need to be modified to treat the water quality volume.	Home Owners Association (HOA)	4.4	2.0
BMP_09	7101 Bay Front Drive (BayWoods of Annapolis)	This site is at an existing wet pond north of the BayWoods of Annapolis Commons and Service building. The wet pond collects runoff from the BayWoods buildings and parking areas from a 21-inch Acrylonitrile Butadiene Styrene (ABS) pipe that enters the pond from the South. Runoff leaves the pond via a low flow pipe to the north and during high flows from an overflow weir with gabions downstream. The pond is surrounded by ornamental plants and is well maintained. There is a foot bridge crossing the pond, a fountain toward the north, and an aerator to the south. This pond is highly visible to the BayWoods community.	Wet Pond Retrofit	Retrofit alternatives at this site include upgrading the existing pond to meet current MDE standards. A berm or wall would be required to create a sediment forebay. The structure may need to be modified slightly to treat the water quality volume. The aesthetics of this pond would have to be maintained, possibly by placing the forebay divider under the existing bridge. The bridge would most likely need to be temporarily moved during construction, and the existing aerator may need to be moved.	Community (Private Cooperative)	12.4	2.5
BMP_16	Northwest of Legion Avenue and West Street (Public Storage West Street)	The site is between a Public Storage facility and an office complex north west of Legion Avenue and West Street. An existing infiltration trench is behind the offices that collects rooftop runoff from the offices. The runoff from Public Storage facility appears to connect directly to the existing storm drain system.	Infiltration Trench	Retrofit alternatives at this site include implementing an infiltration trench upstream of the existing facility to capture runoff from the Public Storage facility. The existing infiltration trench could be upgraded to meet current standards during construction of the proposed new facility. Rooftop disconnects are another alternative at this site.	Private	1.4	1.2
BMP_19	Northwest of Adams Park Road	The site is an existing swale northwest of Adams Park Road, between a school parking lot and residences. The residential property lines are unclear, and homeowners are using the swale area for storage, a treehouse, a chicken coop, etc.	Dry Swale Retrofit	Retrofit alternatives at this site include upgrading the existing swale to a bioswale or infiltration trench. Several trees may be impacted by construction, and the stored items would likely need to be removed.	Private (Multiple Properties)	2.1	1.0
BMP_20	Northwest of Moreland Parkway	The site is an existing wet pond adjacent to a parking lot northwest of Moreland Parkway. The facility collects runoff from the office/industrial complex and has a 60-inch pipe inflow. Water outfalls through large gabion weir without a riser.	Wet Pond Retrofit	Retrofit alternatives at this site include upgrading the existing wet pond to meet current MDE standards. The footprint of the pond would need to be increased substantially, and a berm would be required to create a sediment forebay at the inflow pipe. A riser structure would be required to provide treatment for the water quality volume. Up to 50 trees may be impacted by construction. Wetland permitting would most likely be required at this site, although the site also has potential for constructed wetlands.	Unknown Ownership	54.0	38.0

Table B-2: Severn River Sub-Watersheds Field Investigation Summary

Project ID	Location	Existing Site Conditions	Potential Improvement Project Type	Project Description	Owner	Approximate Drainage Area (Acres)	Approximate Impervious Area (Acres)
City_04	Glen Avenue (Municipal Other)	The site is an open grass area between two residences at Glen Avenue and Beech Street. A 60-inch pipe runs through the site, and there is a manhole located within the grass area.	None - No Feasible	No feasible stormwater management alternatives at this location.	City	Not Applicable	Not Applicable
City_05	Southeast of Claude Street and Giddings Avenue (Municipal Public Work Property)	The site is at an existing outfall in a public works right-of-way southeast of Claude Street and Giddings Avenue. The site is adjacent to Naval Academy housing. The existing outfall is an approximately 48-inch end section. Downstream from the end section there is a scour hole and 3-to-5-foot eroded banks extending 75 feet downstream.	Step Pool Conveyance System	Potential improvements include a step pool conveyance system to improve the outfall channel. Limited space, steep slopes, and heavy brush surrounding the site may cause access and construction issues. Up to 10 trees would be impacted by construction at this location.	City	32.0	12.7
CtyRqst_01	Ridgewood Street and Brewer Avenue	The site is on Ridgewood and Brewer Avenue. The site is the Schubert property and a potential donation. There is an outfall with a scour hole and channel with minor erosion along the banks for approximately 100 feet downstream of the outfall.	Step Pool Conveyance System	Potential improvements include creating a step pool conveyance system in the channel, or stream restoration. Both practices would improve the water quality of College Creek.	Schubert Family, Possible Donation	48.0	21.0
Open_04	South of Bay Front Drive and Bembe Beach Rd	There is an open grass area adjacent to Bembe Beach Road. The grade of Bembe Beach Road does not promote drainage to the open area.	None - Reforestation	This is a potential reforestation area, but will not be considered for conceptual design.	Private	Not Applicable	Not Applicable
Open_10	East of Lowes Access Road and Taylor Avenue	The site is in an open area east of Lowes Access Road and Taylor Road. A catch basin is in the center of the grass area that collects runoff from adjacent building. Fiber optic utility wires were observed on site.	Bioretention	Potential improvements at this site include implementing a filtration practice. The area would need to be re-graded and reconnected to upstream and downstream pipes.	Private (Trust)	3.5	1.6
Open_11	North of Calvert Street and Roscoe Rowe Boulevard	The site is at a Fire/Rescue memorial near the intersection of Calvert Street and Roscoe Rowe Boulevard. One inlet in a grass area collects runoff from the memorial area and some runoff from Roscoe Rowe Boulevard. The memorial is primarily composed of brick walking areas surrounded by grass areas.	Micro-Bioretention	Potential improvements include a micro-bioretention southwest of the existing brick area. The soils are hydrologic group B so an underdrain likely would not be required, and the practice and the existing yard inlet could be used as a riser structure.	State	0.1	0.1
Open_13	Southwest of Capital Drive	The site is southwest of Capital Drive adjacent to the Capital newspaper office parking lot. The site is an open grassy area about 500 feet long and 75 feet wide. A forested area is adjacent to the open area.	None - Reforestation	This is a potential reforestation area, but will not be considered for conceptual design.	Private (LLC)	Not Applicable	Not Applicable
Open_14	Southeast of Farragut Road and Roscoe Rowe Boulevard	The site is an open field next to Anne Arundel County District Courts building on the corner of Roscoe Rowe Boulevard and Farragut Road. An existing storm drain system is in the area. Inlets on walkways at the court building flow downhill to connect to inlets from the court building parking lot, connecting to the storm drain system in the Navy Stadium parking lot.	Bioretention	The site is very large and could accommodate either a large reforestation project or a stormwater management facility in addition to reforestation. An aesthetically-pleasing filtering practice (e.g., a bioretention) or a pond could be implemented in the area. The practice would receive drainage from the inlets along the court building walkway. The outlet would tie-in to the downstream storm drain at the parking lot area.	State	2.9	0.7

Table B-2: Severn River Sub-Watersheds Field Investigation Summary

Project ID	Location	Existing Site Conditions	Potential Improvement Project Type	Project Description	Owner	Approximate Drainage Area (Acres)	Approximate Impervious Area (Acres)
Open_15	Northeast of Capital Drive	This site is adjacent to The Capital building. A large grassy embankment is along the rear parking lot. Downstream there is an inlet and outfall and a stream channel that is a tributary of Weems Creek.	None - Reforestation	This is a potential reforestation area, but will not be considered for conceptual design.	Private	Not Applicable	Not Applicable
Park_06	Chambers Park (North of Dorsey Avenue)	The site is at a City park north of Dorsey Ave. The park contains playgrounds, a basketball court, and multiple educational displays for rain barrels and rain gardens.	Bioswale	There may be room for a small bioswale at the south side of the park between the fence and basketball courts. There is an existing inlet at the corner of the basketball court that bioswale could convey flow to. Two recently planted trees are in this area that may be impacted. A bioswale could provide an educational opportunity, but would reduce open space within the park.	City	0.7	0.5

Table B-3: South River Sub-Watersheds Field Investigation Summary

Project ID	Location	Existing Site Conditions	Potential Improvement Project Type	Project Description	Owner	Approximate Drainage Area (Acres)	Approximate Impervious Area (Acres)
BMP_04	Juliana Circle West and Newtowne Drive (Riders Glen)	This site is at an existing dry pond at the intersection of Juliana Circle and Newtown Drive, in a parking lot for adjacent townhomes. The existing facility collects runoff from the parking lot. Several small trees are in or adjacent to the existing facility.	Dry Pond Retrofit to Pocket Wet Pond or Infiltration Basin	Retrofit alternatives at this site include upgrading the existing pond into a pocket pond or infiltration basin depending on the soil type and water table elevation. A berm would be required to create a stilling basin at the inlet pipe. The entire pond area would need to be cleared of vegetation, and it appears that a riser structure would need to be installed to manage the water quality volume.	Home Owners Association (HOA)	1.6	1.0
BMP_07	Southeast of Coybay Drive and Annapolitan Lane (Annapolis Walk)	The site is at an existing wet pond southeast of Coybay Drive and Annapolitan Lane. The pond receives runoff from the adjacent neighborhood. The water surface is covered with algae, and the riser structure appears to be in good condition.	Wet Pond Retrofit	Retrofit alternatives at this site include upgrading the existing wet pond to meet current Maryland Department of the Environment (MDE) standards. A berm would be required to create a sediment basin at the inlet pipe. Minimal changes would be required to the low flow or high flow structures.	HOA	19.7	6.6
BMP_08	5 Cherry Grove Avenue (The Village Greens)	The site is at an existing wet pond along Cherry Grove Avenue, across from the Village Greens shopping center. The pond was upgraded in 2001 from a dry pond. A new townhome development is under construction on the other side of the pond, including stormwater management ponds. The drainage area to this facility may be reduced due to new construction; however, the drainage area is still expected to include over 2 impervious acres. The facility is surrounded by trees and is covered with vegetation.	Wet Pond Retrofit	Retrofit alternatives at this site include upgrading the existing wet pond to meet current MDE standards. A berm would be required to create a sediment basin at the inlet pipe. The structure may need to be modified to treat the water quality volume.	Private	10.4	7.0
BMP_11	Cobblestone Drive (Annapolis Overlook Parking Lot)	The site is at an existing wet pond on Cobblestone Drive behind the Annapolis Overlook apartment complex. The pond collects runoff from the adjacent parking roof areas. The low flow orifice of the riser is blocked, although the riser appears to be in good condition. A retaining wall is on pond embankment along the apartment buildings.	Wet Pond Retrofit	Retrofit alternatives at this site include upgrading the existing wet pond to meet current MDE standards. A berm would be required to create a sediment basin at the inlet pipe. The structure may need to be modified slightly to treat the water quality volume. Dam permitting will most likely be required based on the size of the facility.	Private	32.8	18.2
BMP_13	South Cherry Grove Avenue (Village Green)	The site is southwest of South Cherry Grove Avenue. The site could not be accessed during the field investigation.	None - Inaccessible	The site was inaccessible; no potential improvements are provided at this site.	Private	Not Applicable	Not Applicable
BMP_14	Harness Creek View Court	The site is an existing wet pond at Harness Creek View Court. The pond receives runoff from the nearby residential area along Harness View Creek Court up to Potters Lane. The outfall is a large riprap lined ditch that extends approximately 200 feet downstream. A large vegetated mound is in the center of the pond. A fence circles the pond and several trees are on the embankment. The City indicated that there are flooding concerns at this location.	Wet Pond Retrofit	Retrofit alternatives at this site include upgrading the existing wet pond to meet current MDE standards. A berm would be required to create a sediment forebay toward the eastern end of the pond. Minimal changes would be required to the low flow or high flow structures. Up to 20 trees may be impacted by construction, including several growing on the pond embankment. The volume of the pond could be increased to reduce flooding, and catch basins or swales could be implemented in areas where localized flooding is occurring.	HOA	25.3	16.5

Table B-3: South River Sub-Watersheds Field Investigation Summary

Project ID	Location	Existing Site Conditions	Potential Improvement Project Type	Project Description	Owner	Approximate Drainage Area (Acres)	Approximate Impervious Area (Acres)
BMP_15	Southwest of Child's Point Road and Woods Road	The site is an existing wet pond in a residential area southwest of Childs Point Road and Woods Road. According to City GIS, the pond is owned by the City; however, this site may be HOA owned. The pond has some algae on the water surface. The riser structure appears to be in good condition. The inflow is mostly submerged.	Wet Pond Retrofit	Retrofit alternatives at this site include upgrading the existing wet pond to meet current MDE standards. A berm would be required to create a sediment basin at the inlet pipe. The structure may need to be modified to manage the water quality volume and to prevent the inflow pipe from being submerged during normal conditions.	City	49.0	23.3
BMP_18	South of Aris T Allen Boulevard and Vineyard Road	This site is an existing wet pond on Vineyard Road and Aris T. Allen Boulevard. This site is most likely owned by SHA, although the City GIS listed the parcel owner as "Unknown" at this location, and plans were not available for this site. The site is heavily overgrown, and inflows were not found in the field, although a storm drain pipe is located along Aris T. Allen Boulevard. The pond is covered by a thick layer of green algae.	Wet Pond Retrofit	Retrofit alternatives at this site include upgrading the existing wet pond to meet current MDE standards. A berm would be required to create a sediment forebay at the inflow pipe. Based on the existing conditions of the pond substantial changes to the riser structure are expected. Up to 10 trees may be impacted by construction, including several growing on the pond embankment.	SHA	5.0	1.3
City_01	Forest Drive (Municipal Housing Authority)	The site is on Tyler Avenue adjacent to a housing development on Forest Drive. Currently, the site is an open area with a storm drain pipe crossing an open field and flowing to a ditch behind the development beyond the utility easement.	Wet Pond or Sand Filter	Potential improvements include a wet pond in the empty space between the stream and the basketball courts. The outfall from pond would be at existing storm drain outfall, and the downstream channel would need to be repaired. This channel is behind three layers of fencing. The soils in the area appear to be hydrologic group D and the drainage area appears to be over 10 acres so infiltration and filtration practices were not considered.	City	17.8	6.9
City_02	Belle Court (Parks and Recreation)	The site is on Belle Court in an open area behind townhomes and parking lot. Yard inlets are in the open space, and they appear to only collect roof drainage.	Bioretention	Potential improvements include a bioretention that could be placed in the open area to collect roof runoff. The existing yard inlet could be retrofit to provide an overflow to the existing storm drain system.	City	0.7	0.3
City_03	Betsy Court (Municipal Housing Authority)	The site is on the Besty Court municipal housing property. Currently, a storm drain pipe end section outfalls to a riprap channel. The channel and end section are almost completely filled in with sediment. A large earthen berm is downstream from the outfall.	Infiltration Basin	Potential improvement includes removing the riprap channel and replacing it with an infiltration basin or filtering practice. There is a relatively large grass area where a practice could be installed. The soils in the area appear to be hydrologic group C, so further soil investigation would be required to verify the suitability of an infiltration practice.	City	1.9	1.2
City_06	Hunt Meadows Drive (Municipal Other)	The site is at an outfall of a 42-inch pipe to Aberdeen Creek behind a pool parking lot on Hunt Meadows Drive. Erosion along the banks and sedimentation downstream were observed. A trail and several footbridges are along the channel, and trees and brush are along the banks of the stream channel.	Wet Pond or Step Pool Conveyance System	Potential improvements include installing a wet pond at the outfall. This could be done without impacting the trail but would cause impacts to trees. A step pool conveyance is another potential retrofit at this location. Stream and/or wetland permits would likely be required for any projects in this area, and up to 50 trees would be impacted.	City	27.0	9.7
CtyRqst_03	Harness Creek View Court	This site is at Harness Creek View Court. See BMP 14.	None - Stream Restoration	See Discussion for BMP 14. No additional stormwater management projects are recommended at this location.	HOA	Not Applicable	Not Applicable

Table B-3: South River Sub-Watersheds Field Investigation Summary

Project ID	Location	Existing Site Conditions	Potential Improvement Project Type	Project Description	Owner	Approximate Drainage Area (Acres)	Approximate Impervious Area (Acres)
Open_01	Southwest of Forest Drive and Martha Court	The site is on a roadside easement along Forest Drive across from a cemetery. A steep vegetated slope is between the roadway and the site, and overhead utility lines run over the site. A sewer line and structure/vent are also in the proposed Best Management Practice (BMP) site.	Micro-Bioretention	There are many utility conflicts in this area but a small micro-bioretention may be feasible depending on the exact locations of the utilities. The facility would receive road runoff and outlet to a downstream drainage ditch.	City	0.2	0.2
Open_02	North of Masque Farm Road	The site could not be accessed during the field investigation.	None - Inaccessible	The site was inaccessible; no potential improvements are provided at this site.	Private (Horse Farm)	Not Applicable	Not Applicable
Open_16	Northeast of Centerfield Road and Hunt Meadow Drive	This site is northeast of Centerfield Road and Hunt Meadows Drive in an open space adjacent to community tennis courts. A storm drain system is along Hunt Meadows Drive, and a manhole is in the roadway that is adjacent to the site.	Bioretention	Runoff could be rerouted from the storm drain to a filtering practice such as a bioretention. A flow diverter could be installed at the northern inlet to split the water quality volume to the bioretention. Several trees are between the manholes on Hunt Meadows Drive and the open space and may be impacted. The outlet for the BMP would tie back into existing storm drain along Canterfield Road or Hunt Meadow Drive.	HOA	2.0	0.9
Park_08	Annapolis Walk Park (Annapolis Walk Drive)	This site is at an open area in Annapolis Walk Park, on Annapolis Walk Drive. Two grass ditches convey drainage to a yard inlet between playground and tennis courts	Dry Swale to Bioswale Retrofit	Potential improvements include retrofitting the existing swales to bioswales. Safety fencing would be required.	City	0.7	0.4
Park_09	Kingsport City Park (West of Bywater Road)	This site is west of Bywater road at an existing 54 inch pipe outfall in a wooded area adjacent to Kingsport City Park. The downstream channel is eroded and there is evidence of previous outfall stabilization. The outfall is surrounded by large trees. It appears that this site will be included in the Bywater Stream and Wetland Restoration performed by the South River Federation.	CIP	This is the location of a future stormwater management project, so no additional stormwater management projects are required at this site. Prior to the field investigation there was some uncertainty as to the exact locations of the proposed projects, but the location was verified following the field investigation.	City	Not Applicable	Not Applicable
Trans_01	Rosecrest and Arborhill Road	This site is on Rosecrest Drive and Arborhill Road, and is the median of Rosecrest Road. Currently, the median is curbed. Stormwater is conveyed down Rosecrest Drive and towards Forest Drive. The median has three trees.	None - No Feasible	No feasible stormwater management alternatives at this location.	City	Not Applicable	Not Applicable

Table B-4: Spa Creek Sub-Watershed Field Investigation Summary

Project ID	Location	Existing Site Conditions	Potential Improvement Project Type	Project Description	Owner	Approximate Drainage Area (Acres)	Approximate Impervious Area (Acres)
BMP_01	1120 Spa Road (St. Martins Lutheran Church)	This site is at an existing dry pond northwest of St. Martins Lutheran Church. The pond collects runoff from the roof of nearby church buildings and has a single inlet. The outlet structure includes a low flow pipe and a concrete riser with a grate inlet that drains to a stormdrain pipe under Forest Drive. No utilities were observed in the pond, and there are two small ornamental trees.	Bioretention	Retrofit alternatives at this site include implementing a bioretention facility in the existing pond footprint. A berm is proposed near the inlet to create a sediment forebay. The low flow pipe of the existing riser would need to be blocked, but the grate inlet could remain to provide overflow control for the bioretention. The soils in the area are hydrologic group C, so an underdrain would most likely be required.	Community (Church, Mosque, etc.)	1.1	0.3
BMP_03	Milkshake Lane	The site is east of Milkshake Lane near the intersection with Hilltop Lane. According to the site plans, the pond collects runoff from properties to the south via a swale, with overflow flowing north out of a 4-inch polyvinyl chloride (PVC) pipe. The pond has significant vegetation growth including several trees. No utilities were observed in the pond, and hydrologic group C soils are in the area; however, infiltration practices are located nearby indicating that the soils may be suitable for infiltration.	Infiltration Basin Retrofit	Retrofit alternatives at this site include implementing an infiltration basin if soil tests provide evidence that the soil is permeable enough for infiltration practices. The existing swale may need to be re-graded, and a berm is proposed near the entrance to the pond to create a stilling basin. The entire pond area would need to be cleared of vegetation, and it appears that a riser structure would need to be installed for volume control.	Private	1.7	0.2
BMP_05	Northeast of Juliana Circle East and Newtowne Drive (Riders Glen)	This site is at an existing dry pond at the intersection Juliana Circle East and Newtowne Drive, in a parking lot for adjacent townhomes. No storm drain is shown on the City's GIS data, but storm drain pipe was found in the field and site plans. The entire pond is covered in light vegetation, although there are no trees.	Dry Pond Retrofit to Sand Filter or Wet Pond	Retrofit alternatives at this site include upgrading the existing pond into a sand filter or wet pond. A berm would be required to create a sediment basin at the inlet pipe. The entire pond area would need to be cleared of vegetation, and a riser structure would need to be installed to treat the water quality volume.	Home Owners Association (HOA)	7.5	4.8
BMP_10	Meridian Nursing Center (Milkshake Ln and Hilltop Ln)	The site is at an existing wet pond west of Meridian Nursing Center. The wet pond collects runoff from the Meridian Nursing Center building and parking from a 27-inch reinforced concrete pipe (RCP) pipe at the eastern end of the pond. A chain link fence, brush, and large trees surround the pond. A walking path is along the south of the pond, and the existing riser does not appear to require repairs. No utilities were observed in the pond, and the pond is not visible to the public.	Wet Pond Retrofit	Retrofit alternatives at this site include upgrading the existing wet pond to meet current MDE standards. A berm would be required to create a sediment forebay toward the eastern end of the pond The structure may need to be modified slightly to treat the water quality volume. Up to 20 trees may be impacted by construction, including several growing on the pond embankment.	Private	5.0	2.2

Table B-4: Spa Creek Sub-Watershed Field Investigation Summary

Project ID	Location	Existing Site Conditions	Potential Improvement Project Type	Project Description	Owner	Approximate Drainage Area (Acres)	Approximate Impervious Area (Acres)
BMP_12	Tuckahoe Creek Court (Oxford Landing Section III)	This site is at an existing infiltration basin adjacent to Forest Drive northeast of Tuckahoe Creek Court. The basin collects runoff from the Oxford landing residential area to the south from two 15-inch RCP pipes that enter the basin from the southwest and southeast. The infiltration basin is on a State Highway Administration (SHA) stormwater easement, and was observed to have standing water. The pond is surrounded by dense vegetation including several large trees, and was difficult to access. The riser structure could not be observed in the field but was identified from aerial imagery. No utilities were observed in the basin, and the basin is not visible to the public.	Infiltration Basin Retrofit	Retrofit alternatives at this site include upgrading the existing infiltration basin to meet current MDE standards. Two berms would be required to create two stilling basins at each inlet pipe. The structure may need to be modified to treat the water quality volume. Up to 36 trees may be impacted by construction, and the entire pond area would most likely need to be excavated to remove fine sediments. Soil tests will be required to verify that an infiltration basin is appropriate: if it is not, a wet pond could be constructed (possibly with some infiltration capacity). The sewer easement south of the pond could be used as a staging area, although the area is partially vegetated. Due to the size of the facility and proximity to Forest Drive and nearby properties, dam safety issues will need to be considered.	SHA	10.9	7.0
City_07	Madison Street (Municipal Housing Authority)	This site is the location of several future Capital Improvement Projects. As a result, this site was not considered as part of this study.	CIP	This site is the location of several future Capital Improvement Projects. As a result, this site was not considered as part of this study.	City	Not Applicable	Not Applicable
CtyRqst_02	North of Lincoln Drive	The City requested that this site be considered. The Spa Creek Conservancy will perform a stream restoration in the area, and the Baldwin family would like to donate the property to the City. During the AECOM field investigation, it was observed that the channel is full of thick vegetation, and the channel thickness varies from 2- to 10-feet wide. Both these factors are likely impeding flow. The slope of the stream is relatively flat in this area. Several residential structures are adjacent to the stream.	None - Stream Restoration	The City has indicated that there are some flooding issues upstream of this stream, and based on preliminary field investigation, it was observed that lack of maintenance of the existing channel could be exacerbating the problem. Stream restoration could be the best option for receiving impervious area credit at this outfall due to the existing grading, and the proximity to adjacent residential structures.	Baldwin Family	Not Applicable	Not Applicable
Open_03	Northwest of the intersection of Forest Drive and Spa Road (Saint Martin's Lutheran Church)	The site is northwest of the intersection of Forest Drive and Spa Road. There is a fenced-in open grass area that is entirely made up of sports fields.	None - No Feasible	No feasible stormwater management alternatives at this location.	Community (Church, Mosque, etc.)	Not Applicable	Not Applicable
Open_05	West of Hilltop Lane and Spa Road	This site is southwest of the intersection of Hilltop Lane and Spa Road. A rain garden is adjacent to the St. Martins Lutheran Church driveway.	None - Reforestation	This is a potential reforestation area and will not be considered for conceptual design.	Community (Church, Mosque, etc.)	Not Applicable	Not Applicable

Table B-4: Spa Creek Sub-Watershed Field Investigation Summary

Project ID	Location	Existing Site Conditions	Potential Improvement Project Type	Project Description	Owner	Approximate Drainage Area (Acres)	Approximate Impervious Area (Acres)
Open_06A	East of Hilltop Lane and Spa Road	This site is northeast of the intersection of Hilltop Lane and Spa Road. An existing inlet on Hilltop Lane intercepts runoff from the road. No utilities were observed in the grass area, and this area has high visibility from Hilltop Lane and Spa Road.	Micro-Bioretention	Potential improvements at this site include installing a micro-bioretention facility in the grass open space. This would require curb cuts upstream and downstream of the existing inlet and partially blocking the existing inlet using a weir. The soils in the area are hydrologic group C so an underdrain would most likely be required. Aesthetically pleasing plantings are recommended due to the visibility of this site, although trees should be avoided to prevent impacting visibility.	Community (Church, Mosque, etc.)	0.3	0.3
Open_06B	East of Hilltop Lane and Spa Road	This site is northeast of the intersection of Hilltop Lane and Spa Road. No storm drain inlets are along Spa Road at the intersection, so runoff travels toward the intersection. A water line is observed at this location, but it can easily be avoided. This area has high visibility from Hilltop Lane and Spa Road.	Micro-Bioretention	Potential improvements at this site include installing a micro-bioretention facility in the grass open space. This would require several curb cuts upstream and downstream of the existing inlet. The soils in the area are hydrologic group D, so an underdrain would be required. Aesthetically pleasing plantings are recommended due to the visibility of this site, although trees should be avoided to prevent negatively impacting visibility. This practice could be constructed entirely in the road right-of-way.	City	0.5	0.5
Open_07	North of Forest Drive and Newtowne Drive	This site is southeast of the Heritage Baptist Church. There are several grass areas with intermittent trees, as well as what appears to be a micro-bioretention. It appears that runoff from a portion of the church and the parking area enters the facility from a curb cut. Plans for the facility could not be located.	None - Reforestation	This is a potential reforestation area and will not be considered for conceptual design.	Community (Church, Mosque, etc.)	Not Applicable	Not Applicable
Open_08	Northwest of Forest Drive and South Cherry Grove Avenue	The site is an existing infiltration trench southwest of the intersection of Forest Drive and Greenbriar Lane. Runoff from Greenbriar Lane and a portion of the adjacent parking lot enters the facility from an 18-inch pipe. The trench includes a concrete overflow structure and geotextile over a gravel layer. An electric pole is adjacent to the facility. The site is in the road right-of-way, and the practice is visible to the public. It appears that the facility may be over hydrologic group D soils, although soil tests would be required to verify.	Infiltration Trench Retrofit	Potential alternatives at this site include upgrading the existing infiltration trench to meet current MDE standards. A berm is proposed near the inlet to create a stilling basin, providing pretreatment for the runoff.	City	0.25	0.25
Open_09	Center of State Circle	The site is a mulch area adjacent to the northeastern corner of the Maryland State House (near the intersection of North Street and State Circle). An existing roof drain connects directly to a metal pipe that appears to be directed to an existing storm drain system (data was unavailable at this location). The existing mulch area has several bushes and ornamental plants.	Rain Garden	Potential improvements at this site include disconnecting the existing roof drain and converting the mulch area into a rain garden to treat roof runoff. This ESD practice would reduce runoff while creating an aesthetically pleasing garden. This is in a highly visible area with high foot traffic, so an educational sign explaining the reasons for a rain garden and its benefits would be beneficial.	State	0.05	0.05

Table B-4: Spa Creek Sub-Watershed Field Investigation Summary

Project ID	Location	Existing Site Conditions	Potential Improvement Project Type	Project Description	Owner	Approximate Drainage Area (Acres)	Approximate Impervious Area (Acres)
Open_12A	Saint John's Campus: Pinkney Hall	The site is a mulch area adjacent to the northeastern face of Pinkney Hall, at the southeastern corner of the building. The existing roof drain conveys runoff to a splash block that directs flow onto the mulch. There was some evidence of erosion in the mulch area.	Rain Garden	Potential improvements at this site include converting a portion of the mulch area into a rain garden to treat roof runoff. This ESD practice would reduce runoff while creating an aesthetically pleasing garden that could provide an educational opportunity.	Community (Private School)	0.05	0.05
Open_12B	Saint John's Campus: Pinkney Hall	The site is a mulch area adjacent to the northeastern face of Pinkney Hall between the two entrances to the building. Two roof drains are in this area; one conveys runoff to a splash block, the other to a rain barrel. The rain barrel was not connected to the roof drain, so runoff drains directly to the mulch. The reason the rain barrel was disconnected was not clear at the time of the field investigation.	Rain Garden	Potential improvements at this site include converting a portion of the mulch area into rain gardens to treat runoff from each roof drain. This ESD practice would reduce runoff while creating an aesthetically pleasing garden that could provide an educational opportunity. The rain barrel should be reconnected with the adjacent roof drain, although an overflow hose could be provided to direct runoff to the proposed rain garden.	Community (Private School)	0.1	0.1
Open_12C	Saint John's Campus: Pinkney Hall	This site is a grass area adjacent to the northeastern face of Pinkney Hall, to the north of the northernmost entrance of the building. The existing roof drain conveys runoff to a splash block that directs flow onto the grass area.	Rain Garden	Potential improvements at this site include converting a portion of the grass area into a rain garden to treat roof runoff. This ESD practice would reduce runoff while creating an aesthetically pleasing garden that could provide an educational opportunity.	Community (Private School)	0.05	0.05
Open_12D	Saint John's Campus: Chase-Stone House	This site is a vegetated mulch area at the northwestern corner of the Chase-Stone House. An existing roof drain connects directly to a metal pipe that is directed to an existing storm drain system (according to 2011 site plan for Hudson Hall). The mulch area is surrounded by brick.	Rain Garden	Potential improvements at this site include disconnecting the existing roof drain and converting the mulch area into a rain garden to treat roof runoff. This ESD practice would reduce runoff while creating an aesthetically pleasing garden that could provide an educational opportunity. The size of the rain garden would be limited to the existing footprint to avoid impacting the existing brick walkways.	Community (Private School)	0.05	0.05
Open_12E	Saint John's Campus: Harrison Health Center	This site is a vegetated mulch semicircular area at the northeastern corner of the Harrison Health Center. The area is bounded by a walkway and a brick swale that drains to a yard inlet. Runoff from the brick walkway and a portion of the building roof drains to this inlet. An existing tree and smaller plants are in the mulch area. The site is over hydrologic group B soils.	Rain Garden	Potential improvements include converting the mulch area to a micro-bioretention or a rain garden. Approximately 2 feet would need to be excavated from the mulch area. A curb cut would be provided at the existing brick swale, as well as a weir structure to promote flow into the proposed facility. The overflow weir would be installed to provide overflow conveyance to the existing yard inlet. Approximately 6 inches of pea gravel slopes are recommended along the walkway to drain runoff from the walkway directly to the rain garden without causing erosion. The proposed facility would not require an underdrain due to the hydrologic group B soils.	Community (Private School)	0.5	0.5
Out_02	North of Lincoln Drive	This site overlaps with City Request 2. See CtyRqst_02 for site description.	None - Stream Restoration	No feasible stormwater management project at this site, although it may be a good candidate for stream restoration.	Private (Baldwin Family)	Not Applicable	Not Applicable

Table B-4: Spa Creek Sub-Watershed Field Investigation Summary

Project ID	Location	Existing Site Conditions	Potential Improvement Project Type	Project Description	Owner	Approximate Drainage Area (Acres)	Approximate Impervious Area (Acres)
Out_03	Northeast of Stonecreek Road and Gemini Drive	The site is northeast of the intersection of Stonecreek Road and Gemini Drive at the outfall of a 48-inch RCP pipe to a tributary of Spa Creek. The existing channel is narrow with incised banks and has significant meanders. The channel is within 50 feet of residential structures on both the east and west banks.	None - No Feasible	No feasible stormwater management project at this site, although it may be a good candidate for stream restoration.	Unknown Site Ownership.	Not Applicable	Not Applicable
Out_06	West of Spa Road and Silopanna Road	The site is at the Bayshore Landing Apartments at the existing grass swale downstream of a 27-inch storm drain pipe. The grass swale intercepts runoff from the Bayshore Landing Apartments and adjacent roadways. An existing scour pool is downstream of the outfall pipe, as well as a pilot channel that appears to have been created by erosive velocities. The existing swale crosses a sewer line, and electric lines are nearby.	Dry Swale Retrofit	Retrofit alternatives at this site include upgrading the existing swale to meet current MDE standards. An armored sedimentation basin with a level spreader would provide pretreatment. Upgrading the swale from the pipe outfall to the existing bridge would treat approximately 10% of the drainage area. The bottom of the swale may need to be excavated and replaced with permeable soils.	Private (LLC)	1.1	0.6
Park_01	LaFayette Avenue and Spa Creek (Lafayette Park)	This site is at LaFayette Park near the intersection of Lafayette Avenue and Spa Creek. The park is composed of a small grass area and is within 25 feet of the Bay.	None - No Feasible	No feasible stormwater management alternatives at this location.	City	Not Applicable	Not Applicable
Park_03	Truxtun Park (North) near Pump House Road	The site is in the parking lot adjacent to Pump House Road at Truxtun Park. Runoff from the parking lot drains to catch basin that conveys runoff to the Bay without treatment. A grass area is to the north of the parking lot with a walking path separating it from the existing pool area. No utilities were observed in the parking lot. Sedimentation was observed in the parking lot at relative low points that suggest occasional flooding.	Bioretention	Potential improvements at this site include converting a portion of the grass area and an unused portion of the parking lot into a bioretention to treat roof runoff. A flow splitter would be required at the existing catch basin to send the water quality volume to the treatment facility. Two additional catch basins are recommended to the east and west of the existing catch basin to intercept flow from the entire parking lot. An overflow yard inlet would be provided to convey overflow to the existing storm drain system. The soils in the area are hydrologic group C so an underdrain would most likely be required.	City	0.9	0.8
Park_04A	Rec Center (Compromise Street and Newman Street)	The site is near Newman Street at the corner of the Recreation Center Building. A roof drain drains to a mulch area, with a diverting hose that appears to be able to connect to a nearby rain barrel (it was not connected at the time of the field investigation).	Rain Garden	Potential improvements at this site include converting the mulch area into a rain garden to treat roof runoff. This ESD practice would reduce runoff while creating an aesthetically pleasing garden that could provide an educational opportunity. Flow from the roof drain can still be diverted to the rain barrel, and an overflow hose can be provided from the rain barrel to a rain garden.	City	0.03	0.03
Park_04B	Rec Center (Compromise Street and Saint Mary's Street)	The site is near Saint Mary's Street at the corner of the Recreation Center Building. A roof drain drains to a mulch area with two small trees.	Rain Garden	Potential improvements at this site include converting the mulch area into a rain garden to treat roof runoff. This ESD practice would reduce runoff while creating an aesthetically pleasing garden that could provide an educational opportunity.	City	0.03	0.03
Park_05	Newman Street Playground	An existing rain garden appears to be treating the majority of the park impervious area.	None - No Feasible	No feasible stormwater management projects are proposed at this location.	City	Not Applicable	Not Applicable

Table B-4: Spa Creek Sub-Watershed Field Investigation Summary

Project ID	Location	Existing Site Conditions	Potential Improvement Project Type	Project Description	Owner	Approximate Drainage Area (Acres)	Approximate Impervious Area (Acres)
Park_07	Amos Garrett Park (Amos Garrett Boulevard)	The site is south of the intersection of Amos Garrett Boulevard and Spaview Avenue at Amos Garrett Park. The park is composed of a walkway the leads from Spaview Avenue to Spa Creek surrounded by grass areas, trees, and bushes. There is a relative low area toward the end of the path near the Bay.	Rain Garden	Potential improvements at this site include implementing a rain garden to treat runoff from the walkway. This ESD practice would reduce runoff while creating an aesthetically pleasing garden that could provide an educational opportunity. The proposed project is within 25 feet of the Bay.	City	0.003	0.003
Park_10	Truxtun Park (South) near the Pip Moyer Recreation Center	The site is at the Pip Moyer Recreation Center at Truxtun Park. Most of the impervious area at this site is treated by bioretentions, micro-bioretention, or what appears to be a wet-swale.	None - No Feasible	No additional stormwater management projects are required at this site.	City	Not Applicable	Not Applicable
Trans_02	Maryland Avenue from King George Street to State Circle	The site is along Maryland Avenue from King George Street south to State Circle. The road is made of bricks, and a parking lot is along the east side of the street. A brick gutter is adjacent to the curb on the east side of the street. Water lines, sewer lines, and possibly gas lines are under Maryland Avenue.	Permeable Pavement	Potential improvements at this site include implementing permeable pavements over the existing parking areas. The sewer lines will need to be avoided, and the water lines may need to be encased.	City	1.5	0.49

Appendix D

Stormwater Concept Designs

Project ID: BMP_05 ..... **1**
Project ID: BMP_07 ..... **8**
Project ID: BMP_08 ..... **16**
Project ID: BMP_09 ..... **23**
Project ID: BMP_14 ..... **30**
Project ID: BMP_15 ..... **38**
Project ID: BMP_17 ..... **45**
Project ID: BMP_20 ..... **52**
Project ID: BMP_21 ..... **59**
Project ID: BMP_22 ..... **67**
Project ID: City Rqst_01 ..... **75**
Project ID: City_01 ..... **83**
Project ID: City_06 ..... **91**
Project ID: Out_01 ..... **99**
Project ID: Out_04 ..... **107**
Project ID: Out_07 ..... **115**

Project ID: BMP_05

Total Treated Drainage Area: 3.12 acres
Total Treated Impervious Area: 1.6 acres
Total Water Quality Volume (WQv):
~5,920 cubic feet; 0.14 acre-foot
Rainfall Depth Treated (Pe): 1 inch
Annual Nutrient Removal:

- TN: 12 lbs
- TP: 1.1 lbs
- TSS: 0.4 ton

Existing Site Description

The existing pond is located northeast of the intersection of Juliana Circle East and Newtowne Drive. A 21-inch reinforced concrete pipe (RCP) discharges to the pond and collects runoff from the high density residential area along Juliana Circle East. The pond drains to the existing storm drain system along Newtowne Drive via a 21-inch RCP. A weir prevents flow from the pond from entering the storm drain system until standing water is at a depth of approximately 1 foot.

The pond is approximately a half mile from the nearest 100-year floodplain as designated on the current Federal Emergency Management Agency (FEMA) map. There is light vegetation within the pond and a wooden fence surrounding its perimeter. Neither sanitary sewer lines nor water lines were identified in the vicinity of the existing pond. The soils in the drainage area are hydrologic soil groups C and D, and the pond is located over hydrologic group D soils. The pond is on a parcel owned by the Rider's Glen Homeowners Association (HOA). Figure 1 shows the existing conditions map with drainage area.

Proposed Project Description

The proposed project involves retrofitting the existing pond to a sand filter. A sand filter would be designed using Maryland Department of Environment's (MDE's) *Stormwater Design Manual*. The inlet pipe would be cut and excavation will be required to create a pretreatment sediment basin to reduce sedimentation within the sand filter media. A perforated standpipe or weir would convey runoff from the sediment basin to the sand filter. An underdrain would be installed in the sand filter media with a single cleanout pipe for maintenance of the system. Overflow from the sand filter (for flows greater than the water quality storm) would be provided by either modifying the existing weir upstream of the outlet pipe or by installing a yard inlet. The quantity control of the existing pond would be maintained by providing additional storage in the proposed sediment forebay, although the 10-year peak flow would still be controlled by the downstream hydraulic grade line. The design team will need to request approval from MDE to verify that the facility can be retrofit to an on-line sand filter (typically MDE prefers sand filters to be built off line).

Minimal excavation will be required within the pond, although the existing vegetation would need to be removed. A maximum slope of 3:1 (Horizontal: Vertical) is recommended for all proposed embankments. If geotechnical analysis indicates that the water table is within 4 feet of the facility bottom (which is not anticipated) then a pocket wetland may be more appropriate with the proposed sediment basin.

Implementation of the sand filter would reduce pollutants such as total nitrogen (TN), total phosphorus (TP), and total suspended solids (TSS). This project will help the City of Annapolis achieve approximately 1.6 acres of impervious area credits toward their upcoming National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) requirements. Figure 2 provides the schematic of the proposed sand filter system, and Figure 3 provides a typical profile.

Feasibility Assessment

Property Ownership	The property is HOA owned; the City would need to coordinate with the HOA to obtain permission to implement this project.
Construction Access	The site can be accessed from Juliana Circle East and Newtowne Drive. Open area is available to stage construction activities. Existing slopes are navigable by construction equipment.
Utility Conflicts	There are no sanitary sewer lines or water lines in the project area. Though there were no indicators of underground electric facilities at the project site (i.e., no light poles or utility boxes), confirmation should be obtained during final design.
Environmental Impacts	There are several trees west of the existing pond, but no impacts are anticipated.
Design/Construction	Geotechnical investigation will be required to determine the groundwater elevation in the project area during final design.

Plans and Permits

The following plans and permits may be required for the implementation of this project:

- Site/Schematic Development Application
- Stormwater Management Plan
- Grading and Erosion Sediment Control Plan
- Temporary Traffic Control Plan

Cost Estimate

Table 1: Cost Estimate for BMP 05 Retrofit

Item	Quantity	Units	Unit Cost	Total
Clear and Grub	700	SY	$2.00	$1,400.00
Excavation and Hauling	700	CY	$50.00	$35,000.00
Grading	700	SY	$3.50	$2,450.00
Sand	140	CY	$70.00	$9,800.00
Rip-Rap	20	CY	$130.00	$2,600.00
Stabilized Construction Entrance	1	EA	$2,000.00	$2,000.00
Grass Seeding	700	SY	$0.75	$525.00
6-inch Perforated PVC Underdrains	90	LF	$15.00	$1,350.00
8-inch PVC	30	LF	$19.00	$570.00
Yard Inlets	1	EA	$1,240.00	$1,240.00
Cleanout Pipes	1	EA	$240.00	$240.00
CY - Cubic Yards SY - Square Yards EA - Each LF - Linear Feet			Initial Project Costs	$57,175
		Contingency	20%	$11,435
		Erosion and Sediment Control	15%	$8,576
		Base Construction Costs		$77,186
		Mobilization	10%	$7,719
		Total Construction Cost[1]		**$84,905**
		20 Years Life Cycle Maintenance Cost[2] (Average Annual Maintenance Cost of $1,431)		$28,620

[1]Additional cost of approximately $100,000 for design, environmental services, geotechnical investigation, survey, and permitting is assumed.
[2] University of Maryland. October 2011. Cost of Stormwater Management Practices in Maryland Counties.

Computations

Table 2: Water Quality Volume (WQv) Calculations

Design Parameters	**Site Value**
Treated Drainage Area (acres), A	3.12
Percent Impervious Cover, I	51%
Rainfall Depth (inches), P	1
Volumetric Runoff Coefficient, R_v	0.52
Water Quality Volume (acre-feet), WQ_v	**0.14**
Water Quality Volume (cubic-feet), WQ_v	**5,920**

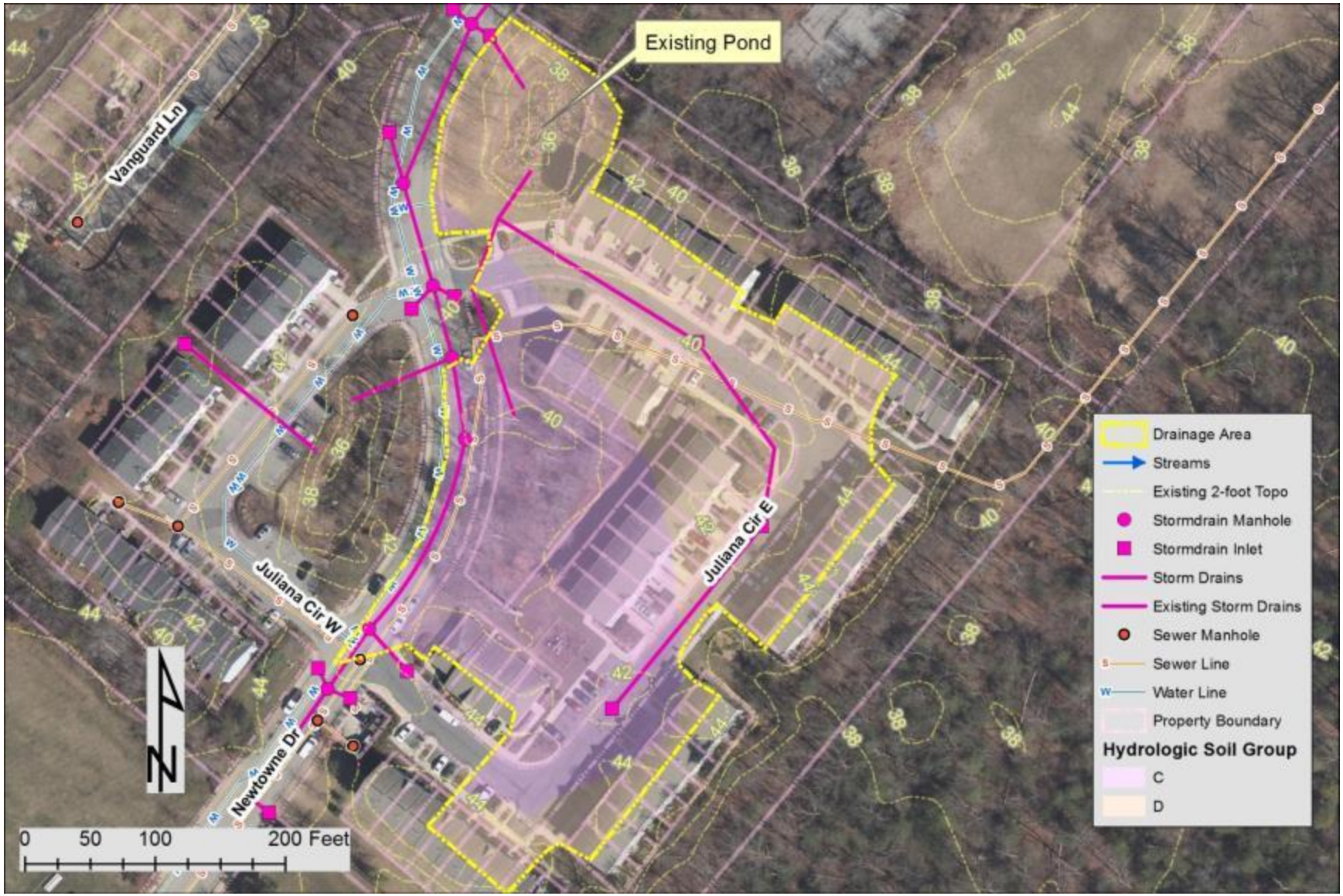

Figure 1: Existing Conditions and Drainage Area

Figure 2: Proposed Retrofit Concept Design

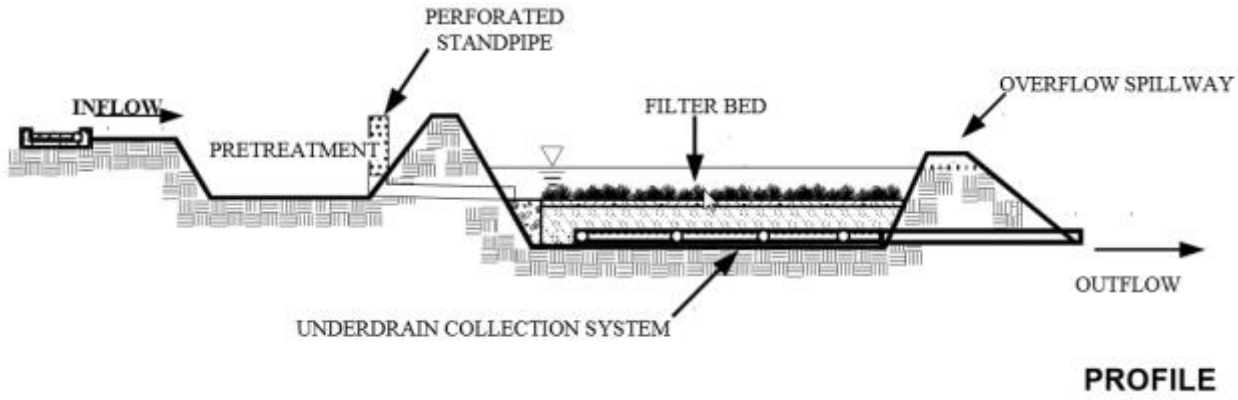

Figure 3: Typical Profile of Sand Filter (MDE 2000 *Stormwater Design Manual*)

Site Photographs

Existing pond near the intersection of Juliana Court East and Newtowne Drive

Project ID: BMP_07

Total Treated Drainage Area: 19.6 acres
Total Treated Impervious Area: 9.5 acres
Total Water Quality Volume (WQv):
~34,594 cubic feet; 0.79 acre-foot
Rainfall Depth Treated (Pe): 1 inch
Annual Nutrient Removal:

- TN: 75.7 lbs
- TP: 6.9 lbs
- TSS: 2.3 tons

Existing Site Description

The existing site is a wet pond in a residential neighborhood. The site is located southeast of the intersection of Coybay Drive and Annapolitan Lane and is owned by the Annapolis Walk HOA. The existing facility receives stormwater runoff from the surrounding residential area and nearby community parks. The facility has two inflow pipes, both of which were submerged during the initial inspection. The water surface was also covered with a thick layer of algae during the inspection. The pond outlet is a riser that ties into a 54-inch RCP that outfalls into a channel behind Whiton Court. Minor to moderate erosion is occurring. There is displaced rip-rap, exposed geotextile fabric, and remnants of a concrete bottom in the channel downstream of the storm drain outfall. The outfall is located approximately 2,000 feet upstream of the confluence with Church Creek. Annapolitan Lane borders the facility on the north and east sides of the pond. A wooded area is to the south of the facility, and a flat, sparsely wooded grassy area is located to the west of the facility, along Coybay Drive. No utilities are located on the site, although water and sewer lines run along Annapolitan Lane and another water line runs along Coybay Drive. The pond and its outfall are located over hydrologic group C soils. The pond is surrounded by chain link fence and is well maintained. Figure 4 shows the existing conditions.

Proposed Project Description

The proposed project includes retrofitting the existing wet pond to increase capacity. The proposed best management practice (BMP) will be designed in accordance with the MDE's *Stormwater Design Manual*. The pond would be excavated an additional 2 feet in depth, and a sediment forebay would be added that is separated from the rest of the pond with an earthen berm. A few existing trees surrounding the pond may be affected. The existing pond embankment may have already been designed to the Maryland Code 378 small pond standards (MD-378) provided by the Maryland Natural Resources Conservation Service (NRCS); however, if it was not, it is possible that the embankment design category will change and require upgrading to the MD-378 standards. A wet pond retrofit would reduce pollutants such as TN, TP, and TSS. Riser modification and outfall channel stabilization is also recommended.

Implementation of the retrofit would mitigate existing erosion issues downstream of the outfall. This project will help the City of Annapolis achieve approximately 9.5 acres of impervious area credits toward their upcoming NPDES MS4 requirements. Figures 5 and 6 show the proposed conditions, and Figure 7 shows a typical profile of a wet pond.

Feasibility Assessment

Property Ownership	The property is HOA owned; the City would need to coordinate with the HOA to obtain permission implement this project.
Construction Access	The site can be accessed either by Coybay Drive or Annapolitan Lane. The facility is surrounded by chain link fence, and the gate is located off of Coybay Drive. A large, mostly clear area is located adjacent to the facility that is between the gate and Coybay Drive.
Utility Conflicts	Existing water and sewer lines run along Annapolitan Lane but should not affect the proposed project. No known utilities are located within the proposed project site.
Environmental Impacts	Trees will be affected during project implementation only if work is done at the outfall. Several medium sized trees are located along the channel banks, downstream of the outfall. Several widely spaced large trees are located upslope of the pond.
Design/Construction	Geotechnical investigation will be required to determine the infiltration rates of the soils in the project area during final design. If the pond qualifies as an MD-378 pond, any retrofit would also require upgrading the pond to meet the current MD-378 small pond standards.

Plans and Permits

The following plans and permits may be required for the implementation of this project:

- Site/Schematic Development Application
- Stormwater Management Plan
- Natural Resources and Forest Stand Delineation
- Forest Conservation Plan/Buffer Management Plan
- Grading and Erosion Sediment Control Plan
- Temporary Traffic Control Plan
- Maryland State Programmatic General Permit (MDSPGP) for activities in US waters
- General Permit for Stormwater Discharge Associated with Construction Activity (if the area disturbed is greater than 1 acre)

Cost Estimate

Table 3: Cost Estimate for BMP 07 Retrofit

Item	Quantity	Units	Unit Cost	Total
Clear and Grub	3910	SY	$2.00	$7,820.00
Excavation and Hauling	1500	CY	$50.00	$75,000.00
Grading	1500	SY	$3.50	$5,250.00
Tree Removal	10	EA	$800.00	$8,000.00
Flow Diversion Structure	1	EA	$10,000.00	$10,000.00
Rip-Rap	150	CY	$130.00	$19,500.00
Clear Water Diversion Pipe	200	LF	$30.00	$6,000.00
Stabilized Construction Entrance	1	EA	$2,000.00	$2,000.00
Grass Seeding	3910	SY	$0.75	$2,932.50
Topsoil	3910	SY	$4.00	$15,640.00
Riser Modification	1	EA	$6,000.00	$6,000.00
CY - Cubic Yards SY - Square Yards EA - Each LF - Linear Feet			Initial Project Costs	$158,142
		Contingency	20%	$31,629
		Erosion and Sediment Control	15%	$23,721
		Base Construction Costs		$213,492
		Mobilization	10%	$21,349
		Total Construction Cost[3]		**$234,841**
		20 Years Life Cycle Maintenance Cost[4] (Average Annual Maintenance Cost of $1,531)		$15,260

[3]Additional cost of approximately $100,000 for design, environmental services, geotechnical investigation, survey, and permitting is assumed.
[4] University of Maryland. October 2011. Cost of Stormwater Management Practices in Maryland Counties.

Computations

Table 4: Water Quality Volume (WQv) Calculations

Design Parameters	**Site Value**
Treated Drainage Area (ac), A	19.6
Percent Impervious Cover, I	48.5%
Rainfall Depth (inches), P	1
Volumetric Runoff Coefficient, R_v	0.49
Water Quality Volume (acre-feet), WQ_v	**0.79**
Water Quality Volume (cubic-feet), WQ_v	**34,594**

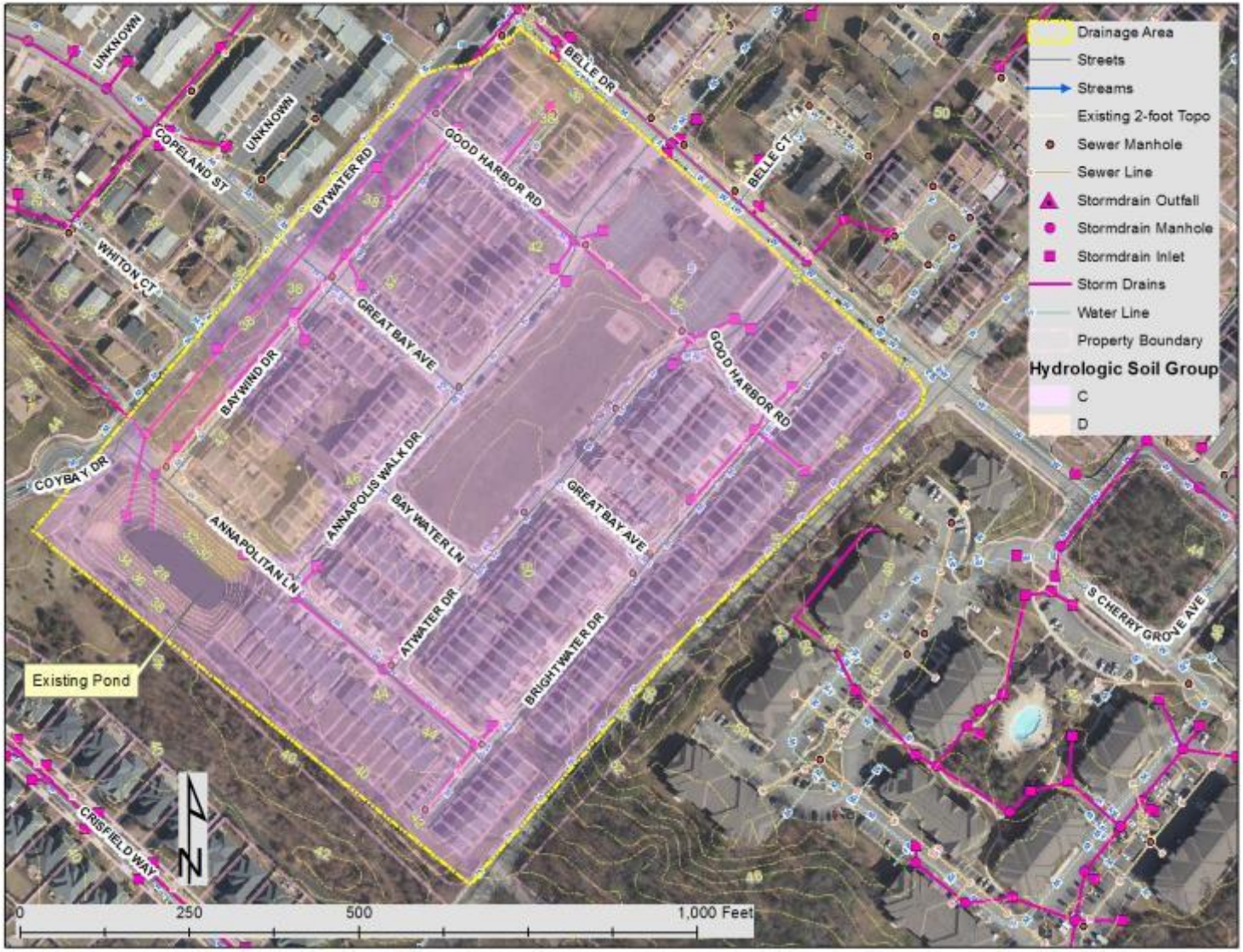

Figure 4: Existing Conditions and Drainage Area

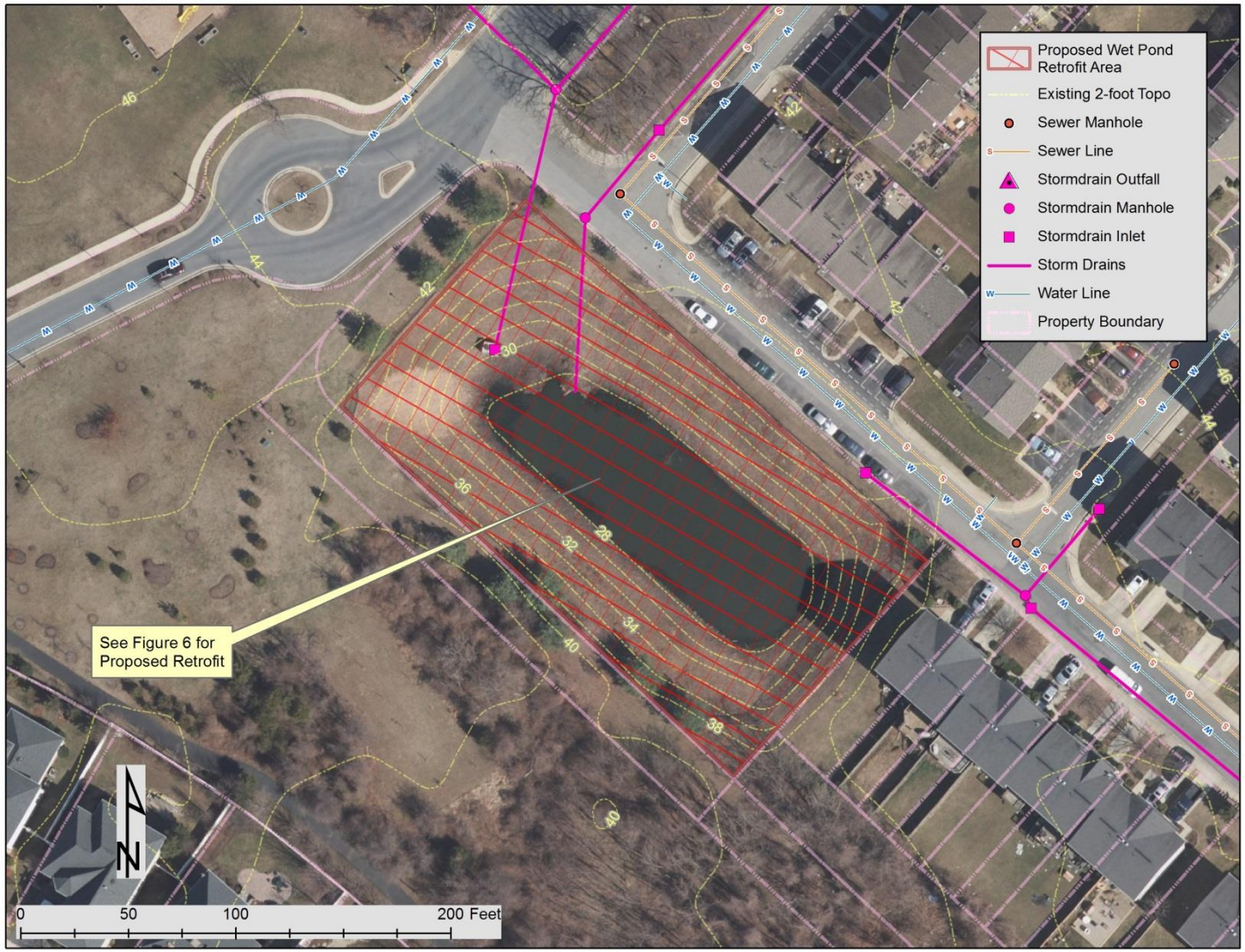

Figure 5: Proposed Retrofit Concept Design

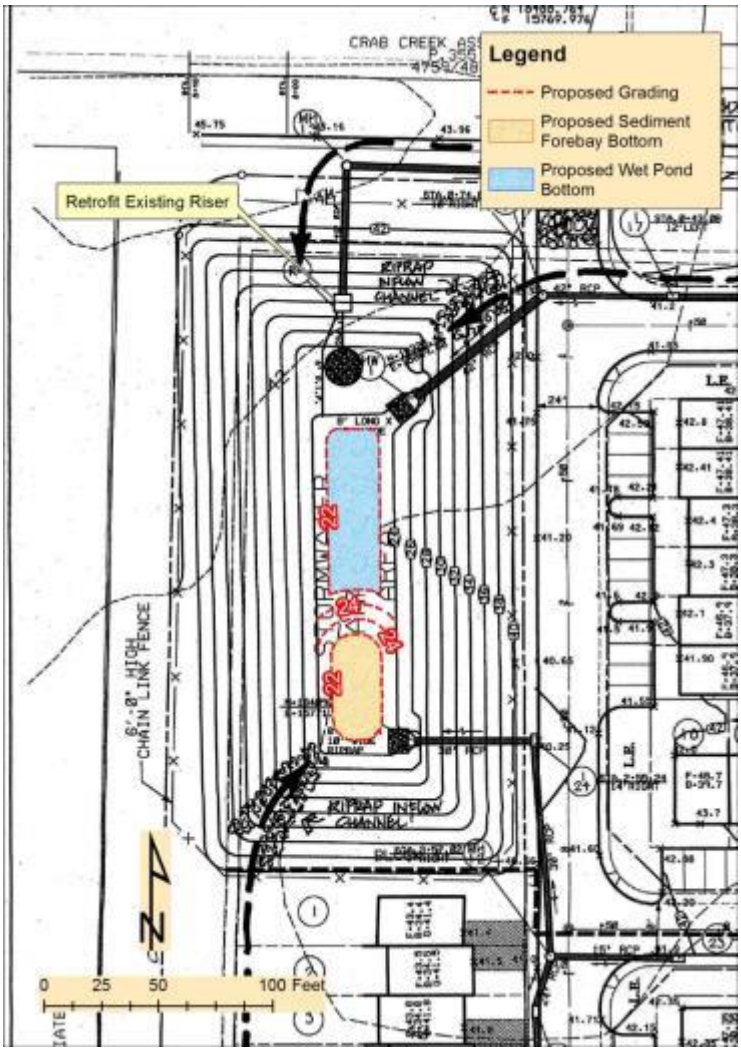

Figure 6: Proposed Retrofit Concept Design Detail Based on Greenhorne & O'Mara Inc. 1994 Design Plan

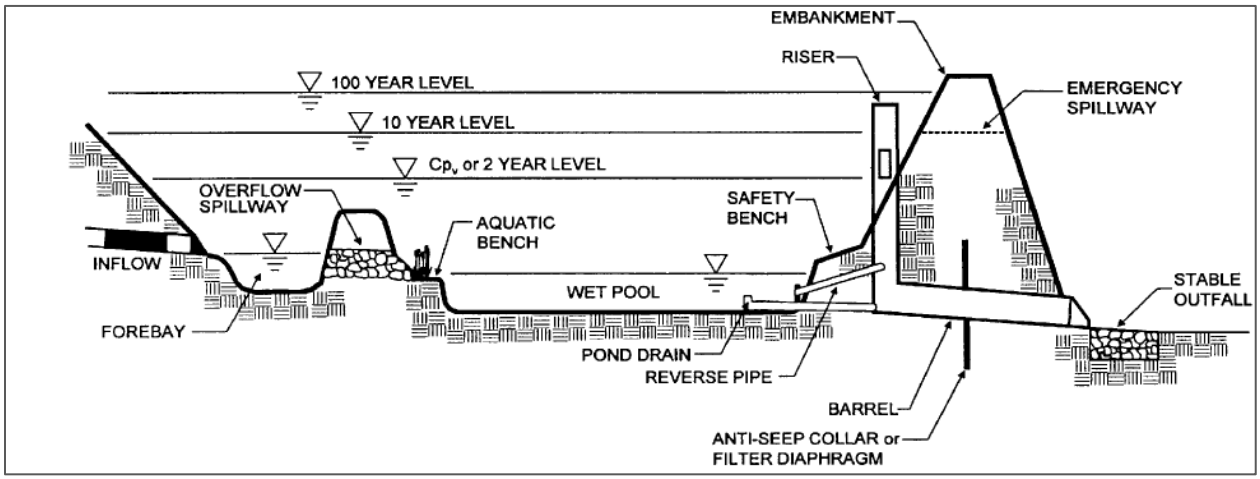

Figure 7: Typical Profile of Wet Pond (MDE 2000 *Stormwater Design Manual*)

Site Photographs

Existing Annapolis Walk Wet Pond (facing northwest)

Existing Annapolis Walk Wet Pond (facing southeast)

Project ID: BMP_08

Total Treated Drainage Area: 9.1 acres
Total Treated Impervious Area: 5.2 acres
Total Water Quality Volume (WQv):
~18,640 cubic feet; 0.43 acre-foot
Rainfall Depth Treated (Pe): 1 inch
Annual Nutrient Removal:

- TN: 35.1 lbs
- TP: 3.2 lbs
- TSS: 1.1 tons

Existing Site Description

The existing wet pond (BMP 08) is adjacent to the shopping center and new townhomes along Skippers Lane. The pond was upgraded from a dry pond to a wet pond in 2001. The facility was not accessible during the site inspection, and a new stormwater management facility was being constructed adjacent to the existing wet pond that appeared to be intended to treat runoff from new townhomes being constructed in the surrounding area. The existing wet pond facility appears to be owned by a HOA, although it may be on a City stormwater easement. A 15-inch RCP discharges to the pond, and flow reenters the storm drain system downstream of a riser structure. The outfall of the facility was not found and may have changed with recent construction in the area. The facility is heavily vegetated with brush and trees, and it is surrounded by a newly constructed metal gate with brick columns. There is a sewer line to the west of the facility along Vanguard Lane. The soils in the drainage area are hydrologic soil groups C and D. See Figure 8 for existing conditions.

Proposed Project Description

The proposed project includes retrofitting the existing wet pond to increase capacity. The proposed BMP will be designed in accordance with the MDE's *Stormwater Design Manual*. The pond would be excavated an additional 2 feet in depth, and a sediment forebay will be added that is separated from the rest of the pond with an earthen berm. Trees surrounding the site would be affected by construction. A wet pond retrofit would reduce pollutants such as TN, TP, and TSS. Riser modifications are also recommended. This project will help the City of Annapolis achieve approximately 5.2 acres of impervious area credits toward its upcoming NPDES MS4 requirements. Figure 9 is a schematic of the proposed wet pond retrofit, and Figure 10 provides a typical profile.

Feasibility Assessment

Property Ownership	The property is owned by an HOA; the City would need to coordinate with the HOA to obtain permission to implement this project if it is not already on a stormwater easement.
Construction Access	The site can be accessed at Vanguard Lane (private drive) and at Skippers Lane. The site is surrounded by a new metal fence. The inspection team was unable to enter facility at time of inspection due to the fence.
Utility Conflicts	There is an existing sewer line along Vanguard Lane. Additional utilities may have been added for the new home construction surrounding the site. A detailed survey will be required to identify and confirm utilities.
Environmental Impacts	Several medium sized trees are located throughout the site. Heavy brush is also present. Tree impacts may be a challenge for this project.
Design/Construction	Geotechnical investigation will be required to determine the infiltration rates of the soils in the project area during final design.

Plans and Permits

The following plans and permits may be required for the implementation of this project:

- Site/Schematic Development Application
- Stormwater Management Plan
- Natural Resources and Forest Stand Delineation
- Forest Conservation Plan/Buffer Management Plan
- Grading and Erosion Sediment Control Plan
- Temporary Traffic Control Plan
- MDSPGP for activities in US waters
- General Permit for Stormwater Discharge Associated with Construction Activity (if the area disturbed is greater than 1 acre)

Cost Estimate

Table 5: Cost Estimate for BMP 08 Retrofit

Item	Quantity	Units	Unit Cost	Total
Clear and Grub	1600	SY	$2.00	$3,200.00
Excavation and Hauling	1600	CY	$50.00	$80,000.00
Grading	1600	SY	$3.50	$5,600.00
Tree Removal	30	EA	$800.00	$24,000.00
Plantings	2000	SY	$10.00	$20,000.00
Rip-Rap	50	CY	$130.00	$6,500.00
Stabilized Construction Entrance	1	EA	$2,000.00	$2,000.00
Grass Seeding	1600	SY	$0.75	$1,200.00
Topsoil	1600	SY	$4.00	$6,400.00
Riser Modification	1	EA	$6,000.00	$6,000.00
CY - Cubic Yards SY - Square Yards EA - Each LF - Linear Feet			Initial Project Costs	$154,900
		Contingency	20%	$30,980
		Erosion and Sediment Control	15%	$23,235
		Base Construction Costs		$209,115
		Mobilization	10%	$20,912
		Total Construction Cost[5]		**$230,027**
		20 Years Life Cycle Maintenance Cost[6] (Average Annual Maintenance Cost of $1,531)		$15,260

[5]Additional cost of approximately $100,000 for design, environmental services, geotechnical investigation, survey, and permitting is assumed.
[6] University of Maryland. October 2011. Cost of Stormwater Management Practices in Maryland Counties.

Computations

Table 6: Water Quality Volume (WQv) Calculations

Design Parameters	**Site Value**
Treated Drainage Area (ac), A	9.1
Percent Impervious Cover, I	57.1%
Rainfall Depth (inches), P	1
Volumetric Runoff Coefficient, R_v	0.56
Water Quality Volume (acre-feet), WQ_v	**0.43**
Water Quality Volume (cubic-feet), WQ_v	**18,640**

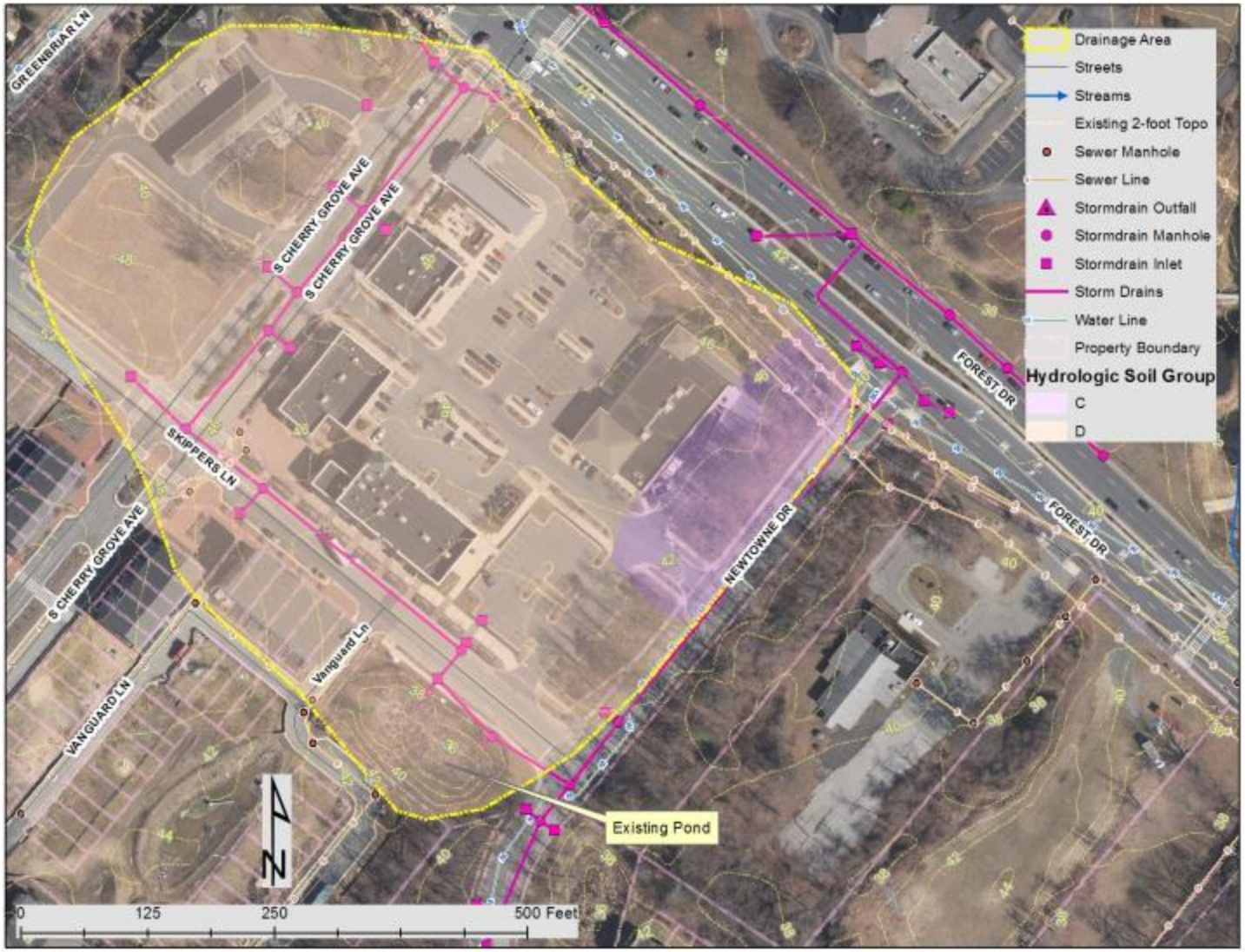

Figure 8: Existing Conditions and Drainage Area

Figure 9: Proposed Retrofit Concept Design

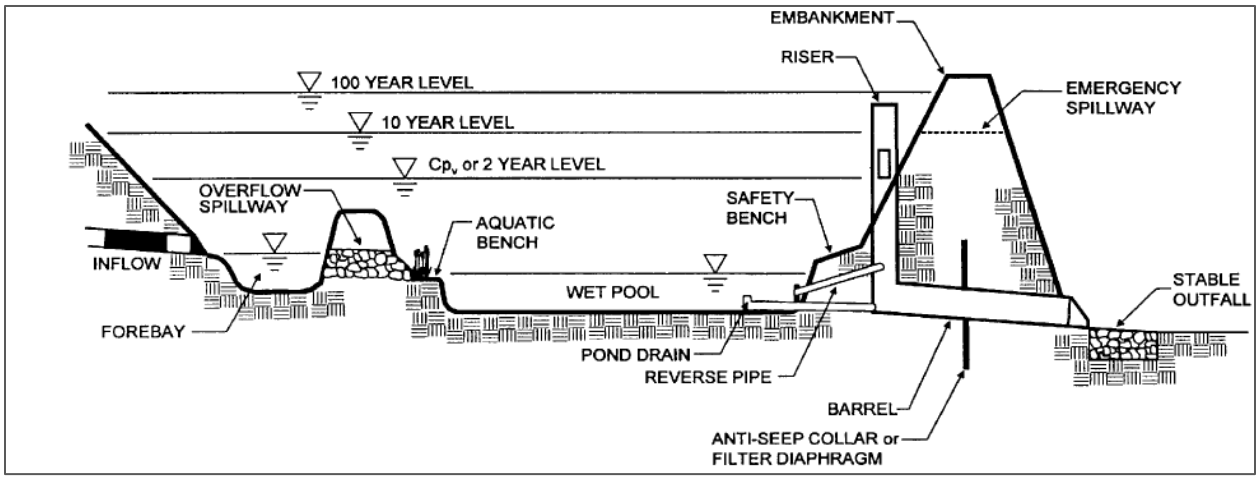

Figure 10: Typical Profile of Wet Pond (MDE 2000 *Stormwater Design Manual*)

Site Photographs

Existing Skipper Lane Wet Pond (including surrounding fence)

Project ID: BMP_09

Total Treated Drainage Area: 4.57 acres
Total Treated Impervious Area: 2.9 acres
Total Water Quality Volume (WQv):
~10,300 cubic feet; 0.236 acre-foot
Rainfall Depth Treated (Pe): 1 inch
Annual Nutrient Removal:

- TN: 17.6 lbs
- TP: 1.6 lbs
- TSS: 0.5 ton

Existing Site Description

The existing pond is located at the BayWoods of Annapolis cooperative retirement community, east of the intersection of Bay Front Drive and Bembe Beach Road. A 24-inch corrugated polyethylene drainage pipe discharges to the pond and collects runoff from the BayWoods of Annapolis property. The pond has a perforated standpipe that drains to a non-tidal wetland filtering area via a 6-inch PVC pipe. Overflow is accommodated by a concrete weir upstream of gabion baskets and filter fabric to reduce runoff velocity and provide preliminary treatment prior to entering the wetland filtering area. The wetland filtering area drains directly to the Chesapeake Bay.

The pond is located in the FEMA 100-year floodplain with a static base flood elevation of 5 feet North American Vertical Datum of 1988. The pond has an aerator and a fountain, although during field investigation water was brown and murky. There is ornamental vegetation around the pond and a footbridge crossing the pond. Neither sanitary sewer lines nor water lines were identified in the vicinity of the existing pond. The soils in the drainage area are hydrologic soil groups C and D, and the pond is located over hydrologic group D soils. The pond is located within the Limited Development Area (LDA); however, Anne Arundel County does not have additional requirements for stormwater management in the LDA. Figure 11 shows the existing conditions map with drainage area.

Proposed Project Description

The proposed project includes upgrading the existing pond to meet current stormwater management standards. The retrofitted wet pond will be designed using MDE's Stormwater Design Manual. Sediment will be removed from the pond as needed to reestablish the design volume, and a pretreatment sediment forebay will be created by installing a weir under the existing bridge. Placing a weir under the bridge will minimize negative aesthetic impacts, and given the high visibility of the pond, an aesthetically pleasing weir (e.g., a sinuous shape) is recommended. Maintenance access will be provided to the sediment forebay so sediment can be removed periodically. This will improve the water quality in the pond while meeting current

MDE standards. The existing perforated standpipe may need to be replaced, although no changes to the overflow weir are proposed.

Minimal excavation will be required within the pond, although some of the existing vegetation will need to be removed. A maximum slope of 3:1 (Horizontal: Vertical) is recommended for all proposed embankments. Geotechnical analysis will be required to identify the location of the groundwater table.

Retrofitting the existing wet pond would reduce pollutants such as TN, TP, and TSS. This project will help the City of Annapolis achieve approximately 2.9 acres of impervious area credits toward its upcoming NPDES MS4 requirements. Figure 12 provides the schematic of the wet pond and Figure 13 provides the grading from the design plans. Based on the drainage area and site conditions at the existing pond a pocket wet pond appears to be the most appropriate retrofit at thesite, and Figure 14 provides the typical profile of a pocket pond.

Feasibility Assessment

Property Ownership	The property is owned by BayWoods of Annapolis, a cooperative retirement community. The City would need to coordinate with BayWoods of Annapolis to obtain permission to implement this project.
Construction Access	The site can be accessed from the open grass areas south of the BayWoods of Annapolis building. Open area is available to stage construction activities. Existing slopes are navigable by construction equipment.
Utility Conflicts	There are no sanitary sewer lines or water lines in the project area. Though there were no indicators of underground electric service at the project site (i.e., no light poles or utility boxes), confirmation should be obtained during final design.
Environmental Impacts	No tree impacts are anticipated as part of this project.
Design/Construction	Geotechnical investigation will be required to determine the groundwater elevation in the project area during final design. If the pond qualifies as an MD-378 pond, any retrofit would also require upgrading the pond to meet the current MD-378 small pond standards.

Plans and Permits

The following plans and permits may be required for the implementation of this project:

- Site/Schematic Development Application
- Stormwater Management Plan
- Grading and Erosion Sediment Control Plan
- Temporary Traffic Control Plan
- MD-378 Pond Approval

Cost Estimate

Table 7: Cost Estimate for BMP 09 Retrofit

Item	Quantity	Units	Unit Cost	Total
Clear and Grub	350	SY	$2.00	$700.00
Excavation and Hauling	350	CY	$50.00	$17,500.00
Grading	350	SY	$3.50	$1,225.00
Flow Diversion Structure	1	EA	$10,000.00	$10,000.00
Rip-Rap	20	CY	$130.00	$2,600.00
Stabilized Construction Entrance	1	EA	$2,000.00	$2,000.00
Grass Seeding	350	SY	$0.75	$262.50
Concrete Weir	30	CY	$900.00	$27,000.00
Principle Spillway Riser Structure	1	EA	$1,850.00	$1,850.00
CY - Cubic Yards SY - Square Yards EA - Each LF - Linear Feet			Initial Project Costs	$63,138
		Contingency	20%	$12,628
		Erosion and Sediment Control	15%	$9,471
			Base Construction Costs	$85,236
		Mobilization	10%	$8,524
			Total Construction Cost[7]	**$93,760**
			20 Years Life Cycle Maintenance Cost[8] (Average Annual Maintenance Cost of $763)	$15,260

Computations

Table 8: Water Quality Volume (WQv) Calculations

Design Parameters	Site Value
Treated Drainage Area (acres), A	4.57
Percent Impervious Cover, I	63%
Rainfall Depth (inches), P	1
Volumetric Runoff Coefficient, R_v	0.62
Water Quality Volume (acre-feet), WQ_v	**0.236**
Water Quality Volume (cubic-feet), WQ_v	**10,300**

[7]Additional cost of approximately $100,000 for design, environmental services, geotechnical investigation, survey, and permitting is assumed.
[8] University of Maryland. October 2011. Cost of Stormwater Management Practices in Maryland Counties.

Figure 11: Existing Conditions and Drainage Area

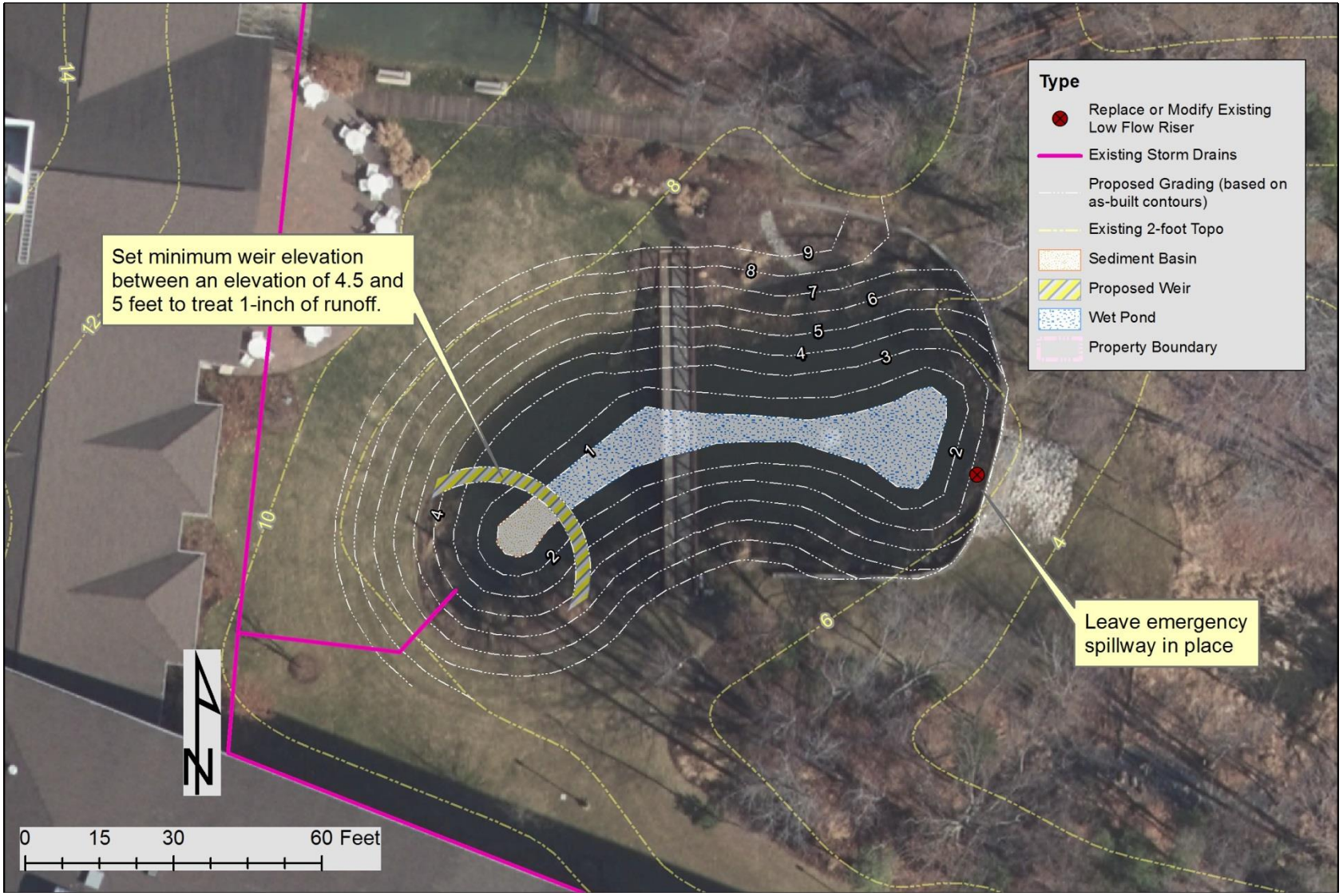

Figure 12: Proposed Retrofit Concept Design

Figure 13: Site Grading from BayWoods of Annapolis 2000 Design Plans

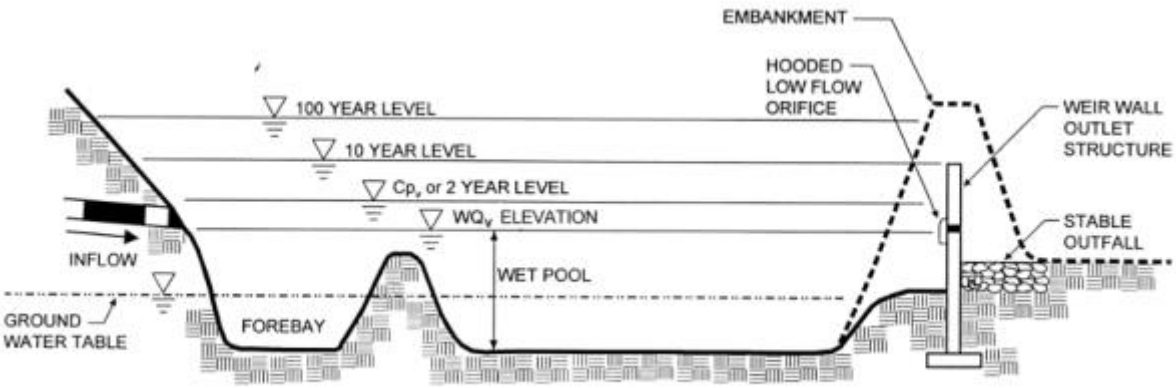

Figure 14: Typical Profile of a Pocket Pond (MDE 2000 *Stormwater Design Manual*)

Site Photographs

Existing Pond at BayWoods of Annapolis (facing east)

Existing Pond at BayWoods of Annapolis Overflow Weir and Outfall Protection (facing northwest)

Project ID: BMP_14

Total Treated Drainage Area: 19.5 acres
Total Treated Impervious Area: 5.0 acres
Total Additional Water Quality Volume (WQv):
~8,478 cubic feet; 0.19 acre-foot
Rainfall Depth Treated (Pe): 1 inch
Annual Nutrient Removal:

- TN: 75.3 lbs
- TP: 6.9 lbs
- TSS: 2.3 tons

Existing Site Description

The existing site is a wet pond located northwest of the intersection of Harness Creek View Court and Harness Creek View Drive. The facility is owned by the Hunt Meadows HOA and receives runoff from surrounding residential areas. Algae was identified on the pond surface during the field investigation, and a vegetated island is located in the center of the pond. The facility has a single 36-inch vitrified clay pipe (VCP) inflow, and there is no riser structure for this facility. The pond outlet is an 80-foot-long rip-rap channel that discharges into an intermittent stream for approximately 180 feet prior to entering a 48-inch by 36-inch corrugated metal pipe (CMP) culvert across Harness Creek View Drive. The CMP culvert is approximately 200 feet upstream of the confluence with Harness Creek. The City indicated that the area surrounding the pond was once an area of flooding concern. The pond is surrounded by a white wooden fence, with houses on the east and north sides of the pond and an intermittent stream west of the facility. A sewage station is located between the pond and Harness Creek View Drive, although no other sewer or water lines were identified in the area. The soils in the area surrounding the pond are hydrologic soil group C. Several small to medium sized trees are located on the slopes of the pond. See Figure 15 for existing conditions.

Proposed Project Description

The proposed project involves retrofitting the existing wet pond to increase capacity. The proposed BMP would be designed in accordance with the MDE's *Stormwater Design Manual*. The pond would be excavated an additional 2 feet in depth, and a sediment forebay would be added that is separated from the rest of the pond with an earthen berm. The sediment basin will reduce sedimentation in the pond, while the increase in volume will provide additional water quality volume and may help alleviate flooding concerns. The existing pond embankment may have already been designed to the MD-378 standards provided by the Maryland NRCS; however, if it was not, it is possible that the embankment design category will change and require upgrading to the MD-378 standards. The pond outlet (rip-rap channel) may need to be modified to be able to treat the larger water quality volume. Access considerations include minimizing

tree impacts on the north side of the pond. A wet pond retrofit will reduce pollutants such as TN, TP, and TSS. The additional pond capacity would manage stormwater runoff quality as well as quantity, reducing flooding issues. This project will help the City of Annapolis achieve approximately 5.0 acres of impervious area credits toward its upcoming NPDES MS4 requirements. Figure 16 and Figure 17 provide the proposed conditions, and Figure 18 provides a typical profile.

Feasibility Assessment

Property Ownership	The property is HOA owned; the City would need to coordinate with the HOA to obtain permission to implement this project.
Construction Access	The site can be accessed at Harness Creek View Court. The facility is surrounded by fence, and the gate is located off of Harness Creek View Court
Utility Conflicts	A sewage station is located southeast of the facility, but no known utilities are within the proposed project site.
Environmental Impacts	Tree impacts are anticipated during project implementation. Two trees and a few shrubs are located near the access gate. Additional tree impacts are anticipated only if work is done at the outfall because several medium sized trees are located along the channel banks, downstream of the outfall. Several widely spaced large trees are located upslope of the pond.
Design/Construction	Geotechnical investigation will be required to determine the infiltration rates of the soils in the project area during final design. If the pond qualifies as an MD-378 pond, any retrofit would also require upgrading the pond to meet the current MD-378 small pond standards.

Plans and Permits

The following plans and permits may be required for the implementation of this project:

- Site/Schematic Development Application
- Stormwater Management Plan
- Natural Resources and Forest Stand Delineation
- Forest Conservation Plan/Buffer Management Plan
- Grading and Erosion Sediment Control Plan
- Temporary Traffic Control Plan
- MDSPGP for activities in US waters
- General Permit for Stormwater Discharge Associated with Construction Activity (if the area disturbed is greater than 1 acre)

Cost Estimate

Table 9: Cost Estimate for BMP 14 Retrofit

Item	Quantity	Units	Unit Cost	Total
Clear and Grub	3200	SY	$2.00	$6,400.00
Excavation and Hauling	1000	CY	$50.00	$50,000.00
Grading	1500	SY	$3.50	$5,250.00
Tree Removal	10	EA	$800.00	$8,000.00
Rip-Rap	200	CY	$130.00	$26,000.00
Clear Water Diversion Pipe	350	LF	$30.00	$10,500.00
Stabilized Construction Entrance	1	EA	$2,000.00	$2,000.00
Grass Seeding	3200	SY	$0.75	$2,400.00
Topsoil	3200	SY	$4.00	$12,800.00
CY - Cubic Yards SY - Square Yards EA - Each LF - Linear Feet			Initial Project Costs	$123,350
		Contingency	20%	$24,670
		Erosion and Sediment Control	15%	$18,503
		Base Construction Costs		$166,523
		Mobilization	10%	$16,652
		Total Construction Cost[9]		**$183,175**
		20 Years Life Cycle Maintenance Cost[10] (Average Annual Maintenance Cost of $763)		$15,260

[9]Additional cost of approximately $100,000 for design, environmental services, geotechnical investigation, survey, and permitting is assumed.
[10] University of Maryland. October 2011. Cost of Stormwater Management Practices in Maryland Counties.

Computations

Table 10: Water Quality Volume (WQv) Calculations

Design Parameters	**Site Value**
Treated Drainage Area (ac), A	19.5
Percent Impervious Cover, I	25.6
Rainfall Depth (inches), P	1
Volumetric Runoff Coefficient, R_v	0.28
Water Quality Volume (acre-feet), WQ_v	**0.46**
Water Quality Volume (cubic-feet), WQ_v	**19,874**

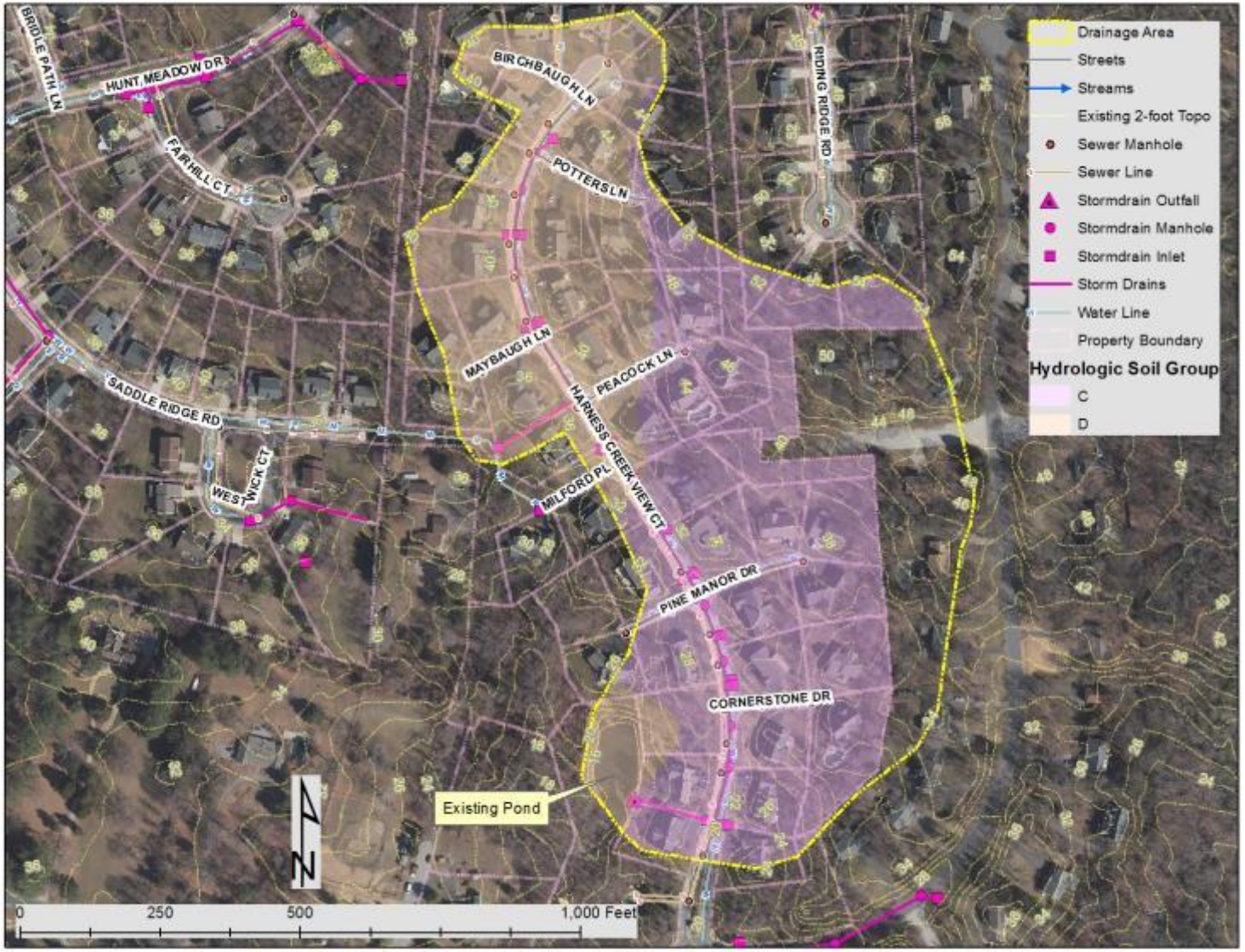

Figure 15: Existing Conditions and Drainage Area

Figure 16: Proposed Retrofit Concept Design

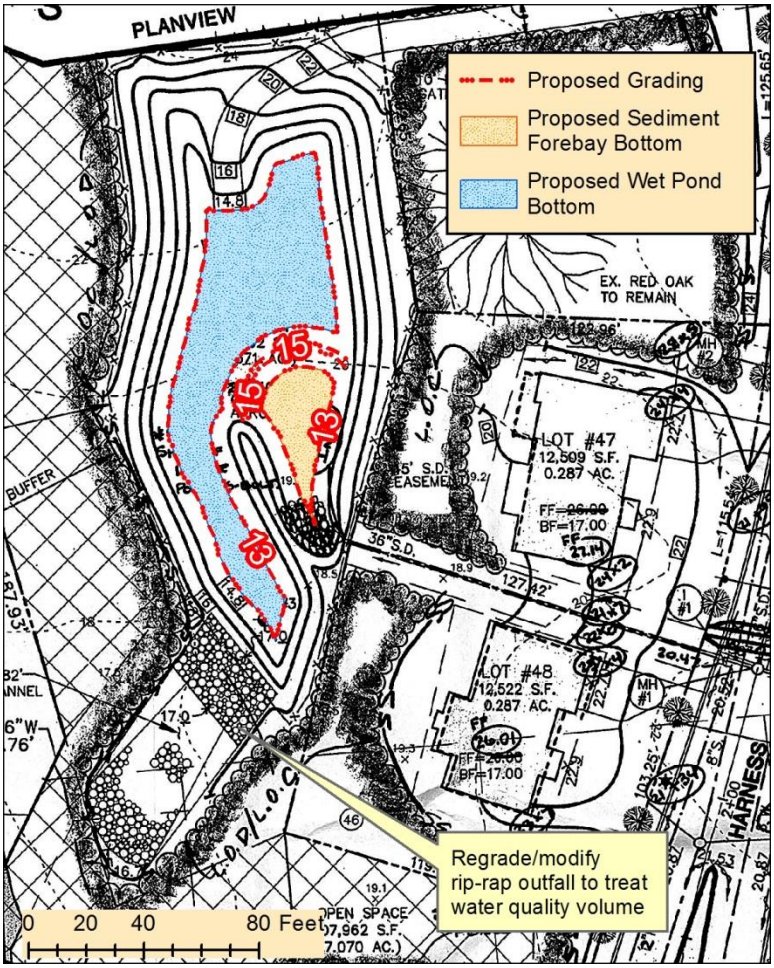

Figure 17: Proposed Retrofit Concept Design Detail Based on RWJ Associates Inc. 2001 As-Built

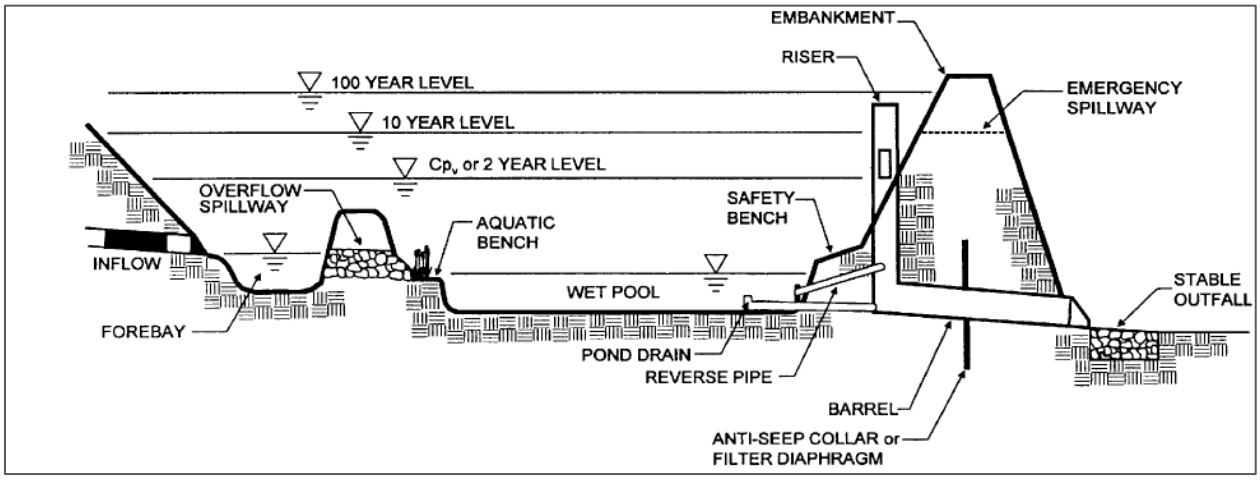

Figure 18: Typical Profile of Wet Pond (MDE 2000 *Stormwater Design Manual*)

Site Photographs

Existing Harness Creek View Court Wet Pond

Existing Outfall for Harness Creek View Court Wet Pond

Project ID: BMP_15

Total Treated Drainage Area: 37.4 acres
Total Treated Impervious Area: 14.5 acres
Total Additional Water Quality Volume (WQv):
~54,160 cubic feet; 1.24 acre-feet
Rainfall Depth Treated (Pe):1 inch
Annual Nutrient Removal:

- TN: 144.4 lbs
- TP: 13.2 lbs
- TSS: 4.4 tons

Existing Site Description

The existing site is a wet pond in a residential neighborhood. The facility is located south of Child's Point Road behind single-family homes and has an asphalt trail surrounding the facility. The property is listed as City owned. The pond receives runoff from Child's Point Road, Caleb Lane, Banneker Lane, and Pilot House Drive. Some algae was observed on the pond surface during the inspection. The facility has one inflow, which was mostly submerged during the inspection, and a concrete riser. The facility is surrounded by a wooden fence and has an asphalt walking path connecting to Child's Point Road. There are no known utilities in the area around the pond. The area surrounding the pond is landscaped and has several widely spaced medium sized trees. The soils in the area are hydrologic soil groups C and D. See Figure 19 for existing conditions.

Proposed Project Description

The proposed project involves retrofitting the existing wet pond to increase capacity. The proposed BMP will be designed in accordance with the MDE's *Stormwater Design Manual*. The pond would be excavated an additional 2 feet in depth, and a sediment forebay would be added that is separated from the rest of the pond with an earthen berm. Currently the pond is under capacity, and the retrofitted wet pond will be designed to provide the required capacity. Riser modifications would also be required to treat the additional water quality volume. Access could be maintained using existing asphalt paths. Wet pond retrofit will reduce pollutants such as TN, TP, and TSS. The additional pond capacity would manage stormwater runoff quality as well as quantity requirements, reducing flooding issues. This project will help the City of Annapolis achieve approximately 14.5 acres of impervious area credits toward its upcoming NPDES MS4 requirements. Figure 20 provides the schematic of the proposed wet pond retrofit, and Figure 21 provides a typical profile.

Feasibility Assessment

Property Ownership	The property is listed as City owned but is likely HOA owned; if this is the case, the City would need to coordinate with the HOA to obtain permission to implement this project.
Construction Access	The site can be accessed at Child's Point Road via asphalt walking path. The facility is surrounded by fence, and the gate is located along the asphalt path.
Utility Conflicts	Existing water and sewer lines run along Child's Point Road but should not affect the proposed project. No known utilities are located within the proposed project site.
Environmental Impacts	Because the trees are widely spaced, this project could be implemented without impacts on trees.
Design/Construction	Geotechnical investigation will be required to determine the infiltration rates of the soils in the project area during final design.

Plans and Permits

The following plans and permits may be required for the implementation of this project:

- Site/Schematic Development Application
- Stormwater Management Plan
- Natural Resources and Forest Stand Delineation
- Forest Conservation Plan/Buffer Management Plan
- Grading and Erosion Sediment Control Plan
- Temporary Traffic Control Plan
- MDSPGP for activities in US waters
- General Permit for Stormwater Discharge Associated with Construction Activity (if the area disturbed is greater than 1 acre)

Cost Estimate

Table 11: Cost Estimate for BMP 15 Retrofit

Item	Quantity	Units	Unit Cost	Total
Clear and Grub	3750	SY	$2.00	$7,500.00
Excavation and Hauling	2500	CY	$50.00	$125,000.00
Grading	3750	SY	$3.50	$13,125.00
Rip-Rap	50	CY	$130.00	$6,500.00
Clear Water Diversion Pipe	350	LF	$30.00	$10,500.00
Stabilized Construction Entrance	1	EA	$2,000.00	$2,000.00
Grass Seeding	1000	SY	$0.75	$750.00
Riser	1	EA	$6,000.00	$6,000.00
Topsoil	3750	SY	$4.00	$15,000.00
CY - Cubic Yards SY - Square Yards EA - Each LF - Linear Feet	Initial Project Costs			$186,375
		Contingency	20%	$37,275
	Erosion and Sediment Control		15%	$27,956
		Base Construction Costs		$251,606
		Mobilization	10%	$25,161
		Total Construction Cost[11]		**$276,767**
	20 Years Life Cycle Maintenance Cost[12] (Average Annual Maintenance Cost of $763)			$15,260

Computations

Table 12: Water Quality Volume (WQv) Calculations

Design Parameters	Site Value
Treated Drainage Area (ac), A	37.4
Percent Impervious Cover, I	38.8
Rainfall Depth (inches), P	1
Volumetric Runoff Coefficient, R_v	0.40
Water Quality Volume (acre-feet), WQ_v	**1.24**
Water Quality Volume (cubic-feet), WQ_v	**54,160**

[11]Additional cost of approximately $100,000 for design, environmental services, geotechnical investigation, survey, and permitting is assumed.
[12] University of Maryland. October 2011. Cost of Stormwater Management Practices in Maryland Counties.

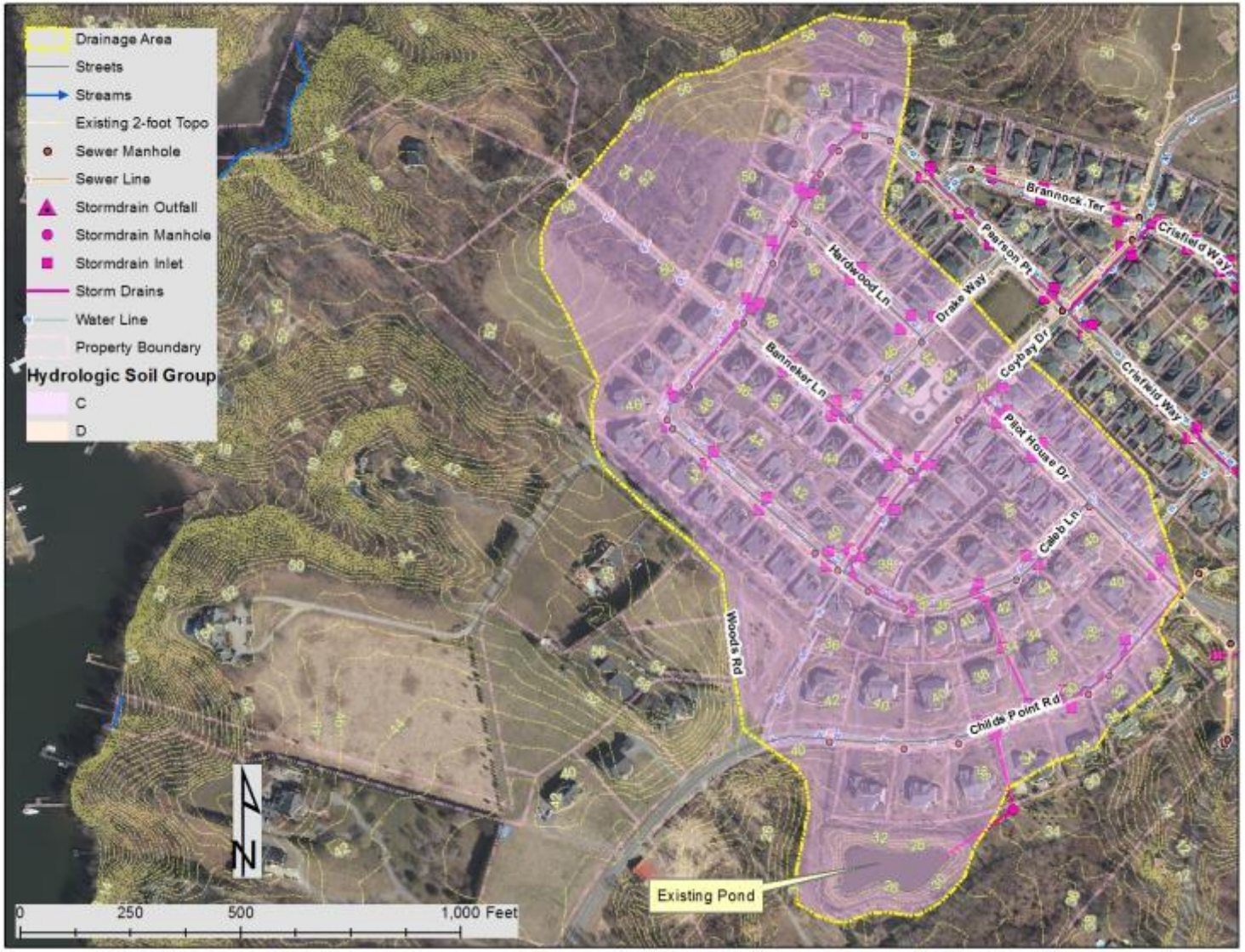

Figure 19: Existing Conditions and Drainage Area

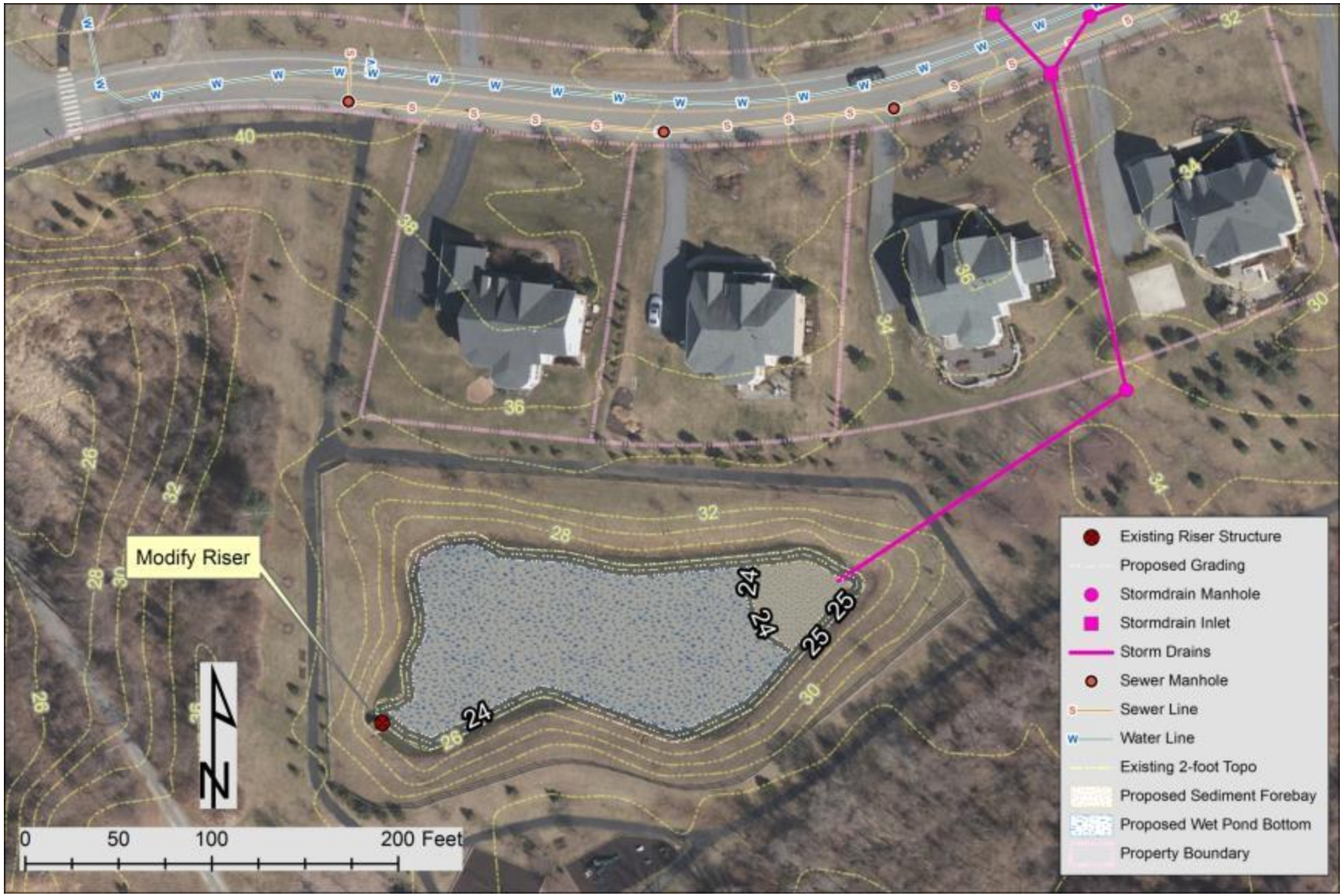

Figure 20: Proposed Retrofit Concept Design

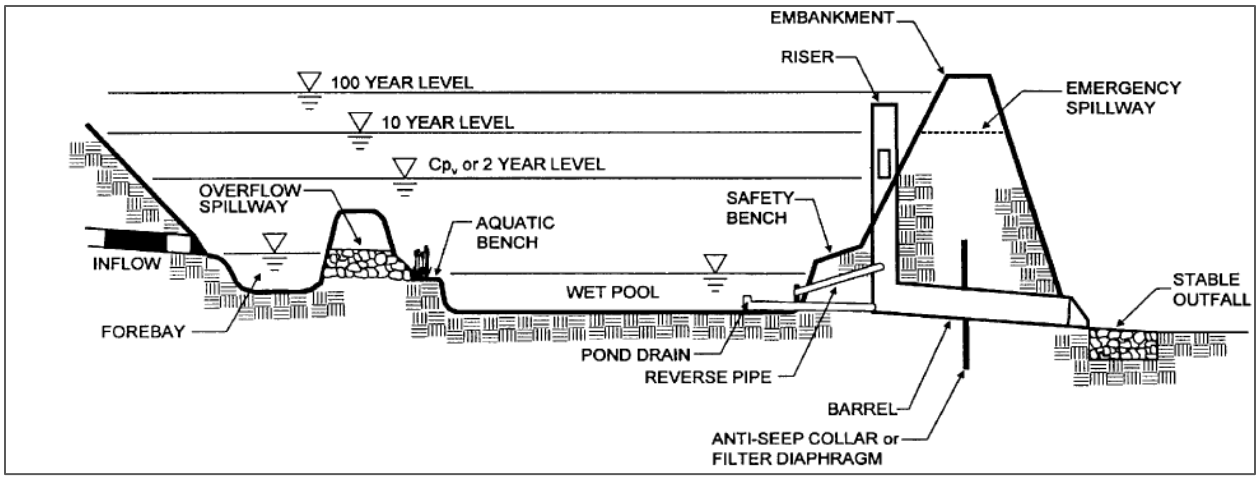

Figure 21: Typical Profile of Wet Pond (MDE 2000 *Stormwater Design Manual*)

Site Photographs

Existing Facility

Access to Site

Existing Riser Structure

Project ID: BMP_17

Total Treated Drainage Area: 0.69 acre
Total Treated Impervious Area: 0.47 acre
Total Water Quality Volume (WQv):
~1,647 cubic feet; 0.04 acre-foot
Rainfall Depth Treated (Pe): 1 inch
Annual Nutrient Removal:

- TN: 2.7 lbs
- TP: 0.2 lb
- TSS: 0.1 ton

Existing Site Description

The existing infiltration trench is at the northwest end of the Georgetown Plaza, a commercial property on Bay Ridge Road. A curb cut at the northwest end of the parking lot, adjacent to the infiltration trench, collects stormwater runoff from the western portion of the parking lot and discharges to the infiltration trench. Excess flow from the infiltration trench is captured by the yard inlet located at the northeast end of the property. A portion of open area located northwest of the property also drains to the infiltration trench. The open area currently has some trees. The infiltration trench was constructed in 1986, prior to the current Maryland stormwater management standards, and therefore does not receive any credit for stormwater management.

A wooden fence surrounds the perimeter of the infiltration trench. Neither sanitary sewer lines nor water lines were identified in the vicinity of the infiltration trench. The soils in the drainage area are hydrologic soil groups C and D, and the infiltration trench is located over hydrologic group C soils. The infiltration trench is located on a parcel owned by a private owner. Figure 22 shows the existing conditions map with drainage area.

Proposed Project Description

The proposed project would convert the existing infiltration trench to a bioretention facility. A bioretention would be designed using MDE's *Stormwater Design Manual*. The existing curb cut at the northwest end of the property would serve as one inlet to the proposed bioretention. A second inlet would be created by adding a curb cut to the parking lot. Pretreatment sediment basins will be excavated at the two inlets to reduce sedimentation within the bioretention. A weir would be constructed to convey runoff from the sediment basins to the bioretention facility, and an underdrain would be installed within the bioretention facility with a two cleanout pipes for maintenance of the system. The new weir would provide overflow from the bioretention (for flows greater than the water quality storm) to the yard inlet at the north east end of the property. A ponding depth of 1 foot would accumulate in the bioretention to capture and treat the design water quality volume. Excavation of the existing infiltration trench and adjacent open area will result in removal of approximately four existing trees in the open area.

Implementation of the bioretention would reduce pollutants such as TN, TP, and TSS. This project will help the City of Annapolis achieve approximately 0.47 acre of impervious area credits toward its upcoming NPDES MS4 requirements. Figure 23 provides the schematic of the proposed bioretention system, and Figure 24 provides a typical profile.

Feasibility Assessment

Property Ownership	The property is privately owned; the City would need to coordinate with the property owner to obtain permission to implement this project.
Construction Access	The site can be accessed from the parking lot of Georgetown Plaza located on Bay Ridge Road. Area is available to stage construction activities. Existing slopes are navigable by construction equipment.
Utility Conflicts	There are no sanitary sewer lines or water lines in the project area. Though there were no indicators of underground electric utilities at the project site (i.e., no light poles or utility boxes), confirmation should be obtained during final design.
Environmental Impacts	There are approximately 4 trees in the open space adjacent to the infiltration trench that would be affected by this project.
Design/Construction	Geotechnical investigation will be required to determine the groundwater elevation and the infiltration rate in the project area during final design. If the infiltration rate is 0.52 inch per hour or greater, then the underdrain may not be required.

Plans and Permits

The following plans and permits may be required for the implementation of this project:

- Site/Schematic Development Application
- Stormwater Management Plan
- Grading and Erosion Sediment Control Plan

Cost Estimate

Table 13: Cost Estimate for BMP 17 Retrofit

Item	Quantity	Units	Unit Cost	Total
Clear and Grub	500	SY	$2.00	$1,000.00
Excavation and Hauling	410	CY	$50.00	$20,500.00
Grading	410	SY	$3.50	$1,435.00
Tree Removal	4	EA	$800.00	$3,200.00
Rip-Rap	100	CY	$130.00	$13,000.00
Stabilized Construction Entrance	1	EA	$2,000.00	$2,000.00
Gravel Bed	40	TON	$38.00	$1,520.00
Bioretention Soil Mix	110	CY	$150.00	$16,500.00
Mulch	140	SY	$7.00	$980.00
Bioretention Plantings – Trees	4	EA	$300.00	$1,200.00
Bioretention Plantings – Shrubs	20	EA	$57.40	$1,148.00
Bioretention Plantings – Herbaceous Plants	270	EA	$7.00	$1,890.00
6-inch Perforated PVC Underdrains	110	LF	$15.00	$1,650.00
Cleanout Pipes	1	EA	$240.00	$480.00
CY - Cubic Yards SY - Square Yards EA - Each LF - Linear Feet			Initial Project Costs	$66,503
		Contingency	20%	$13,301
		Erosion and Sediment Control	15%	$9,975
		Base Construction Costs		$89,779
		Mobilization	10%	$8,978
		Total Construction Cost[13]		**$98,757**
		20 Years Life Cycle Maintenance Cost[14] (Average Annual Maintenance Cost of $1,531)		$30,620

[13]Additional cost of approximately $100,000 for design, environmental services, geotechnical investigation, survey, and permitting is assumed.
[14] University of Maryland. October 2011. Cost of Stormwater Management Practices in Maryland Counties.

Computations

Table 14: Water Quality Volume (WQv) Calculations

Design Parameters	**Site Value**
Treated Drainage Area (acres), A	0.69
Percent Impervious Cover, I	68%
Rainfall Depth (inches), P	1
Volumetric Runoff Coefficient, R_v	0.66
Water Quality Volume (acre-feet), WQ_v	**0.04**
Water Quality Volume (cubic-feet), WQ_v	**1,647**

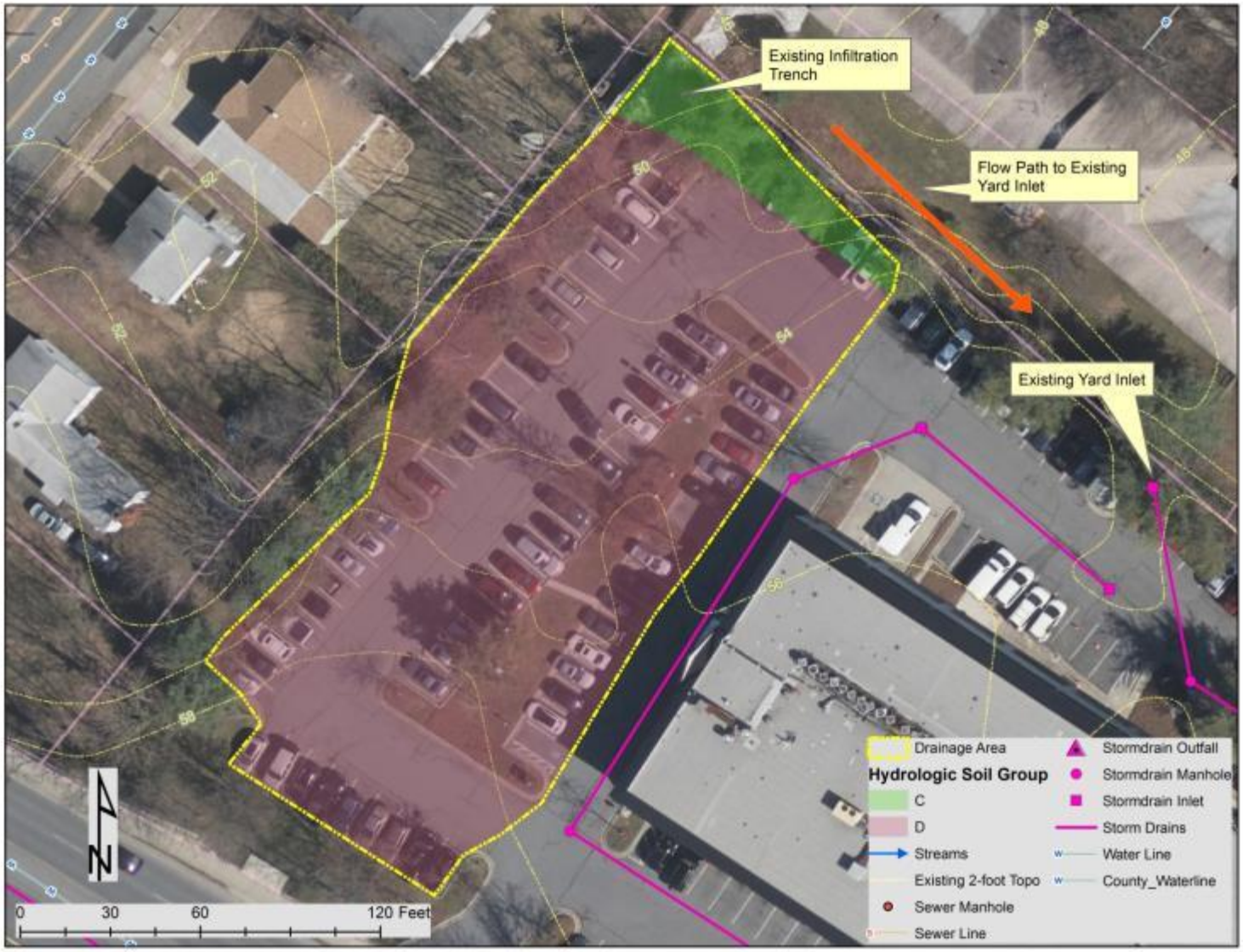

Figure 22: Existing Conditions and Drainage Area

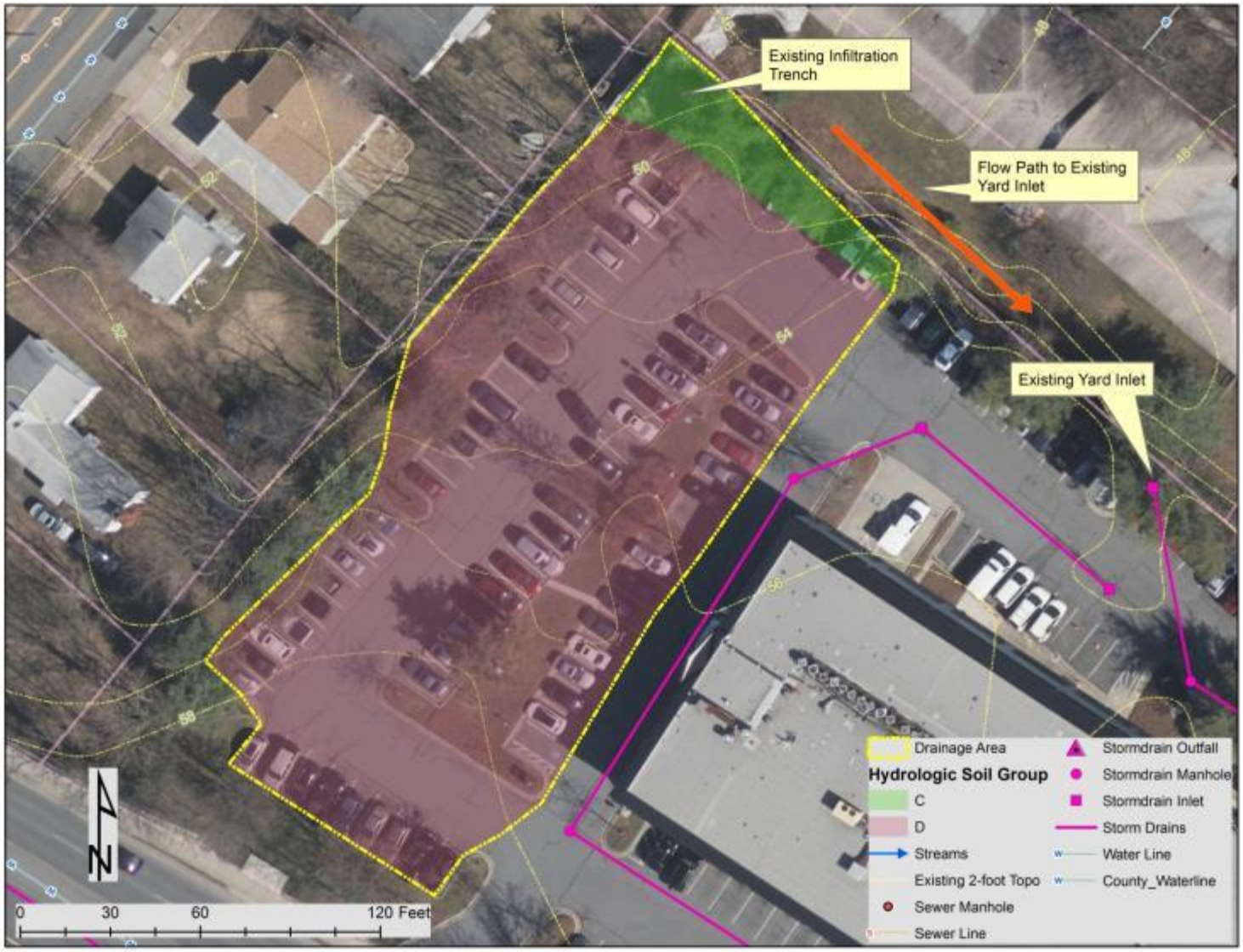

Figure 23: Proposed Retrofit Concept Design

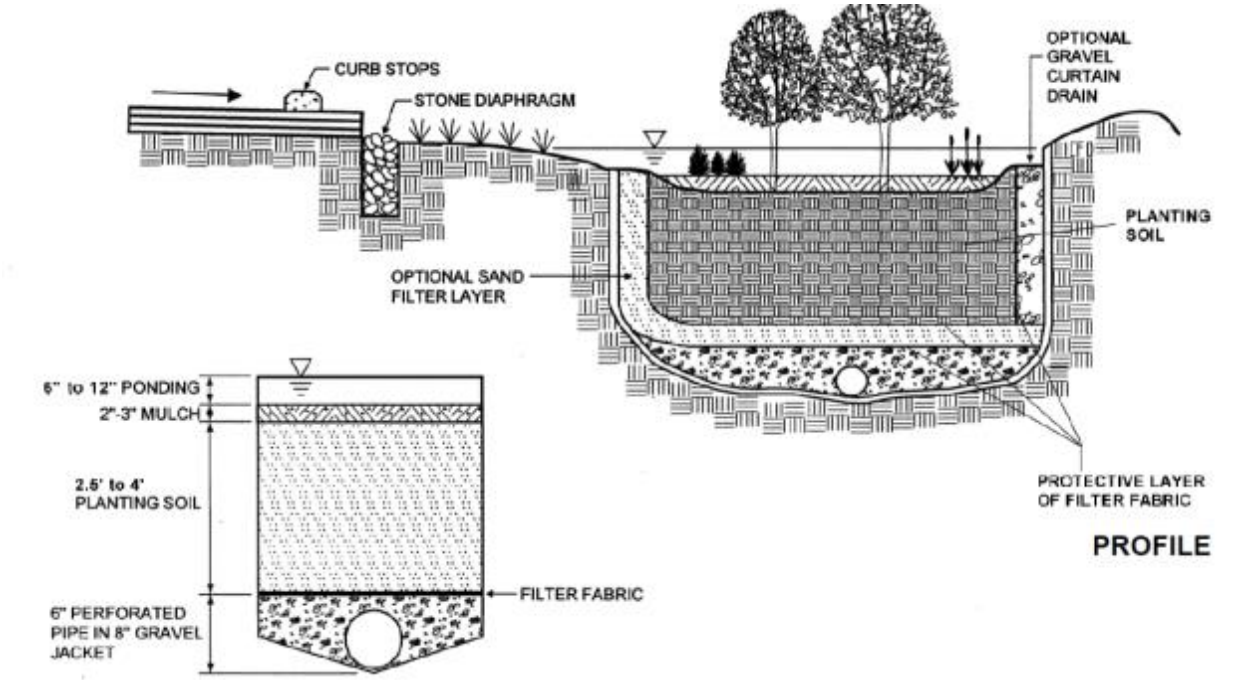

Figure 24: Typical Profile of Bioretention (MDE 2000 *Stormwater Design Manual*)

Site Photographs

Existing Infiltration Trench at the North End of Georgetown Plaza

Project ID: BMP_20

Total Treated Drainage Area: 56.8 acres
Total Treated Impervious Area: 39.8 acres
Total Additional Water Quality Volume (WQv):
~140,336 cubic feet; 3.22 acre-feet
Rainfall Depth Treated (Pe): 1 inch
Annual Nutrient Removal:

- TN: 219 lbs
- TP: 20.1 lbs
- TSS: 6.7 tons

Existing Site Description

The existing site is a wet pond located in a commercial area along Moreland Parkway behind a parking lot. Site ownership of the pond is unknown. The pond has one 60-inch RCP inflow and receives runoff from Moreland Parkway, Bowman Court, West Street, and parking lots on both sides of Lee Street. Part of the pond bottom appears to be lined with concrete, although the extent was unclear during the field investigation. The facility does not have a riser, but instead the outlet is a large gabion weir. Sediment has accumulated in the middle of the pond. The outfall channel is stagnant and not clearly defined. The area surrounding the facility is wooded and has several large trees. There are no utilities in the area of the pond, but an existing water and sewer line run along Moreland Parkway. The soils in the area are hydrologic soil groups C and D. See Figure 25 for existing conditions.

Proposed Project Description

The proposed project entails retrofitting the existing wet pond to increase capacity. The proposed BMP will be designed in accordance with the MDE's *Stormwater Design Manual*. The pond would be extended up to 100 feet to the north and excavated to additional depth, and a sediment forebay would be added that is separated from the rest of the pond with an earthen berm. A riser is also proposed to treat the additional water volume. Additional pond capacity may also reduce flooding downstream of the existing facility.

Based on the soil types in the vicinity of the pond and the large drainage area, a lining is not proposed for the excavated areas. The existing pond embankment may have already been designed to the MD-378 standards provided by the Maryland NRCS; however, if it was not, it is possible that the embankment design category will change and require upgrading to the MD-378 standards. Construction access is available from the parking lot at Moreland Parkway.

A wet pond retrofit will reduce pollutants such as TN, TP, and TSS. The additional pond capacity would manage stormwater runoff quality as well as quantity. This project will help the City of Annapolis achieve approximately 39.8 acres of impervious area credits toward its

upcoming NPDES MS4 requirements. Figure 26 provides the schematic of the proposed wet pond retrofit, and Figure 27 provides a typical profile.

Feasibility Assessment

Property Ownership	The property owner is unknown, though it is most likely either privately owned or owned by the City. The City would need to coordinate with the property owner to obtain permission to implement this project.
Construction Access	The site can be accessed from the slope from the parking lot along Moreland Parkway.
Utility Conflicts	Existing water and sewer lines run along Moreland Parkway but should not affect the proposed project. No utilities were identified within the proposed project site.
Environmental Impacts	The area surrounding the pond and downstream of the existing facility is heavily wooded, and several large trees would be affected by the proposed retrofit.
Design/Construction	Geotechnical investigation will be required to determine the infiltration rates of the soils in the project area during final design. If the pond qualifies as an MD-378 pond, any retrofit would also require upgrading the pond to meet the current MD-378 small pond standards.

Plans and Permits

The following plans and permits may be required for the implementation of this project:

- Site/Schematic Development Application
- Stormwater Management Plan
- Natural Resources and Forest Stand Delineation
- Forest Conservation Plan/Buffer Management Plan
- Grading and Erosion Sediment Control Plan
- Temporary Traffic Control Plan
- MDSPGP for activities in US waters
- General Permit for Stormwater Discharge Associated with Construction Activity (if the area disturbed is greater than 1 acre)

Cost Estimate

Table 15: Cost Estimate for BMP 20 Retrofit

Item	Quantity	Units	Unit Cost	Total
Clear and Grub	3350	SY	$2.00	$6,700.00
Excavation and Hauling	2140	CY	$50.00	$107,000.00
Grading	3200	SY	$3.50	$11,200.00
Tree Removal	50	EA	$800.00	$40,000.00
Rip-Rap	50	CY	$130.00	$6,500.00
Stabilized Construction Entrance	1	EA	$2,000.00	$2,000.00
Grass Seeding	1000	SY	$0.75	$750.00
Riser	1	EA	$6,000.00	$6,000.00
Topsoil	3200	SY	$4.00	$12,800.00
CY - Cubic Yards SY - Square Yards EA - Each LF - Linear Feet			Initial Project Costs	$192,950.00
		Contingency	20%	$38,590
		Erosion and Sediment Control	15%	$28,943
		Base Construction Costs		$260,483
		Mobilization	10%	$26,048
		Total Construction Cost[15]		**$286,531**
		20 Years Life Cycle Maintenance Cost[16] (Average Annual Maintenance Cost of $763)		$15,260

Computations

Table 16: Water Quality Volume (WQv) Calculations

Design Parameters	Site Value
Treated Drainage Area (ac), A	56.8
Percent Impervious Cover, I	70.1
Rainfall Depth (inches), P	1
Volumetric Runoff Coefficient, R_v	0.68
Water Quality Volume (acre-feet), WQ_v	**3.22**
Water Quality Volume (cubic-feet), WQ_v	**140,336**

[15]Additional cost of approximately $100,000 for design, environmental services, geotechnical investigation, survey, and permitting is assumed.
[16] University of Maryland. October 2011. Cost of Stormwater Management Practices in Maryland Counties.

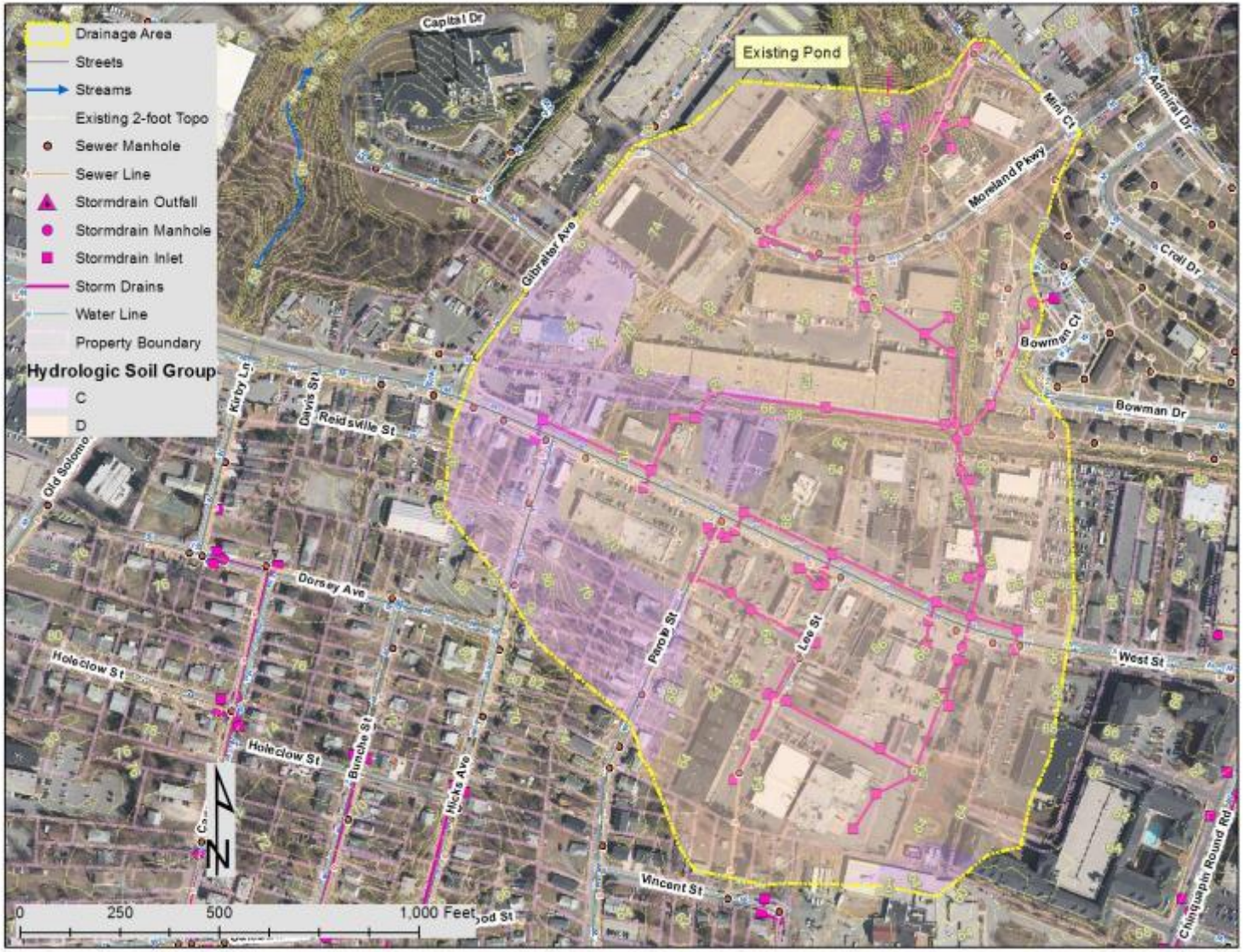

Figure 25: Existing Conditions and Drainage Area

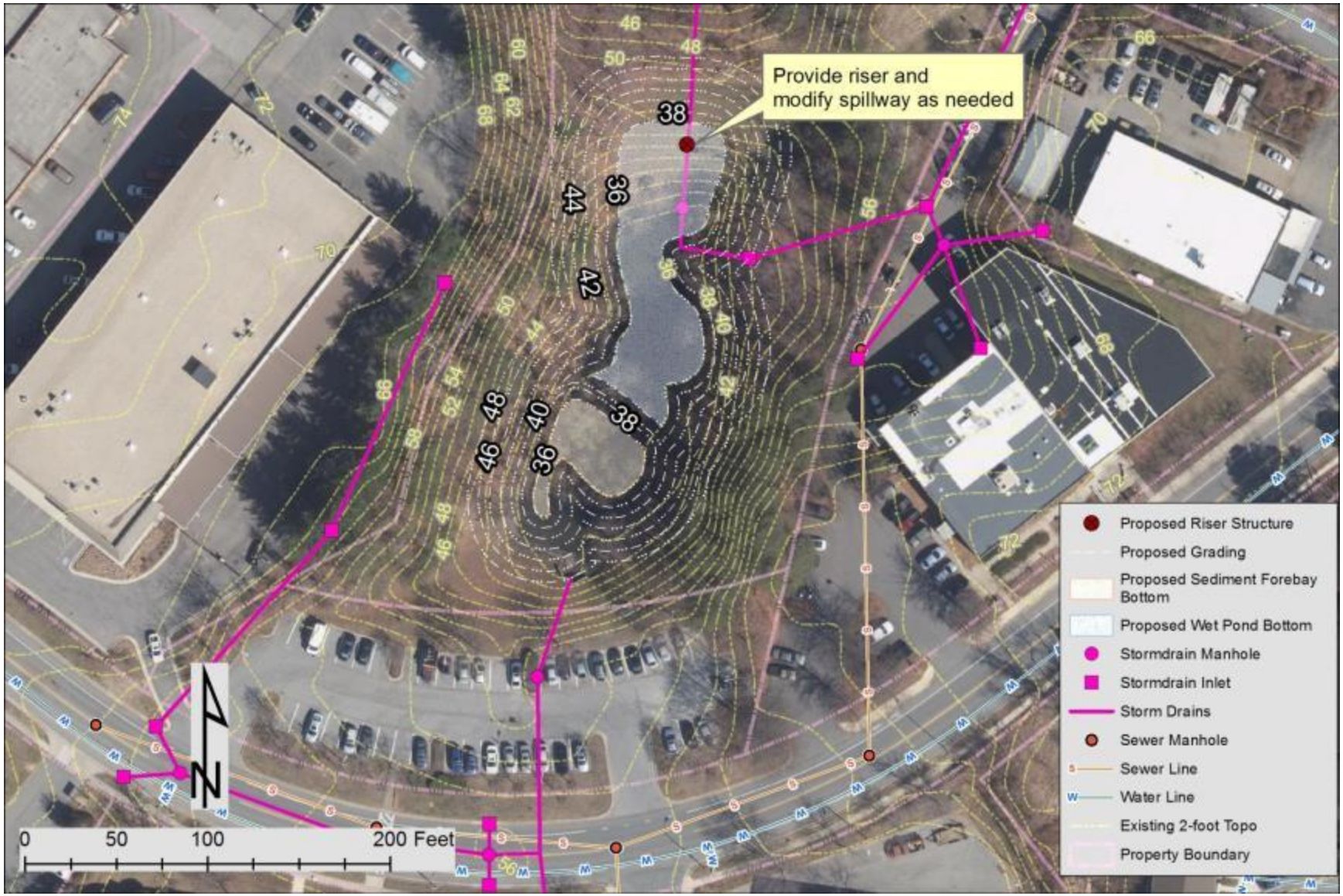

Figure 26: Proposed Retrofit Concept Design

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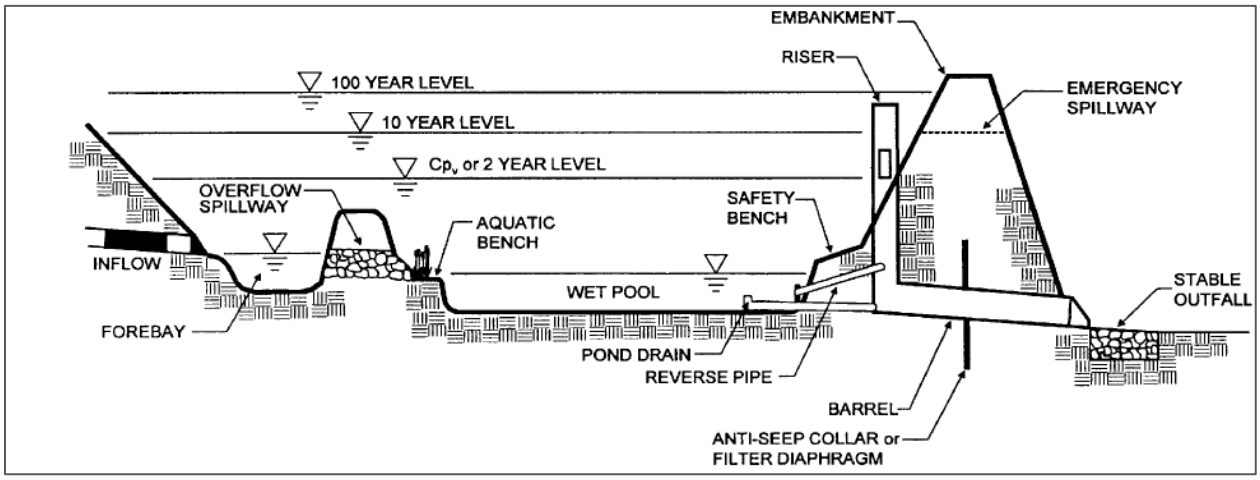


Figure 27: Typical Profile of Wet Pond (MDE 2000 *Stormwater Design Manual*)

Site Photographs

Existing Wet Pond North of Moreland Parkway

Existing Wet Pond Gabion Outlet Structure

Existing Pond Outfall

Project ID: BMP_21

Total Treated Drainage Area: 55.6 acres
Total Treated Impervious Area: 19.2 acres
Total Water Quality Volume (WQv):
~73,700 cubic feet; 1.67 acre-feet
Rainfall Depth Treated (Pe): 1 inch
Annual Nutrient Removal:

- TN: 215 lbs
- TP: 20 lbs
- TSS: 6.6 tons

Existing Site Description

The existing pond is located at the Ambridge community northeast of the intersection of Langdon Court and Berwick Drive. A 48-inch concrete drainage pipe discharges to the pond and collects runoff from the Ambridge HOA, as well as portions of Janwall Street, Woods Drive, Summerfield Drive, and Ellington Drive. The pond has a principal spillway riser structure and emergency riser structure that drain to outfalls upstream of Back Creek via 36-inch and 48-inch pipes, respectively.

The pond is approximately 800 feet upstream of the nearest FEMA 100-year floodplain. The pond may have been designed as a dry pond, although during the field visit, the ground was saturated and some areas had up to 1 foot of standing water. Several trees are currently growing within the pond or on the embankment. Neither sanitary sewer lines nor water lines were identified in the vicinity of the existing pond. The soils in the drainage area are hydrologic soil groups C and D, and the pond is located over hydrologic group D soils. Figure 28 shows the existing conditions map with drainage area.

Proposed Project Description

The proposed project involves upgrading the existing pond to meet current stormwater management standards. The retrofitted wet pond will be designed using MDE's *Stormwater Design Manual*. The pond will be excavated approximately 2 feet to provide a 4-foot-deep pool, with some of the excavated materials used to create a sediment forebay and to increase the elevation at the northwestern end of the pond. Raising the elevation at the northwestern end of the pond would reduce the likelihood of the retrofit flooding the yards of adjacent properties. The existing fence around the facility will be upgraded to prevent unauthorized access to the facility and/or a safety bench will be added. The sediment forebay will be placed along the northwestern face of the pond starting at the existing stormdrain inlet. This will reduce sedimentation in the pond, and as it will be placed downstream of the existing drainage easement, sediment can be removed periodically. This will improve the water quality in the pond while meeting current MDE standards. The existing principal spillway structure will need to be

modified, and the weir elevation of the emergency overflow riser may need to be raised (likely by adding concrete). The existing pond embankment may have already been designed to the MD-378 standards provided by the Maryland NRCS; however, if it was not, it is possible that the embankment design category will change and require upgrading to the MD-378 standards.

Approximately 2 feet of excavation will be required within the pond, although the footprint of the pond will not be altered. Several trees and brushy vegetation will need to be removed from the pond and the embankment. A maximum slope of 3:1 (Horizontal: Vertical) is recommended for all proposed embankments. Geotechnical analysis will be required to identify soil properties and the location of the groundwater table.

Retrofitting the existing wet pond would reduce pollutants such as TN, TP, and TSS. This project will help the City of Annapolis achieve approximately 19.2 acres of impervious area credits toward its upcoming NPDES MS4 requirements. Figure 29 provides the schematic of the proposed wet pond, and Figure 30 provides a typical profile.

Feasibility Assessment

Property Ownership	The property is owned by an HOA, and several privately owned properties. The City would need to coordinate with the HOA and the private property owners to obtain permission to implement this project.
Construction Access	The site can be accessed from the maintenance easement from Langdon Court to the existing pond. Open area is available to stage construction activities, although temporary easements may be necessary. Existing slopes toward the west of the pond are navigable by construction equipment.
Utility Conflicts	There are no sanitary sewer lines or water lines in the project area. Though there were no indicators of underground electric utilities at the project site (i.e., no light poles or utility boxes), confirmation should be obtained during final design.
Environmental Impacts	More than 12 trees are anticipated to be affected as part of this project.
Design/Construction	Geotechnical investigation will be required to determine the soils and location of the groundwater table in the project area during final design. If the pond qualifies as an MD-378 pond, any retrofit would also require upgrading the pond to meet the current MD-378 small pond standards.

Plans and Permits

The following plans and permits may be required for the implementation of this project:

- Site/Schematic Development Application
- Stormwater Management Plan
- Grading and Erosion Sediment Control Plan
- Temporary Traffic Control Plan
- MD-378 Pond Approval

Cost Estimate

Table 17: Cost Estimate for BMP 21 Retrofit

Item	Quantity	Units	Unit Cost	Total
Clear and Grub	500	SY	$2.00	$1,000.00
Excavation and Hauling	340	CY	$50.00	$17,000.00
Grading	3500	SY	$3.50	$12,250.00
Rip-Rap	120	CY	$130.00	$15,600.00
Stabilized Construction Entrance	1	EA	$2,000.00	$2,000.00
Grass Seeding	3000	SY	$0.75	$2,250.00
Yard Inlets	1	EA	$1,240.00	$1,240.00
Fence	1020	LF	$25.00	$25,500.00
Concrete to Raise Overflow Structure	2	CY	$900.00	$1,800.00
Principle Spillway Riser Structure	1	EA	$1,850.00	$1,850.00
CY - Cubic Yards SY - Square Yards EA - Each LF - Linear Feet			Initial Project Costs	$80,490
		Contingency	20%	$16,098
		Erosion and Sediment Control	15%	$12,074
		Base Construction Costs		$108,662
		Mobilization	10%	$10,866
		Total Construction Cost[17]		**$119,528**
		20 Years Life Cycle Maintenance Cost[18] (Average Annual Maintenance Cost of $763)		$15,260

[17] Additional cost of approximately $100,000 for design, environmental services, geotechnical investigation, survey, and permitting is assumed.
[18] University of Maryland. October 2011. Cost of Stormwater Management Practices in Maryland Counties.

Computations

Table 18: Water Quality Volume (WQv) Calculations

Design Parameters	**Site Value**
Treated Drainage Area (acres), A	55.6
Percent Impervious Cover, I	35%
Rainfall Depth (inches), P	1.0
Volumetric Runoff Coefficient, R_v	0.36
Water Quality Volume (acre-feet), WQ_v	**1.67**
Water Quality Volume (cubic-feet), WQ_v	**72,700**

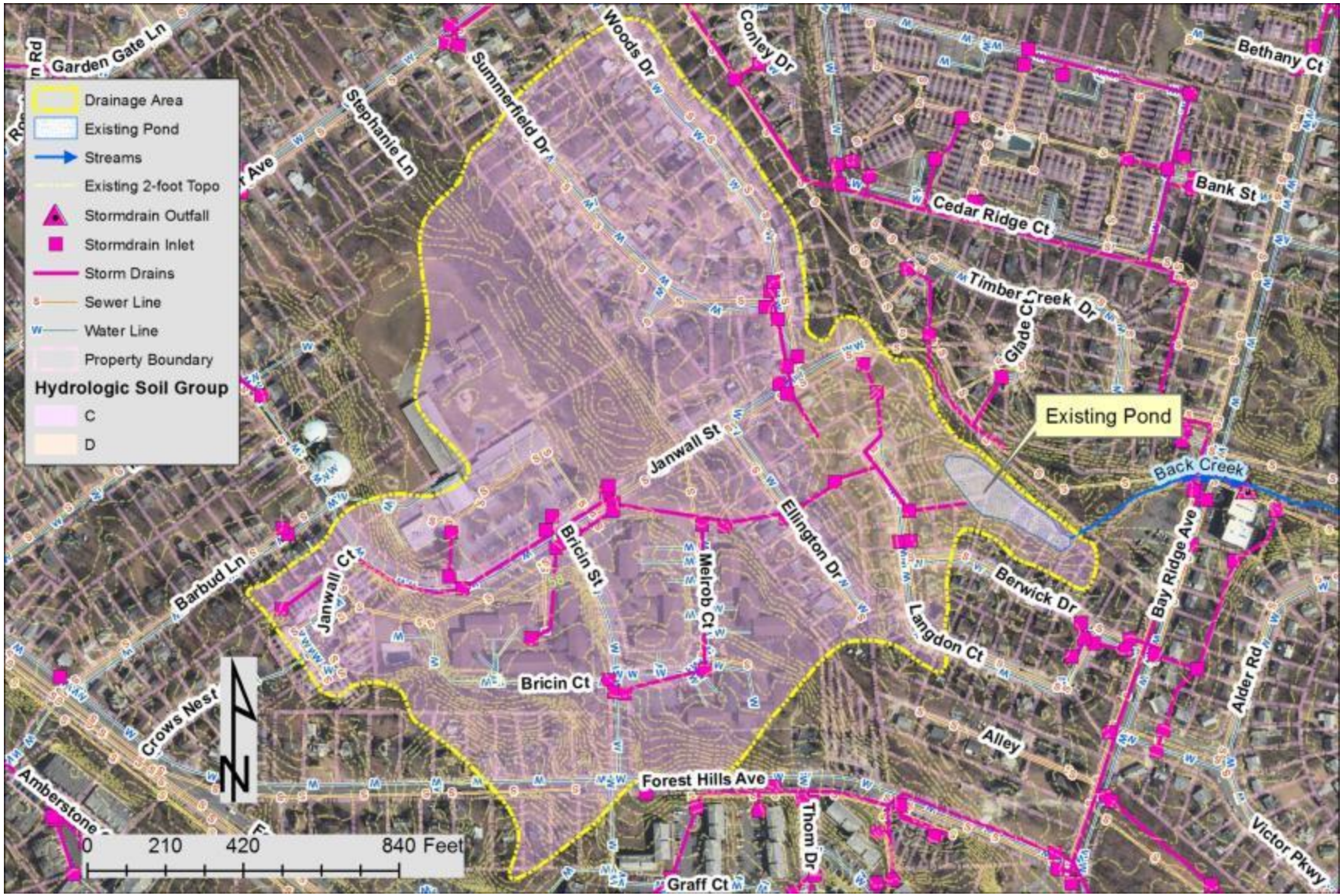


Figure 28: Existing Conditions and Drainage Area

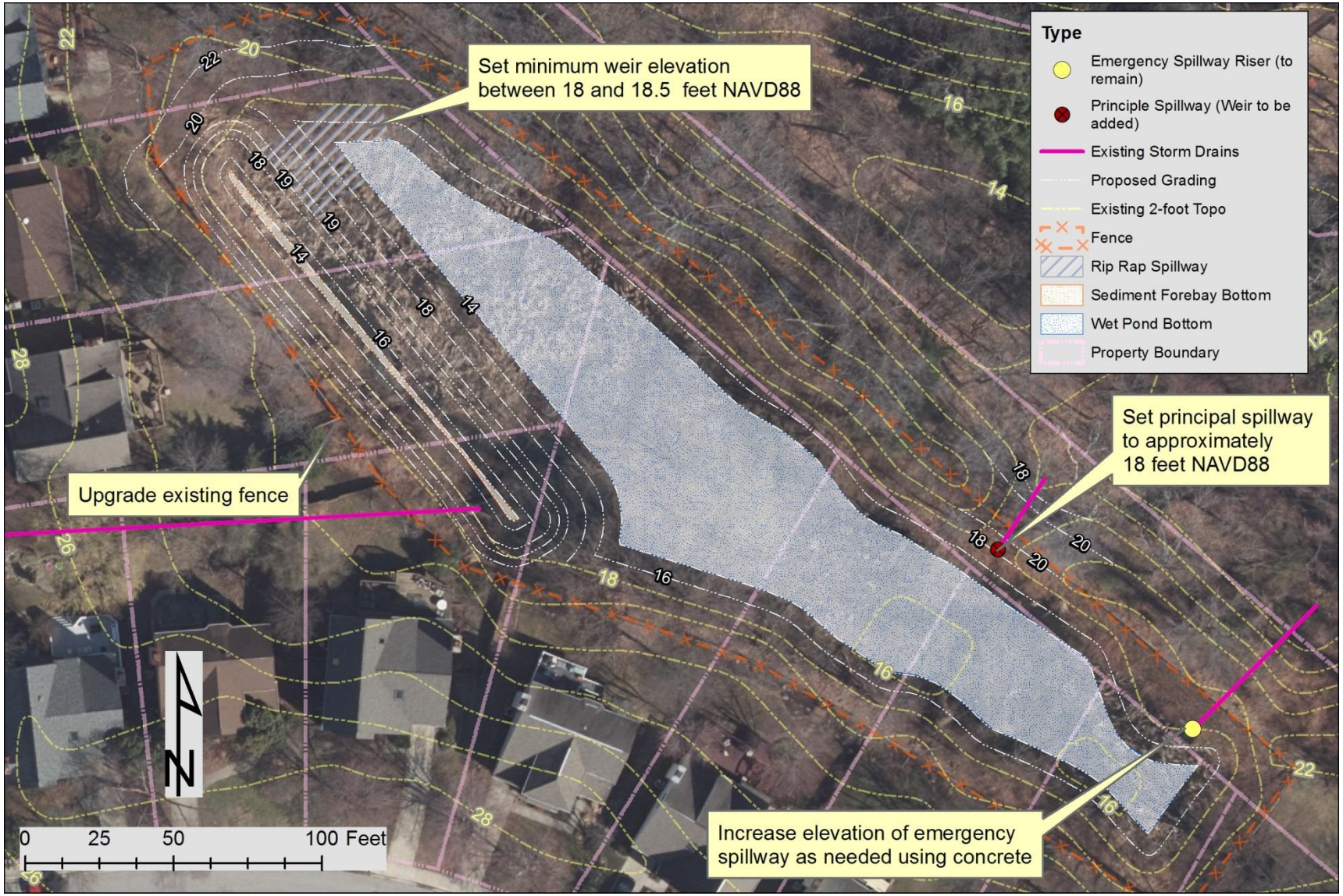


Figure 29: Proposed Retrofit Concept Design

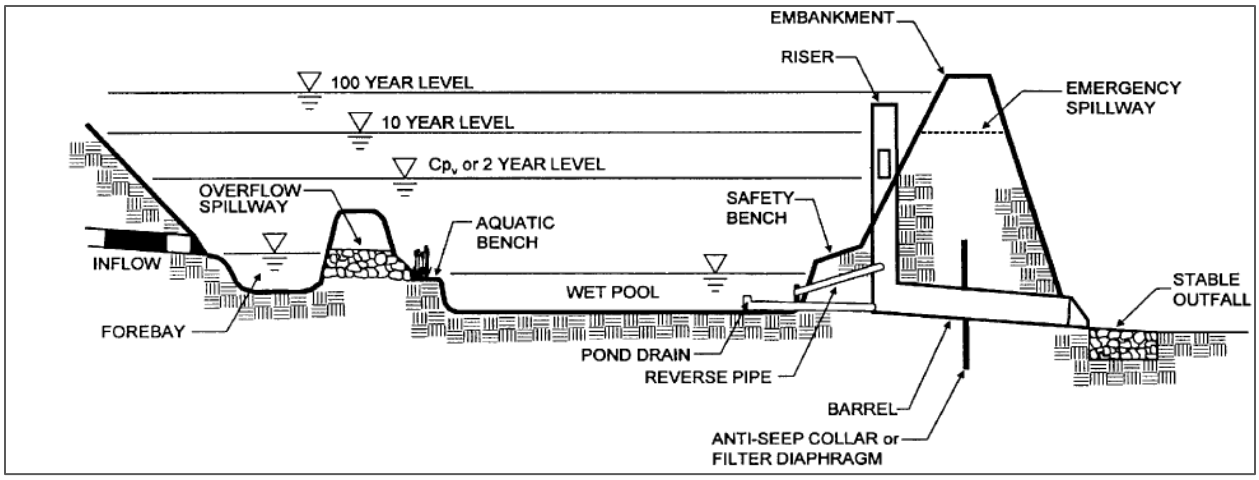


Figure 30: Typical Profile of Wet Pond (MDE 2000 *Stormwater Design Manual*)

Site Photographs

Existing Ambridge Pond (including Emergency Spillway Riser)

Existing Ambridge Pond Principal Spillway (with 36-inch pipe through embankment)

Project ID: BMP_22

Total Treated Drainage Area: 0.51 acre
Total Treated Impervious Area: 0.16 acre
Total Water Quality Volume (WQv):
~920 cubic feet; 0.021 acre-foot
Additional Rainfall Depth Treated (Pe): 0.5 inch
Additional Annual Nutrient Removal:

- TN: 0.4 lb
- TP: 0.04 lb
- TSS: 0.01 ton

Existing Site Description

The existing site is composed of a grass swale that drains to a bioretention area. The bioretention area is primarily composed of bare soil and grass, and has two PVC cleanout pipes. According to the 2002 design plans, the facility has a 6-inch perforated PVC underdrain that ties into a 24-inch storm drain pipe downstream of the grate inlet. This site was selected by the City of Annapolis based on feedback from residents after submission of the interim submittal.

The site is located in the LDA; however, Anne Arundel County does not have additional requirements for stormwater management in the LDA. Neither sanitary sewer lines nor water lines were identified in the vicinity of the existing bioretention or swale, although an electric utility box is located northeast of the existing swale approximately 130 feet from the bioretention area. The soils in the drainage area are hydrologic soil groups B. The bioretention and swale are located on parcel owned by the City of Annapolis. Figure 31 shows the existing conditions map with drainage area.

Proposed Project Description

The proposed project entails adding vegetation to the existing bioretention, retrofitting part of the existing grass swale to a bio-swale, and adding educational signs at the site. It is recommended that native and aesthetically pleasing bushes, flowers, and grasses be added to the bioretention area based on feedback from residents. This will provide water quality benefits while improving the aesthetics of the bioretention. A peat gravel walkway could also be added to allow residents to walk through the facility to better examine the proposed vegetation.

A bio-swale would be designed using MDE's *Stormwater Design Manual*. To avoid impacts on utilities, the proposed bio-swale would extend from the bioretention to approximately 10 feet southwest of the existing electric utility box. Excavation will be required to implement 2 feet of planting media and 0.5 foot of gravel, although the design slope and grade will be maintained. An underdrain is not recommended because the soils are hydrologic group B, and this bio-swale will drain to the existing bioretention area (effectively acting as a joint system). Native and

aesthetically pleasing trees, bushes, flowers, and grasses are recommended that are visible from the sidewalk along Rowe Boulevard and from the residences.

Two educational signs are recommended to explain the function and purpose of the bioretention and bio-swale. One would be placed within the property, and the other adjacent to the sidewalk along Rowe Boulevard. These signs will help educate the public on the purposes of stormwater management in the City, and how these types of practices protect the Chesapeake Bay.

Implementation of the bio-swale would reduce pollutants such as TN, TP, and TSS. This project will help the City of Annapolis achieve approximately 0.02 additional impervious acre credits toward its upcoming NPDES MS4 requirements. Figure 32 provides the schematic of the proposed bio-swale, and Figure 33 provides a typical profile.

Feasibility Assessment

Property Ownership	The property is City owned, so no additional easements will be necessary.
Construction Access	The site can be accessed by Bloomsbury Square. Existing slopes are navigable by construction equipment.
Utility Conflicts	There are no sanitary sewer lines or water lines in the project area. One utility box was identified outside the proposed project area; however, confirmation should be obtained for all utilities during final design.
Environmental Impacts	Several trees are located in the existing bioretention and west of the proposed bio-swale, but no impacts are anticipated.
Design/Construction	Geotechnical investigation will be required to confirm that an underdrain is not required for the bio-swale.

Plans and Permits

The following plans and permits may be required for the implementation of this project:

- Site/Schematic Development Application
- Stormwater Management Plan
- Grading and Erosion Sediment Control Plan

Cost Estimate

Table 19: Cost Estimate for BMP 22 Retrofit

Item	Quantity	Units	Unit Cost	Total
Clear and Grub	250	SY	$2.00	$500.00
Excavation and Hauling	50	CY	$50.00	$2,500.00
Grading	250	SY	$3.50	$875.00
Stabilized Construction Entrance	1	EA	$2,000.00	$2,000.00
Gravel Bed	10	TON	$38.00	$380.00
Bioretention Soil Mix	50	CY	$150.00	$7,500.00
Bioretention Plantings -Trees	10	EA	$300.00	$3,000.00
Bioretention Plantings- Shrubs	30	EA	$57.40	$1,722.00
Bioretention Plantings - Herbaceous Plants	400	EA	$7.00	$2,800.00
Mulch	50	SY	$7.00	$350.00
Grass Seeding	250	SY	$0.75	$188.00
Educational Sign	2	EA	$1,000.00	$2,000.00
CY - Cubic Yards SY - Square Yards EA - Each LF - Linear Feet			Initial Project Costs	$23,815
		Contingency	20%	$4,763
		Erosion and Sediment Control	15%	$3,572
		Base Construction Costs		$32,150
		Mobilization	10%	$3,215
		Total Construction Cost[19]		**$35,365**
		20 Years Life Cycle Maintenance Cost[20] (Average Annual Maintenance Cost of $1,531)		$30,620

[19] Additional cost of approximately $100,000 for design, environmental services, geotechnical investigation, survey, and permitting is assumed.
[20] University of Maryland. October 2011. Cost of Stormwater Management Practices in Maryland Counties.

Computations

Table 20: Water Quality Volume (WQv) Calculations

Design Parameters	**Site Value**
Treated Drainage Area (acres), A	0.51
Percent Impervious Cover, I	31%
Rainfall Depth Treated by Existing Bioretention (inches),	1
Rainfall Depth Treated by Proposed Bio-Swale (inches)	0.5
Total Rainfall Depth Treated	1.5
Volumetric Runoff Coefficient, R_v	0.52
Water Quality Volume (acre-feet), WQ_v	**0.021**
Water Quality Volume (cubic-feet), WQ_v	**920**

Figure 31: Existing Conditions and Drainage Area

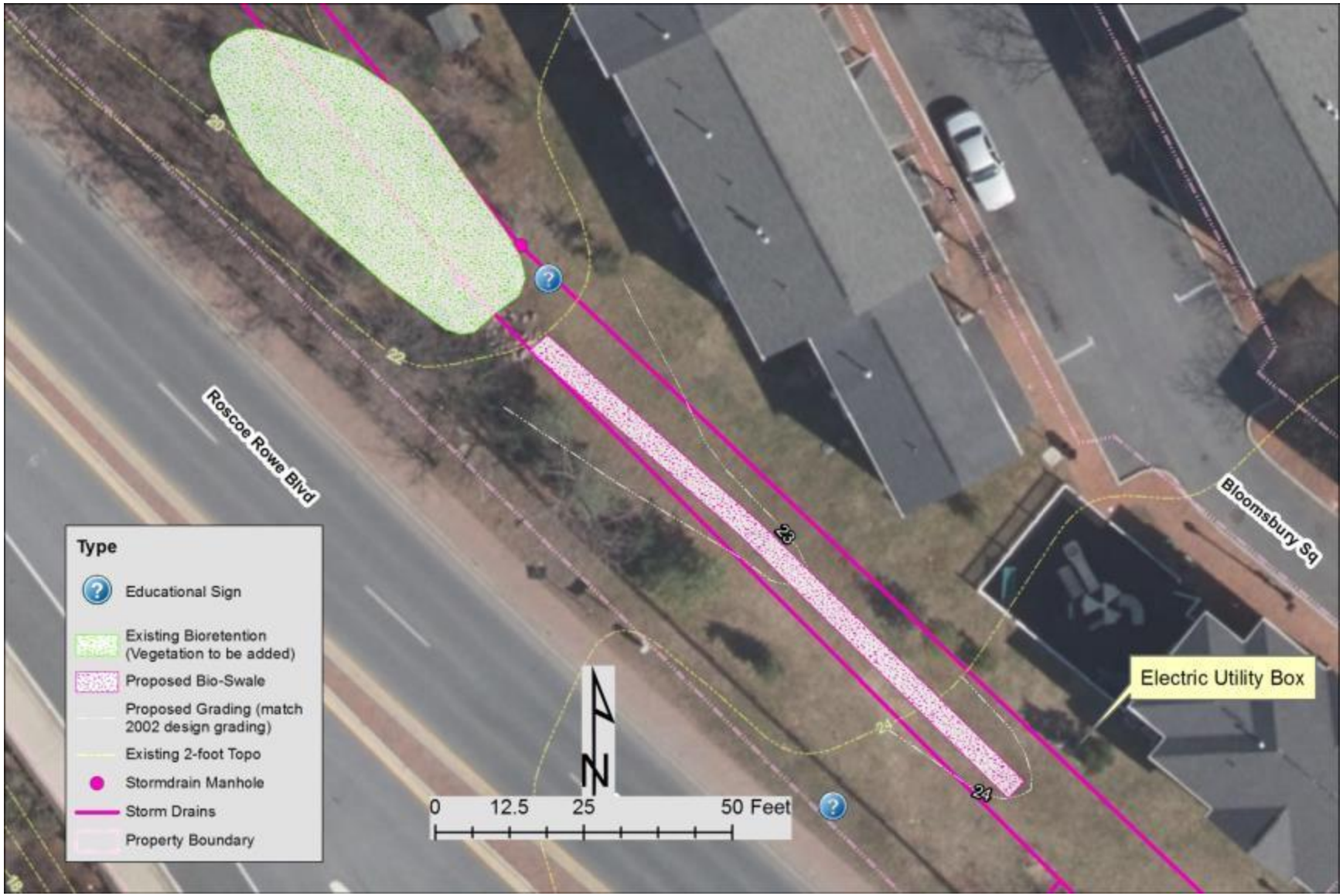


Figure 32: Proposed Retrofit Concept Design

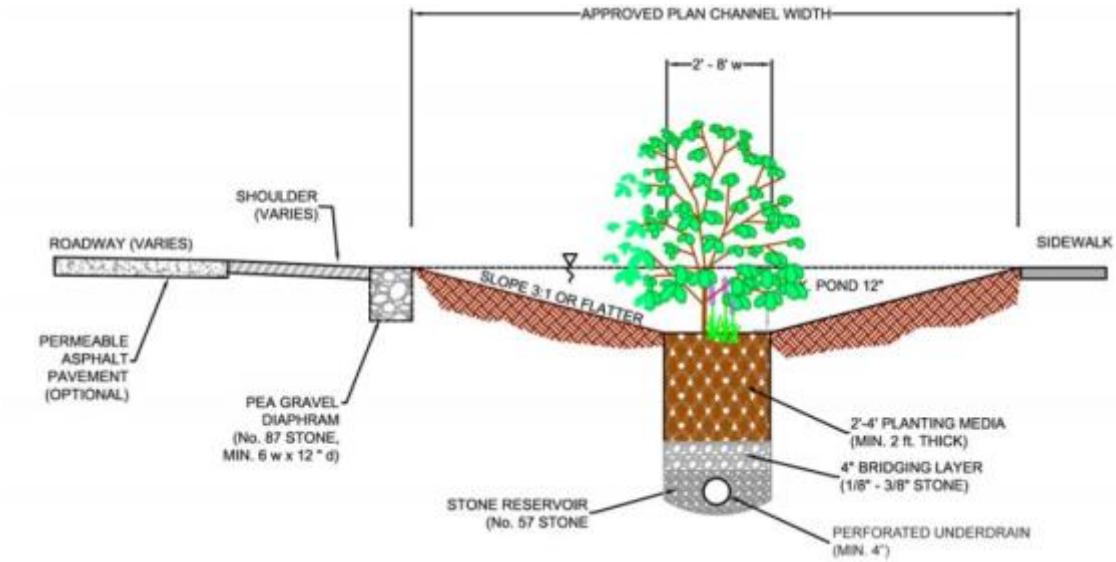


Figure 33: Typical Profile of Bio-Swale (MDE 2009 *Environmental Site Design Manual*)

Site Photographs

Existing Bioretention between Bloomsbury Square and Rowe Boulevard

Existing Grass Swale Upstream of Existing Bioretention

Project ID: City Rqst_01

Total Treated Drainage Area: 82.1 acres
Total Treated Impervious Area: 40.0 acres
Total Water Quality Volume (WQv):
~145,581 cubic feet; 3.34 acre-feet
Rainfall Depth Treated (Pe): 1 inch
Annual Nutrient Removal:

- TN: 547.5 lbs
- TP: 36.8 lbs
- TSS: 10.3 tons

Existing Site Description

The existing site is a privately owned undeveloped parcel in a residential neighborhood. The site is located northwest of the intersection of Ridgewood Street and Woodlawn Avenue. There is an existing elliptical pipe that drains into a tributary of College Creek approximately 1,000 feet upstream of the confluence with College Creek. A scour hole has formed at the outfall downstream of the existing pipe. The outfall receives runoff from the residential area along Beech Street, Linden Avenue, Poplar Avenue, North Southwood Avenue, and North Homeland Avenue. No other stormwater management facilities were observed in the drainage area. The stream banks are wooded, and several large trees are located on the banks. The soils in the drainage area are mostly hydrologic soil group C. See Figure 34 for existing conditions.

Proposed Project Description

The proposed project involves converting the existing channel to a step pool storm conveyance system (SPSC). The SPSC would be designed using the Anne Arundel County *Regenerative Step Pool Storm Conveyance Design Guidelines* (Revised December 2012) and MDE's *Stormwater Design Manual*. According to the design guidance, the existing slope of 2 percent is suitable to implement the SPSC system. An 800-foot SPSC is recommended with approximately six pools. A sand filter surface area of approximately 9,000 square feet will be required to capture and treat the entire water quality volume from the drainage area. The pools would have a maximum depth of 3 feet with 3 to 1 side slopes. Implementation of the SPSC would reduce pollutants such as TN, TP, and TSS. Implementation of a SPSC would also mitigate existing erosion downstream of the outfall, as these systems are designed to manage stormwater runoff quantity and quality requirements. Figure 35 provides the schematic of the proposed SPSC system, and Figure 36 provides a typical profile.

Feasibility Assessment

Property Ownership	The property is privately owned and is a potential donation from the Schubert Family.
Construction Access	The site can be accessed from Woodlawn Avenue east of the intersection with Beech Street. Limited open space is available for staging. The channel is heavily wooded, and tree impacts would be expected during construction.
Utility Conflicts	An existing sewer line runs across the stream in the project area. A detailed survey should be performed to identify exact location of the sewer line. Water and sewer lines also exist along the adjacent roads (Woodlawn Avenue and Beech Street) but should not impact the proposed project.
Environmental Impacts	Trees will be affected during project implementation. Several large trees are located along the channel banks downstream of the outfall.
Design/Construction	Geotechnical investigation will be required to determine the infiltration rates of the soils in the project area during final design.

Plans and Permits

The following plans and permits may be required for the implementation of this project:

- Site/Schematic Development Application
- Stormwater Management Plan
- Natural Resources and Forest Stand Delineation
- Forest Conservation Plan/Buffer Management Plan
- Grading and Erosion Sediment Control Plan
- Temporary Traffic Control Plan
- MDSPGP for activities in US waters
- General Permit for Stormwater Discharge Associated with Construction Activity (if the area disturbed is greater than 1 acre)

Cost Estimate

Table 21: Cost Estimate for City Request 01 Retrofit

Item	Quantity	Units	Unit Cost	Total
Clear and Grub	8500	SY	$2.00	$17,000.00
Excavation and Hauling	6200	CY	$50.00	$310,000.00
Grading	6200	SY	$3.50	$21,700.00
Sand	1380	CY	$70.00	$96,600.00
Filter Fabric	100	SY	$4.00	$400.00
Tree Removal	50	EA	$800.00	$40,000.00
Flow Diversion Structure	1	EA	$10,000.00	$10,000.00
Plantings	4000	SY	$10.00	$40,000.00
Sand Stone Boulders	70	CY	$240.00	$16,800.00
Cobble Weir	40	CY	$90.00	$3,600.00
Wood Chips	420	CY	$25.00	$10,500.00
Rip-Rap	200	CY	$130.00	$26,000.00
Clear Water Diversion Pipe	800	LF	$30.00	$24,000.00
Stabilized Construction Entrance	1	EA	$2,000.00	$2,000.00
CY - Cubic Yards SY - Square Yards EA - Each LF - Linear Feet			Initial Project Costs	$618,600
		Contingency	20%	$123,720
		Erosion and Sediment Control	15%	$92,790
		Base Construction Costs		$835,110
		Mobilization	10%	$83,511
		Total Construction Cost[21]		**$918,621**
		20 Years Life Cycle Maintenance Cost[22] (Average Annual Maintenance Cost of $891)		$17,820

[21]Additional cost of approximately $100,000 for design, environmental services, geotechnical investigation, survey, and permitting is assumed.
[22] University of Maryland. October 2011. Cost of Stormwater Management Practices in Maryland Counties.

Computations

Table 22: Water Quality Volume (WQv) Calculations

Design Parameters	**Site Value**
Treated Drainage Area (ac), A	82.1
Percent Impervious Cover, I	49%
Rainfall Depth (inches), P	1
Volumetric Runoff Coefficient, R_v	0.49
Water Quality Volume (acre-feet), WQ_v	**3.34**
Water Quality Volume (cubic-feet), WQ_v	**145,581**

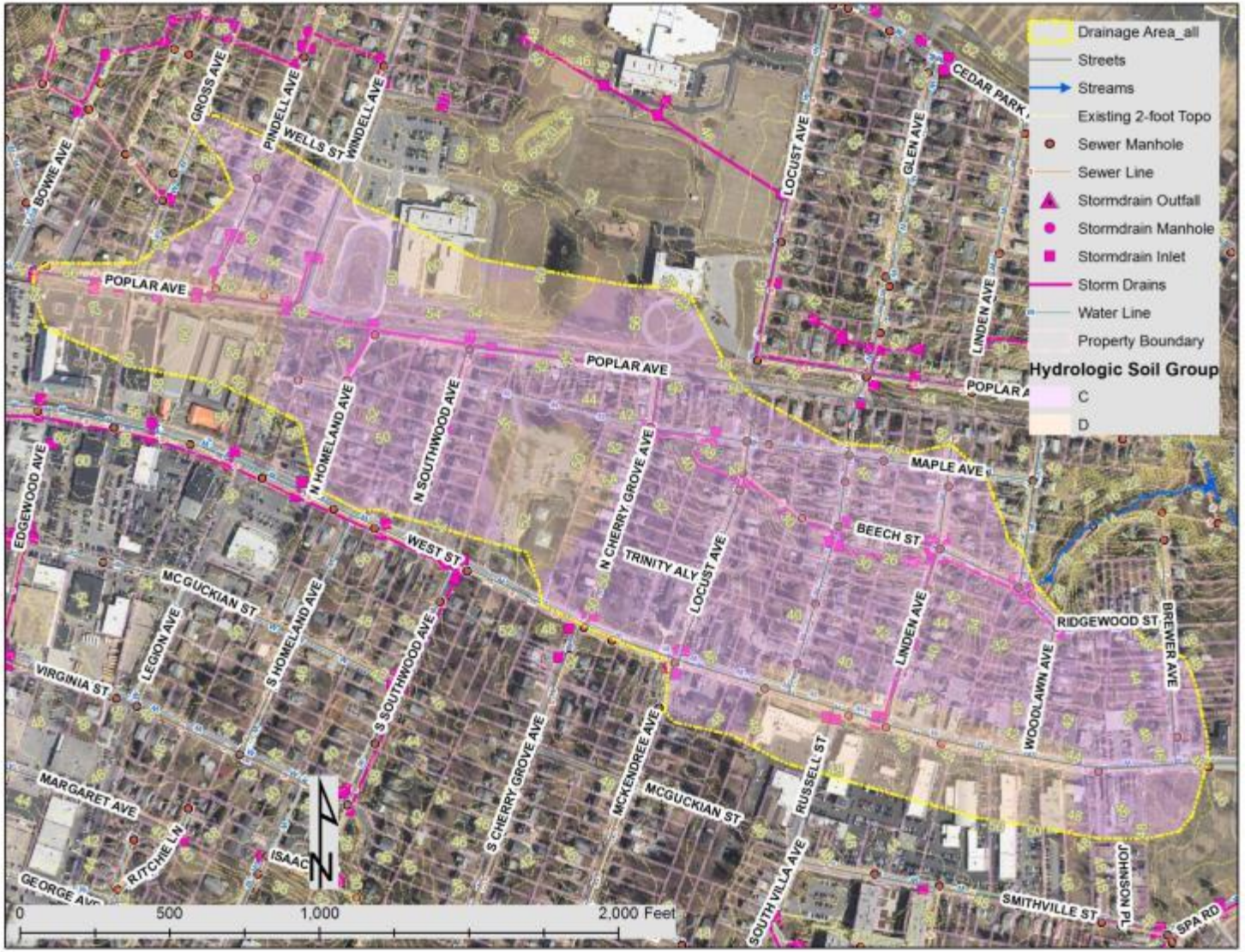


Figure 34: Existing Conditions and Drainage Area

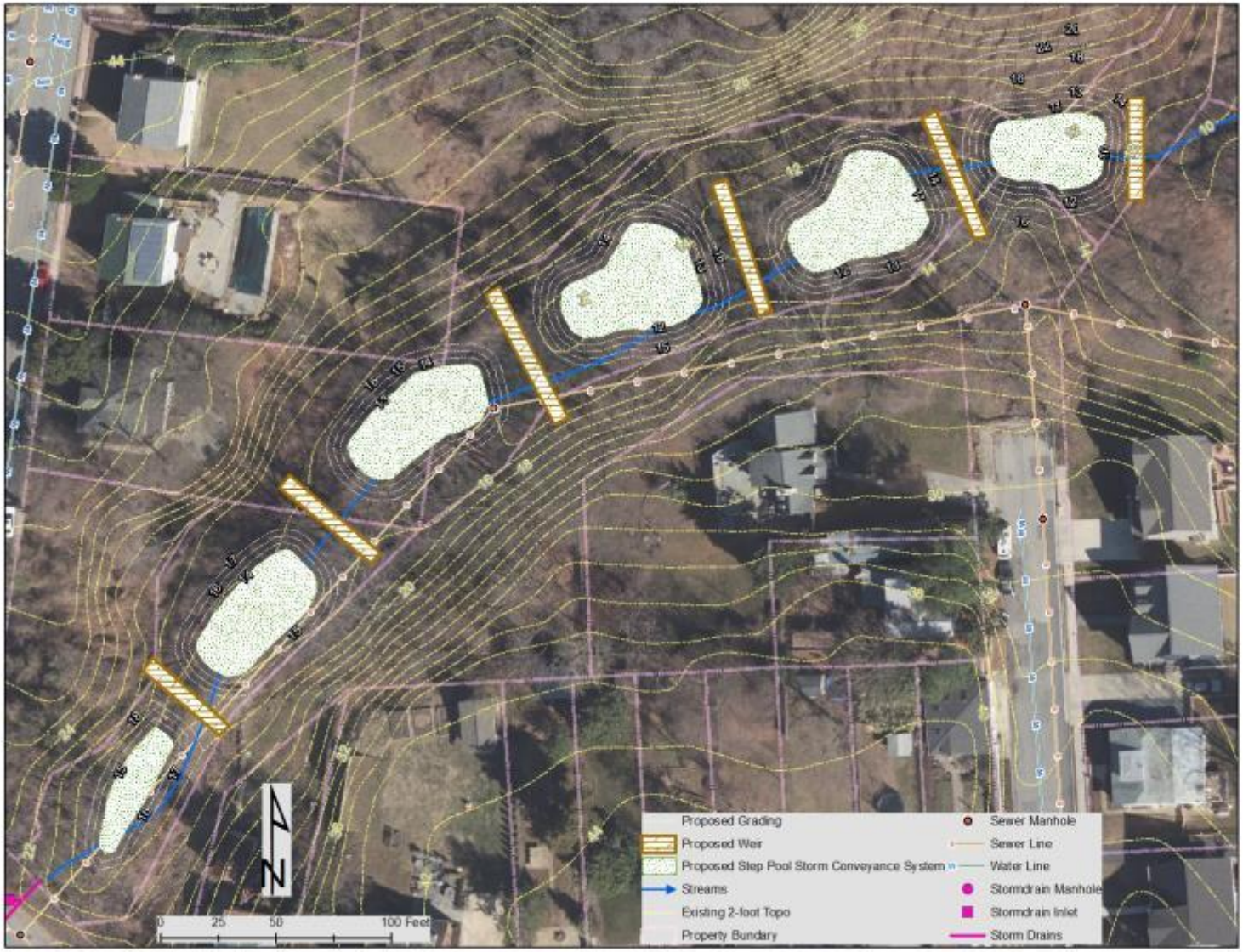


Figure 35: Proposed Retrofit Concept Design

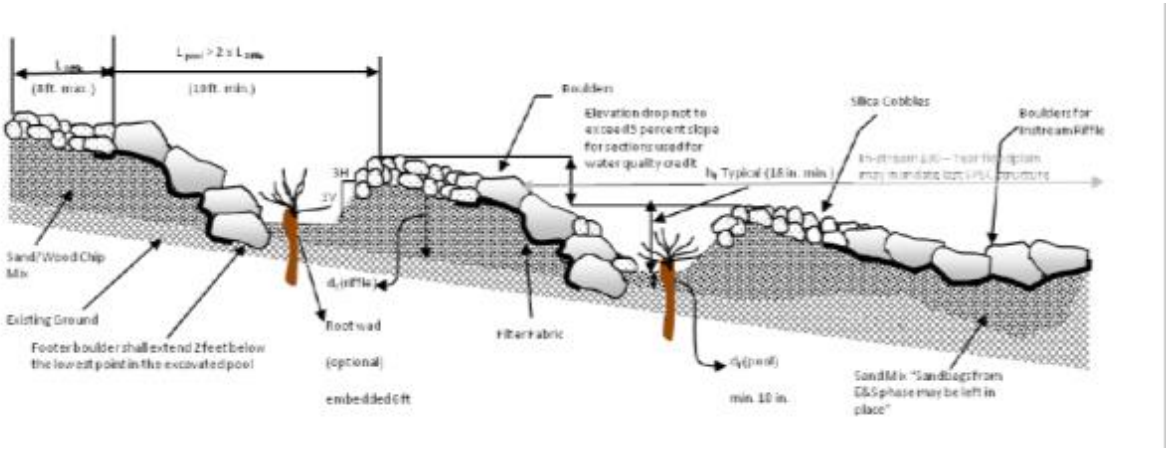


Figure 36: Typical Profile of SPSC (Anne Arundel County's *Regenerative Step Pool Storm Conveyance Design Guidelines* [Revised December 2012])

Site Photographs

Existing Outfall Northwest of the Intersection of Ridgewood Street and Woodlawn Avenue

Tributary to College Creek Northwest of the Intersection of Ridgewood Street and Woodlawn Avenue

Project ID: City_01

Total Treated Drainage Area: 16.7 acres
Total Treated Impervious Area: 7.4 acres
Total Additional Water Quality Volume (WQv):
~27,207 cubic feet; 0.62 acre-foot
Rainfall Depth Treated (Pe):1 inch
Annual Nutrient Removal:

- TN: 64.5 lbs
- TP: 5.9 lbs
- TSS: 2.0 tons

Existing Site Description

The existing site is in an open field with a storm drain pipe running under it. The site is behind a City-owned housing development off Taylor Avenue. The facility receives runoff from along Tyler Avenue. A storm drain pipe runs from Tyler Avenue, across a parking lot and along the basketball courts, playground, and pavilion, to outfall into a channel that is a tributary to Aberdeen Creek. The receiving channel is about 600 feet upstream from Aberdeen Creek. Two fences run perpendicular to the storm drain outfall pipe. These two fences are 10 feet apart and delineate an existing utility easement that runs parallel to the receiving channel. The outfall area is wooded with many large trees along the channel. The soils in the site are hydrologic soil group D. See Figure 37 for existing conditions.

Proposed Project Description

The proposed project entails creating a wet pond in the open area downstream (east) of the existing basketball court, where the storm drain currently runs. The storm drain pipe would be partially removed and the field excavated for storage. The original storm drain outfall would be used as the outfall of the proposed facility, though it would need some restoration. The proposed BMP will be designed in accordance with the MDE's *Stormwater Design Manual*. The site would be accessed through the parking lot off Tyler Avenue. Access may be an issue because of the nearby basketball court. The clear access area is only about 10 feet wide, and a chain link fence surrounds the basketball court. Utilities are present in the area near the outfall. Water and sewer lines run adjacent to the outfall.

Wet Pond placement will reduce pollutants such as TN, TP, and TSS. The pond capacity would manage stormwater runoff quality as well as quantity, reducing downstream erosion issues. This project will help the City of Annapolis achieve approximately 7.4 acres of impervious area credits toward its upcoming NPDES MS4 requirements. Figure 38 provides the schematic of the proposed wet pond retrofit, and Figure 39 provides a typical profile.

Feasibility Assessment

Property Ownership	The property is located in a recreation area of a City-owned housing development.
Construction Access	The site can be accessed from a parking lot off Tyler Avenue. Access to the field would need to be through a 10-foot-wide clear area adjacent to the basketball court. The clear area is bounded by a chain link fence surrounding the basketball court on one side and a heavily wooded area on the other side. Access may be difficult for large equipment.
Utility Conflicts	Existing water and sewer lines run parallel to the outfall channel, upstream of the outfall structure. Two fences demarcate the utility easement.
Environmental Impacts	Tree impacts are possible in the area around the outfall, which is heavily wooded. Some trees may need to be removed to access the site.
Design/Construction	Geotechnical investigation will be required to determine the infiltration rates of the soils in the project area during final design.

Plans and Permits

The following plans and permits may be required for the implementation of this project:

- Site/Schematic Development Application
- Stormwater Management Plan
- Natural Resources and Forest Stand Delineation
- Forest Conservation Plan/Buffer Management Plan
- Grading and Erosion Sediment Control Plan
- Temporary Traffic Control Plan
- MDSPGP for activities in US waters
- General Permit for Stormwater Discharge Associated with Construction Activity (if the area disturbed is greater than 1 acre)

Cost Estimate

Table 23: Cost Estimate for City 01 Retrofit

Item	Quantity	Units	Unit Cost	Total
Clear and Grub	1500	SY	$2.00	$3,000.00
Excavation and Hauling	1670	CY	$50.00	$83,500.00
Grading	1000	SY	$3.50	$3,500.00
Filter Fabric	90	SY	$4.00	$360.00
Rip-Rap	100	CY	$130.00	$13,000.00
Tree Removal	50	EA	$800.00	$40,000.00
Safety Fence	420	LF	$4.00	$1,680
Clear Water Diversion Pipe	400	LF	$30.00	$12,000.00
Stabilized Construction Entrance	1	EA	$2,000.00	$2,000.00
Riser	1	EA	$6,000.00	$6,000.00
Topsoil	1000	SY	$4.00	$4,000.00
CY - Cubic Yards SY - Square Yards EA - Each LF - Linear Feet	Initial Project Costs			$169,040
	Contingency		20%	$33,808
	Erosion and Sediment Control		15%	$25,356
	Base Construction Costs			$228,204
	Mobilization		10%	$22,820
	Total Construction Cost[23]			**$251,024**
	20 Years Life Cycle Maintenance Cost[24] (Average Annual Maintenance Cost of $891)			$17,820

[23] Additional cost of approximately $100,000 for design, environmental services, geotechnical investigation, survey, and permitting is assumed.
[24] University of Maryland. October 2011. Cost of Stormwater Management Practices in Maryland Counties.

Computations

Table 24: Water Quality Volume (WQv) Calculations

Design Parameters	**Site Value**
Treated Drainage Area (ac), A	16.7
Percent Impervious Cover, I	44.3
Rainfall Depth (inches), P	1
Volumetric Runoff Coefficient, R_v	0.45
Water Quality Volume (acre-feet), WQ_v	**0.62**
Water Quality Volume (cubic-feet), WQ_v	**27,207**

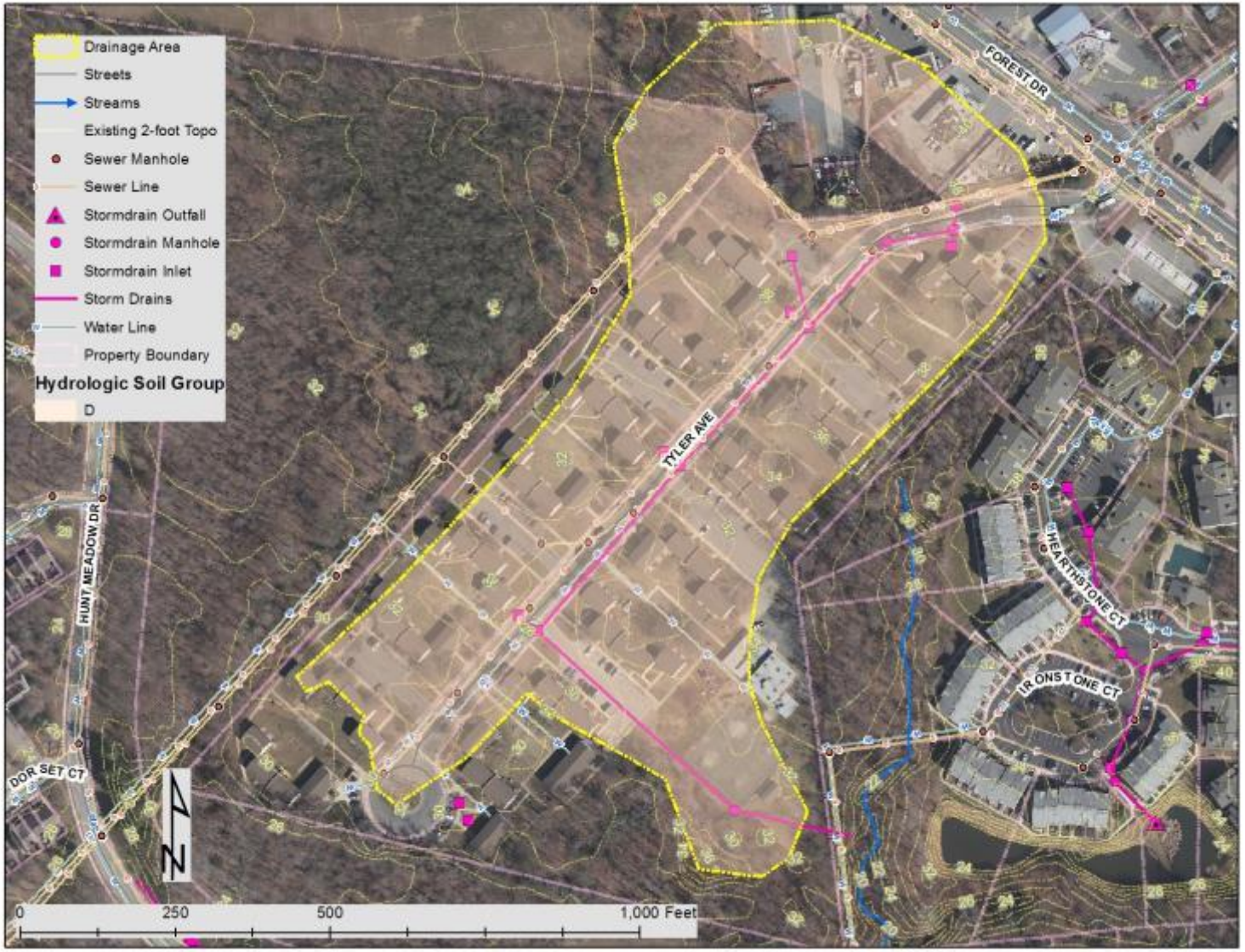


Figure 37: Existing Conditions and Drainage Area

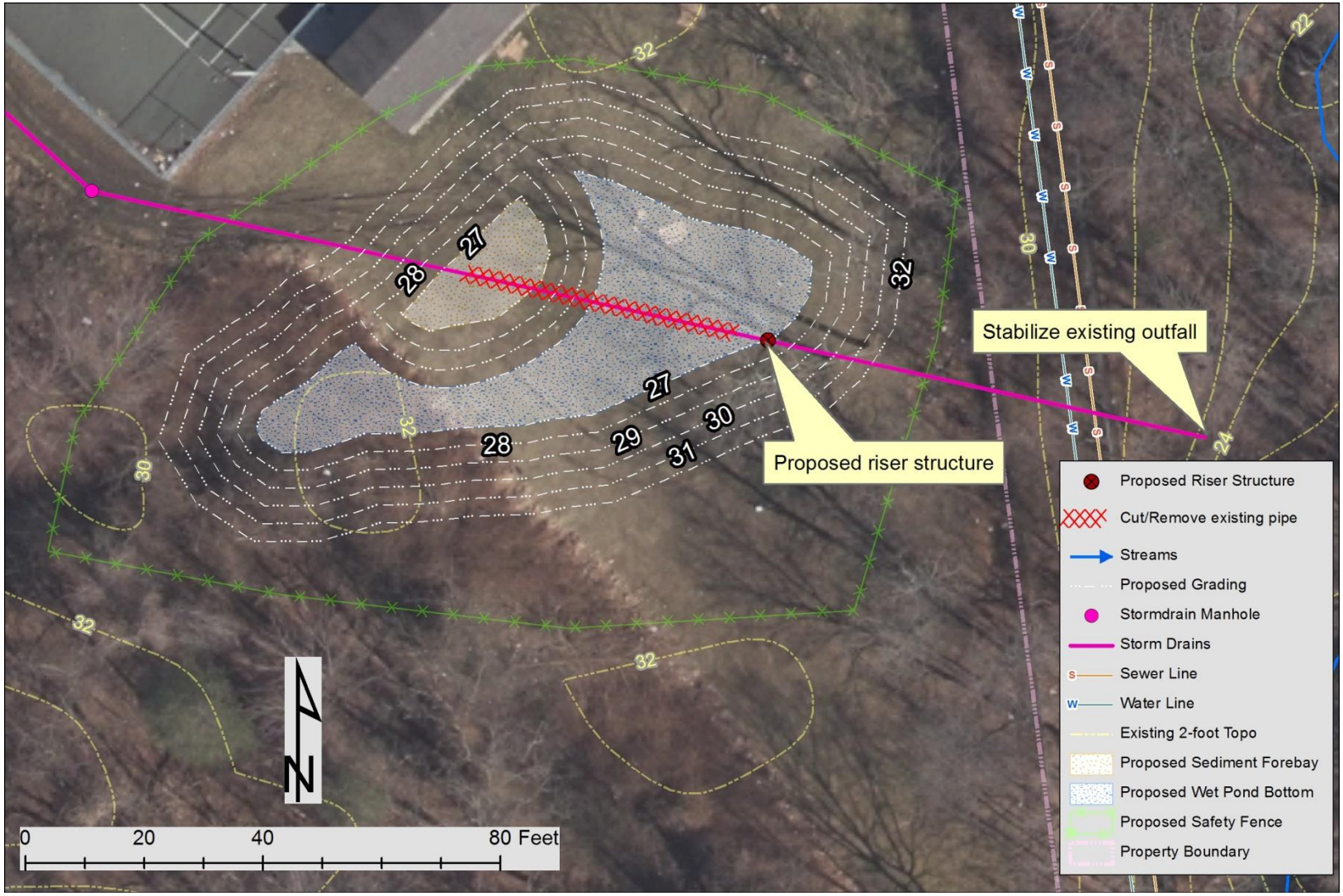


Figure 38: Proposed Retrofit Concept Design

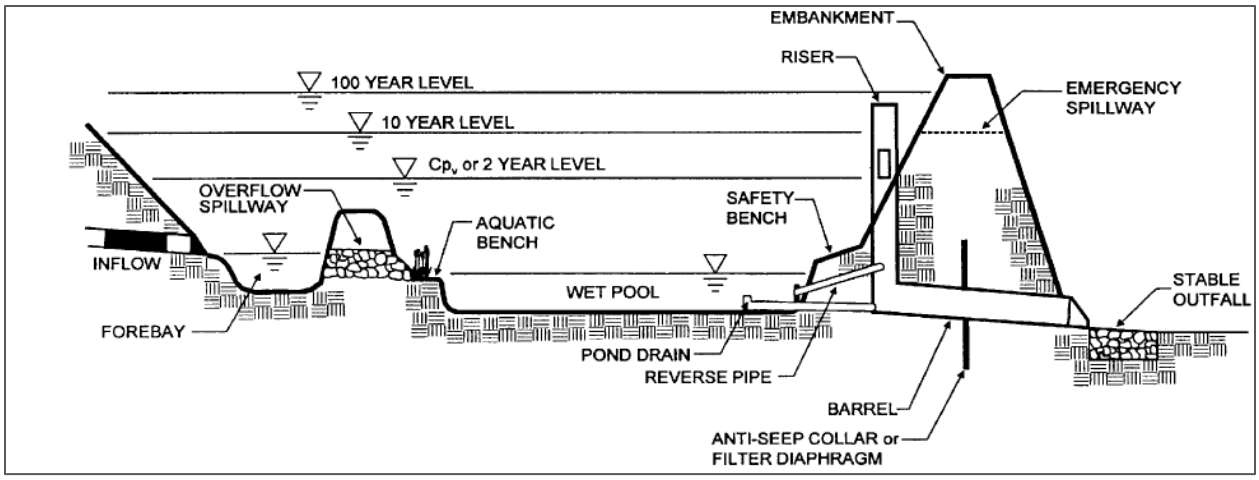


Figure 39: Typical Profile of Wet Pond (MDE 2000 *Stormwater Design Manual*)

Site Photographs

Open Space for Proposed Facility

Access Area

Fences along Utility Easement

Project ID: City_06

Total Treated Drainage Area: 34.8 acres
Total Treated Impervious Area: 9.2 acres
Total Water Quality Volume (WQv):
~36,300 cubic feet; 0.83 acre-foot
Rainfall Depth Treated (Pe): 1 inch
Annual Nutrient Removal:

- TN: 232.3 lbs
- TP: 15.6 lbs
- TSS: 4.4 tons

Existing Site Description

The existing site is a storm drain outfall behind the parking lot to the community pool on Hunt Meadows Drive. The outfall receives runoff from residential areas, including Hunt Meadows Drive, Riding Ridge Road, Hunting Wood Road, and the community pool. Another storm drain outfall is located approximately 300 feet downstream of this outfall. No other stormwater management facilities were observed within the drainage area. The outfall drains to a tributary to Aberdeen Creek approximately 2,200 feet upstream of Harness Creek Road. Currently there are gabion basket weirs and significant sedimentation downstream of the outfall. A walking path follows the drainage channel and crosses over a footbridge several hundred feet from the outfall. The area along the channel is heavily wooded. The soils along the channel are hydrologic soil groups C and D. Figure 40 shows the existing conditions map with drainage area.

Proposed Project Description

The proposed project involves converting the existing channel to a SPSC. The SPSC would be designed using the Anne Arundel County *Regenerative Step Pool Storm Conveyance Design Guidelines* (Revised December 2012) and MDE's *Stormwater Design Manual*. According to the design guidance, the existing slope of 2 percent is suitable to implement the SPSC system. A SPSC of approximately 300 feet is recommended. Approximately four pools with a sand filter surface area of approximately 2,500 square feet will be required to capture and treat the entire water quality volume from the drainage area. The pools would have a maximum depth of 3 feet with 3 to 1 side slopes.

Implementation of the SPSC would reduce pollutants such as TN, TP, and TSS. Implementation of SPSC would also mitigate existing erosion issues downstream of the outfall, as these systems are designed to manage stormwater runoff quantity along with quality. This project will help the City of Annapolis achieve approximately 9.2 acres of impervious area credits toward its upcoming NPDES MS4 requirements. Figure 41 provides the schematic of the proposed SPSC system, and Figure 42 provides a typical profile.

Feasibility Assessment

Property Ownership	The property is located behind a community pool parking lot and is City owned.
Construction Access	The site can be accessed through the parking lot at the pool on Hunt Meadows Drive. The site can also be accessed using an existing woodchip foot path (approximately 10 feet wide) that follows the drainage channel.
Utility Conflicts	There are no utilities in the area immediately surrounding the site. A sewer line crosses the channel approximately 800 feet downstream of the outfall.
Environmental Impacts	The channel is heavily wooded, and tree impacts would be expected during construction. The project may also affect the existing footpath and associated bridges.
Design/Construction	Geotechnical investigation will be required to determine the infiltration rates of the soils in the project area during final design.

Plans and Permits

The following plans and permits may be required for the implementation of this project:

- Site/Schematic Development Application
- Stormwater Management Plan
- Natural Resources and Forest Stand Delineation
- Forest Conservation Plan/Buffer Management Plan
- Grading and Erosion Sediment Control Plan
- Temporary Traffic Control Plan
- MDSPGP for activities in US waters
- General Permit for Stormwater Discharge Associated with Construction Activity (if the area disturbed is greater than 1 acre)

Cost Estimate

Table 25: Cost Estimate for City 06 Retrofit

Item	Quantity	Units	Unit Cost	Total
Clear and Grub	3000	SY	$2.00	$6,000.00
Excavation and Hauling	2500	CY	$50.00	$125,000.00
Grading	2500	SY	$3.50	$8,750.00
Sand	500	CY	$70.00	$35,000.00
Filter Fabric	70	SY	$4.00	$280.00
Tree Removal	50	EA	$800.00	$40,000.00
Flow Diversion Structure	10	EA	$10,000.00	$100,000.00
Plantings	1500	SY	$10.00	$15,000.00
Sand Stone Boulders	50	CY	$240.00	$12,000.00
Cobble Weir	30	CY	$90.00	$2,700.00
Wood Chips	150	CY	$25.00	$3,750.00
Rip-Rap	200	CY	$130.00	$26,000.00
Clear Water Diversion Pipe	350	LF	$30.00	$10,500.00
Stabilized Construction Entrance	1	EA	$2,000.00	$2,000.00
CY - Cubic Yards SY - Square Yards EA - Each LF - Linear Feet			Initial Project Costs	$386,980
		Contingency	20%	$77,396
		Erosion and Sediment Control	15%	$58,047
		Base Construction Costs		$522,423
		Mobilization	10%	$52,242
		Total Construction Cost[25]		**$574,665**
		20 Years Life Cycle Maintenance Cost[26] (Average Annual Maintenance Cost of $891)		$17,820

[25] Additional cost of approximately $100,000 for design, environmental services, geotechnical investigation, survey, and permitting is assumed.
[26] University of Maryland. October 2011. Cost of Stormwater Management Practices in Maryland Counties.

Computations

Table 26: Water Quality Volume (WQv) Calculations

Design Parameters	**Site Value**
Treated Drainage Area (ac), A	34.8
Percent Impervious Cover, I	26.3
Rainfall Depth (inches), P	1
Volumetric Runoff Coefficient, R_v	0.29
Water Quality Volume (acre-feet), WQ_v	**0.83**
Water Quality Volume (cubic-feet), WQ_v	**36,300**

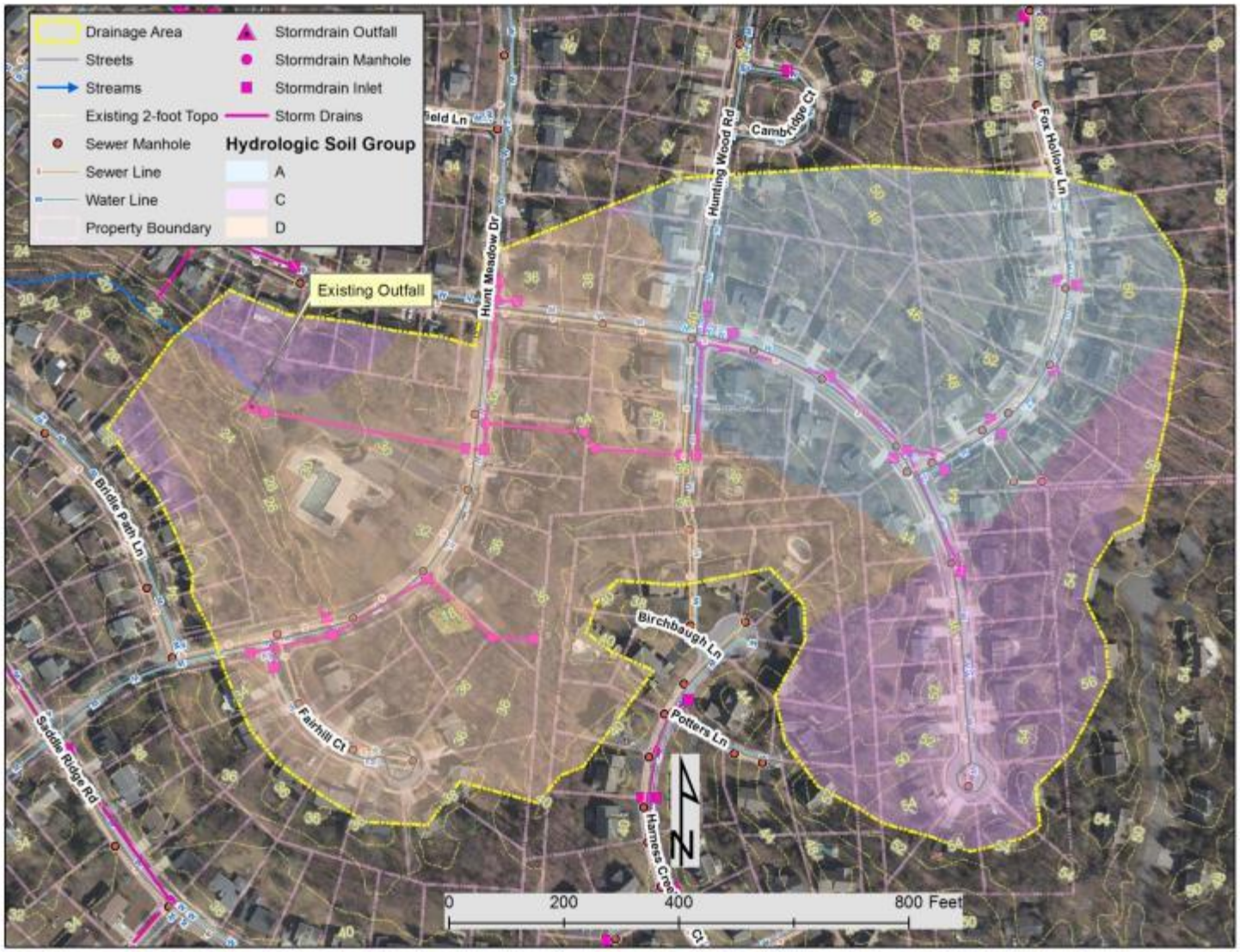


Figure 40: Existing Conditions and Drainage Area

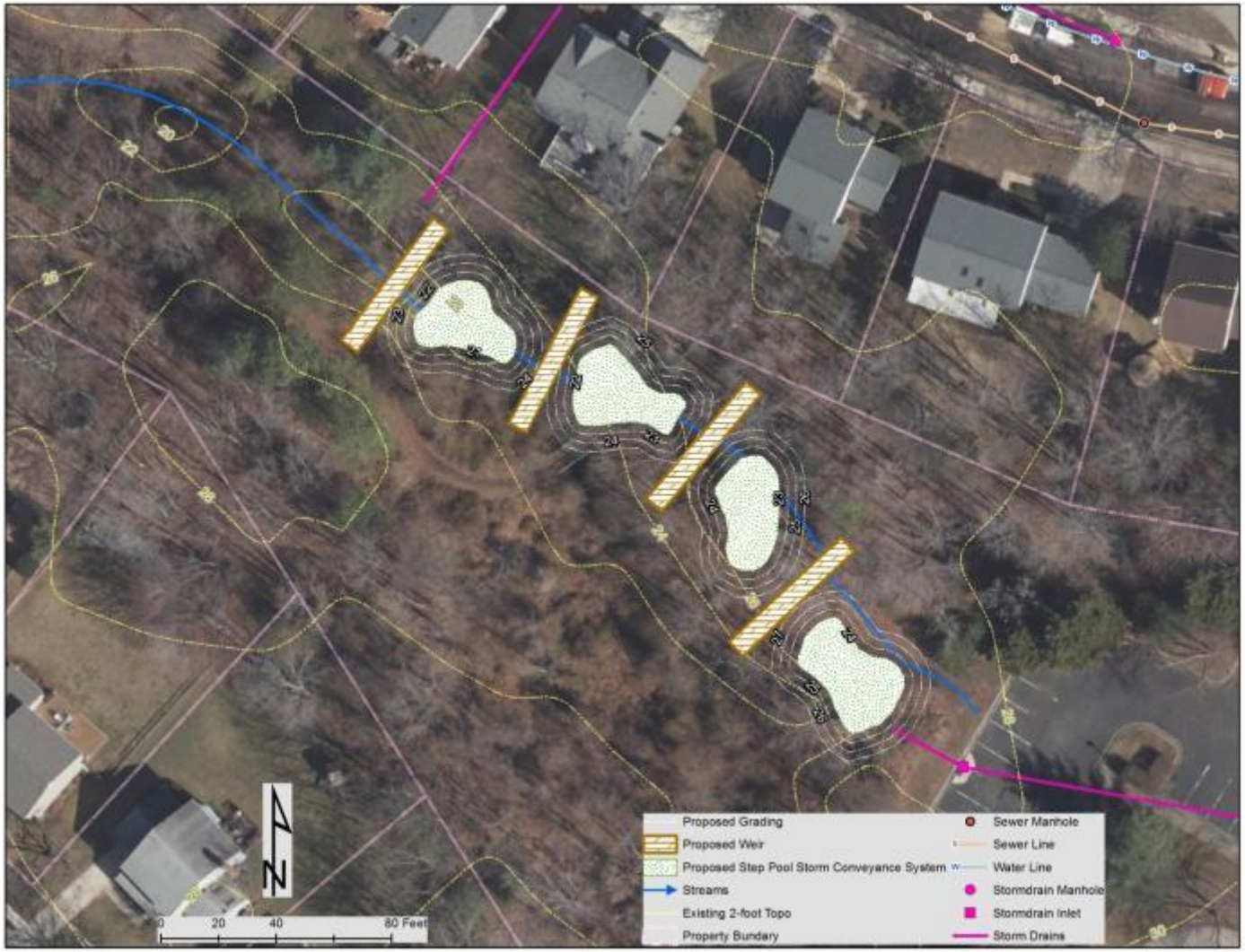


Figure 41: Proposed Retrofit Concept Design

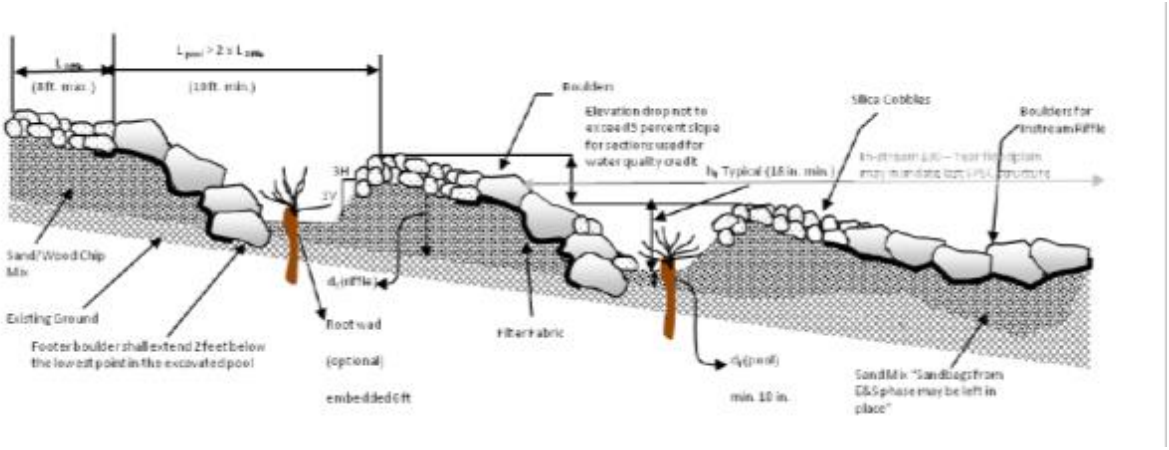


Figure 42: Typical Profile of SPSC (Anne Arundel County's *Regenerative Step Pool Storm Conveyance Design Guidelines* [Revised December 2012])

Site Photographs

Existing Outfall

Sedimentation Downstream from Outfall

Footpath and Bridge

Project ID: Out_01

Total Treated Drainage Area: 34.6 acres
Total Treated Impervious Area: 15.1 acres
Total Water Quality Volume (WQv):
~55,471 cubic feet; 1.27 acre-feet
Rainfall Depth Treated (Pe): 1 inch
Annual Nutrient Removal:

- TN: 230.9 lbs
- TP: 15.5 lbs
- TSS: 4.4 tons

Existing Site Description

The existing outfall pipes include a 36-inch vitrified clay pipe extra strength (VCPX) and 12-inch RCP located north of Edgewood Road. Stormwater runoff from Annapolis Water Reclamation facility and from Edgewood Road is collected by the stormdrain system and discharged from the outfalls directly to Back Creek. There are no existing stormwater management facilities within this drainage area. Stormwater runoff from the outfalls confluence approximately 20 feet north of the outfalls and flows approximately 230 feet before entering Back Creek. The outfalls are located in the existing FEMA 100-year floodplain. Several trees are located along the stream banks, and there is a foot bridge approximately 50 feet from the outfalls. A water utility line was identified 25 feet upstream of the outfalls. The soils in the drainage area and downstream of the outfall area are hydrologic soil groups B/D, C, and D. The outfall area is on a parcel owned by the City. Figure 43 shows the existing conditions map with drainage area.

Proposed Project Description

The proposed project would convert the existing outfall to a SPSC. The SPSC would be designed using the Anne Arundel County *Regenerative Step Pool Storm Conveyance Design Guidelines* (Revised December 2012) and MDE's *Stormwater Design Manual*. In accordance with the design guidance, the existing slope of 1.5 percent is suitable to implement the SPSC system. A SPSC of approximately 150 feet is recommended. Approximately three pools with a sand filter surface area of approximately 3,000 square feet will be required to capture and treat the entire water quality volume from the drainage area. The pools would have a maximum depth of 3 feet with 3 to 1 side slopes.

Implementation of the SPSC would reduce pollutants such as TN, TP, and TSS. This project will help the City of Annapolis achieve approximately 15.1 acres of impervious area credits toward its upcoming NPDES MS4 requirements. Figure 44 provides the schematic of the proposed SPSC system, and Figure 45 provides a typical profile.

Feasibility Assessment

Property Ownership	The property is owned by the City; therefore, no ownership issues are anticipated for the implementation of this project.
Construction Access	The site can be access from Edgewood Road. Open area is available to stage construction activities. Existing slopes are navigable by construction equipment.
Utility Conflicts	There is an existing water pipe 20 feet upstream from the outfall, but this project will not cause any impacts to it. Though there were no indicators of underground electric utilities at the project site (i.e., no light poles or utility boxes), confirmation should be obtained during final design.
Environmental Impacts	Potential tree impacts are anticipated to be a challenge for this project. Several mature trees along the banks would be affected during project implementation.
Design/Construction	Geotechnical investigation will be required to determine the infiltration rates of the soils in the project area during final design.

Plans and Permits

The following plans and permits may be required for the implementation of this project:

- Site/Schematic Development Application
- Stormwater Management Plan
- Natural Resources and Forest Stand Delineation
- Forest Conservation Plan/Buffer Management Plan
- Grading and Erosion Sediment Control Plan
- Temporary Traffic Control Plan
- MDSPGP for activities in US waters
- General Permit for Stormwater Discharge Associated with Construction Activity (if the area disturbed is greater than 1 acre)

Cost Estimate

Table 27: Cost Estimate for Outfall 01 Retrofit

Item	Quantity	Units	Unit Cost	Total
Clear and Grub	1250	SY	$2.00	$2,500.00
Excavation and Hauling	800	CY	$50.00	$40,000.00
Grading	800	SY	$3.50	$2,800.00
Sand	590	CY	$70.00	$41,300.00
Filter Fabric	50	SY	$4.00	$200.00
Tree Removal	20	EA	$800.00	$16,000.00
Plantings	600	SY	$10.00	$6,000.00
Sand Stone Boulders	40	CY	$240.00	$9,600.00
Cobble Weir	30	CY	$90.00	$2,700.00
Wood Chips	180	CY	$25.00	$4,500.00
Rip-Rap	300	CY	$130.00	$39,000.00
Clear Water Diversion Pipe	150	LF	$30.00	$4,500.00
Stabilized Construction Entrance	1	EA	$2,000	$2,000.00
CY - Cubic Yards SY - Square Yards EA - Each LF - Linear Feet			Initial Project Costs	$171,100
		Contingency	20%	$34,220
		Erosion and Sediment Control	15%	$25,665
		Base Construction Costs		$230,985
		Mobilization	10%	$23,099
		Total Construction Cost[27]		**$254,084**
		20 Years Life Cycle Maintenance Cost[28] (Average Annual Maintenance Cost of $891)		$17,820

[27] Additional cost of approximately $100,000 for design, environmental services, geotechnical investigation, survey, and permitting is assumed.
[28] University of Maryland. October 2011. Cost of Stormwater Management Practices in Maryland Counties.

Computations

Table 28: Water Quality Volume (WQv) Calculations

Design Parameters	**Site Value**
Treated Drainage Area (ac), A	34.6
Percent Impervious Cover, I	44%
Rainfall Depth (inches), P	1
Volumetric Runoff Coefficient, R_v	0.44
Water Quality Volume (acre-feet), WQ_v	**1.27**
Water Quality Volume (cubic-feet), WQ_v	**55,471**

Figure 43: Existing Conditions and Drainage Area

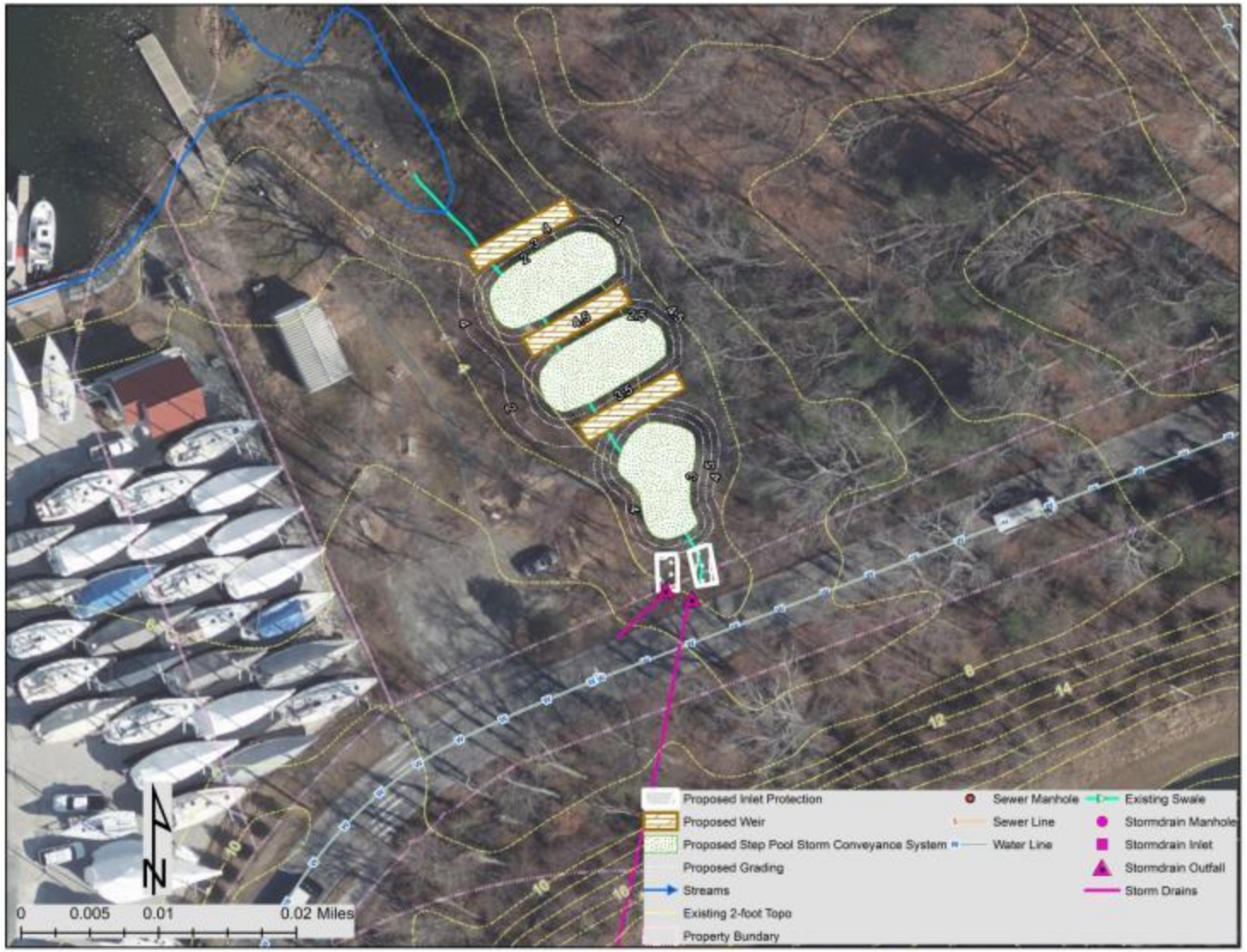


Figure 44: Proposed Retrofit Concept Design

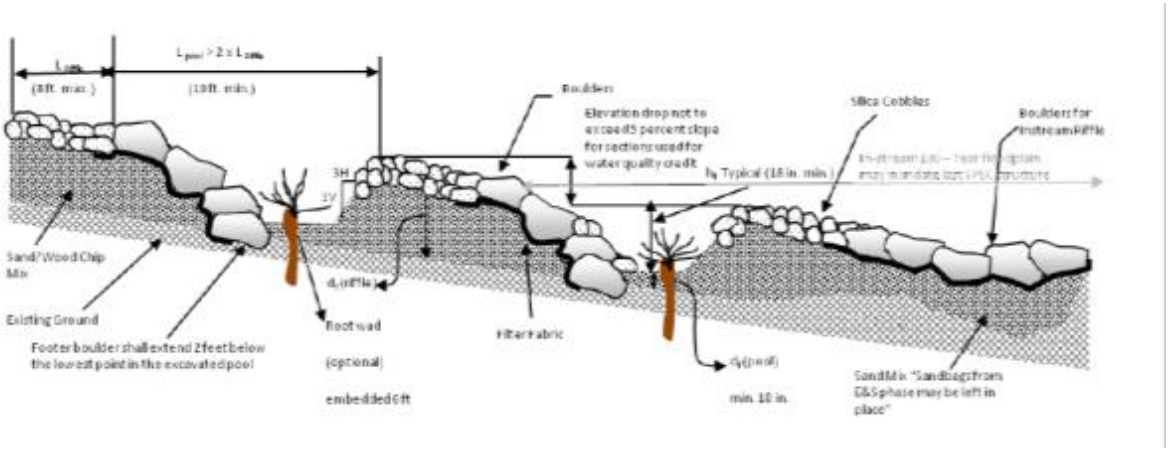
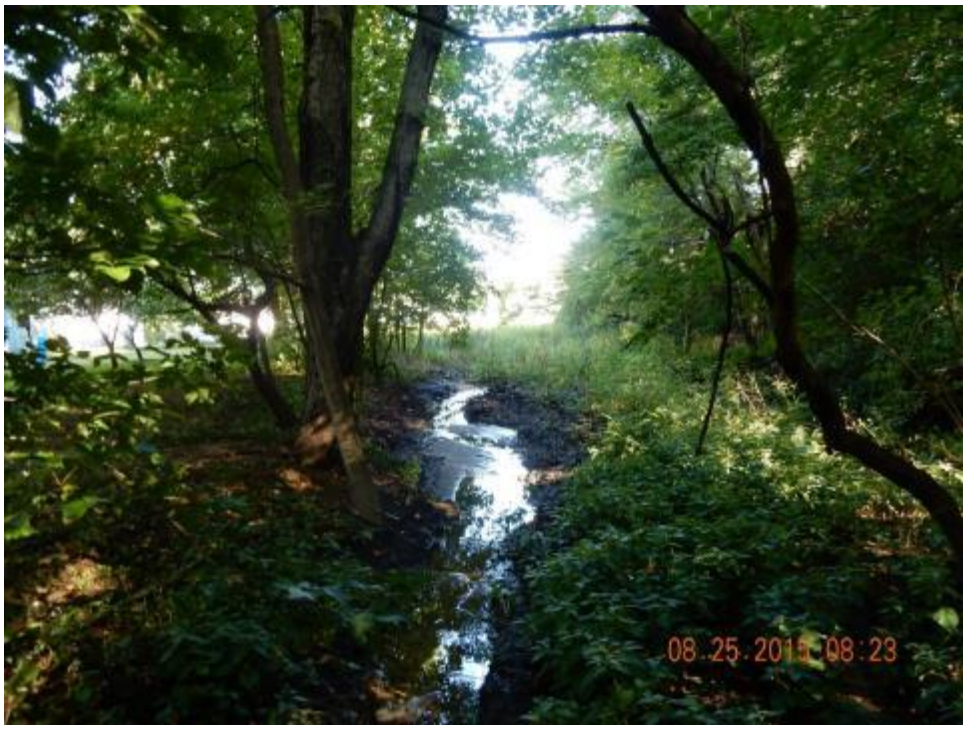


Figure 45: Typical Profile of SPSC (Anne Arundel County's *Regenerative Step Pool Storm Conveyance Design Guidelines* (Revised December 2012)

Site Photographs

Existing Outfalls



Downstream of Outfalls

Project ID: Out_04

Total Treated Drainage Area: 120.7 acres
Total Treated Impervious Area: 54.6 acres
Total Water Quality Volume (WQv):
~200,323 cubic feet; 4.60 acre-feet
Rainfall Depth Treated (Pe): 1 inch
Annual Nutrient Removal:

- TN: 805.1 lbs
- TP: 54.2 lbs
- TSS: 15.2 tons

Existing Site Description

The existing outfall pipes include two 72-inch RCPs located south of Bay Ridge Avenue and a 24-inch RCP located north of Alder Road. Stormwater runoff from medium- and low-density residential and commercial land uses is collected by the stormdrain system and discharged from the outfalls directly to Back Creek. The proposed Ambridge retention pond retrofit (BMP 21), also selected by the City as a potential project, is located upstream of the outfalls. The collected stormwater runoff from the outfalls converges approximately 100 feet east of the 72-inch RCP pipes and is discharged into Back Creek. The outfalls are approximately 250 feet from the existing FEMA 100-year floodplain. Several trees are located along the stream banks. A sewer line crosses the stream approximately 250 feet from the outfalls. The sewer pipe crosses approximately 8 feet above the stream and is held up by wooden cross bracing. The soils in the drainage area and downstream of the outfall area are hydrologic soil groups B, C, C/D, and D. The outfalls are on privately owned parcels. Figure 46 shows the existing conditions map with drainage area.

Proposed Project Description

The proposed project involves converting the existing outfalls to a SPSC. The SPSC would be designed using the Anne Arundel County *Regenerative Step Pool Storm Conveyance Design Guidelines* (Revised December 2012) and MDE's *Stormwater Design Manual*. In accordance with the design guidance, the existing slope of 1.6 percent is suitable to implement the SPSC system. A SPSC of approximately 550 feet is recommended. Approximately six pools with a sand filter surface area of approximately 11,800 square feet will be required to capture and treat the entire water quality volume from the drainage area. The pools would have a maximum depth of 3 feet with 3 to 1 side slopes.

Implementation of the SPSC would reduce pollutants such as TN, TP, and TSS. This project will help the City of Annapolis achieve approximately 54.6 acres of impervious area credits toward its upcoming NPDES MS4 requirements. Figure 47 provides the schematic of the proposed SPSC system, and Figure 48 provides a typical profile.

Feasibility Assessment

Property Ownership	The proposed project is located on privately owned properties and the property owned by Society for the Prevention of Cruelty to Animals; the City would need to coordinate with the property owners to obtain permission to implement this project.
Construction Access	The site can be access from Bay Ridge Avenue. Open area is available to stage construction activities. Existing slopes are navigable by construction equipment.
Utility Conflicts	There is an existing water pipe 80 feet upstream of the outfall, but this project will not affect this water pipe. A sewer line supported by wooden cross bracing approximately 8 feet above the stream crosses the stream approximately 250 feet from the outfalls. Implementation of this project will affect the sewer line, and the sewer line may need to be relocated. Though there were no indicators of underground electric utilities at the project site (i.e., no light poles or utility boxes), confirmation should be obtained during final design.
Environmental Impacts	Potential tree impacts are anticipated to be a challenge for this project. Several mature trees along the banks would be affected during project implementation.
Design/Construction	Geotechnical investigation will be required to determine the infiltration rates of the soils in the project area during final design.

Plans and Permits

The following plans and permits may be required for the implementation of this project:

- Site/Schematic Development Application
- Stormwater Management Plan
- Natural Resources and Forest Stand Delineation
- Forest Conservation Plan/Buffer Management Plan
- Grading and Erosion Sediment Control Plan
- Temporary Traffic Control Plan
- MDSPGP for activities in US waters
- General Permit for Stormwater Discharge Associated with Construction Activity (if the area disturbed is greater than 1 acre)

Cost Estimate

Table 29: Cost Estimate for Outfall 04 Retrofit

Item	Quantity	Units	Unit Cost	Total
Clear and Grub	5110	SY	$2.00	$10,220.00
Excavation and Hauling	3400	CY	$50.00	$170,000.00
Grading	3400	SY	$3.50	$11,900.00
Sand	2190	CY	$70.00	$153,300.00
Filter Fabric	100	SY	$4.00	$400.00
Tree Removal	40	EA	$800.00	$32,000.00
Plantings	2500	SY	$10.00	$25,000.00
Sand Stone Boulders	70	CY	$240.00	$16,800.00
Cobble Weir	50	CY	$90.00	$4,500.00
Wood Chips	660	CY	$25.00	$16,500.00
Rip-Rap	300	CY	$130.00	$39,000.00
Clear Water Diversion Pipe	600	LF	$30.00	$18,000.00
Stabilized Construction Entrance	2	EA	$2,000	$4,000.00
CY - Cubic Yards SY - Square Yards EA - Each LF - Linear Feet			Initial Project Costs	$501,620
		Contingency	20%	$100,324
		Erosion and Sediment Control	15%	$75,243
		Base Construction Costs		$677,187
		Mobilization	10%	$67,719
		Total Construction Cost[29]		**$744,906**
		20 Years Life Cycle Maintenance Cost[30] (Average Annual Maintenance Cost of $891)		$17,820

[29] Additional cost of approximately $100,000 for design, environmental services, geotechnical investigation, survey, and permitting is assumed.
[30] University of Maryland. October 2011. Cost of Stormwater Management Practices in Maryland Counties.

Computations

Table 30: Water Quality Volume (WQv) Calculations

Design Parameters	**Site Value**
Treated Drainage Area (ac), A	120.7
Percent Impervious Cover, I	45.2
Rainfall Depth (inches), P	1
Volumetric Runoff Coefficient, R_v	0.46
Water Quality Volume (acre-feet), WQ_v	**4.60**
Water Quality Volume (cubic-feet), WQ_v	**200,323**

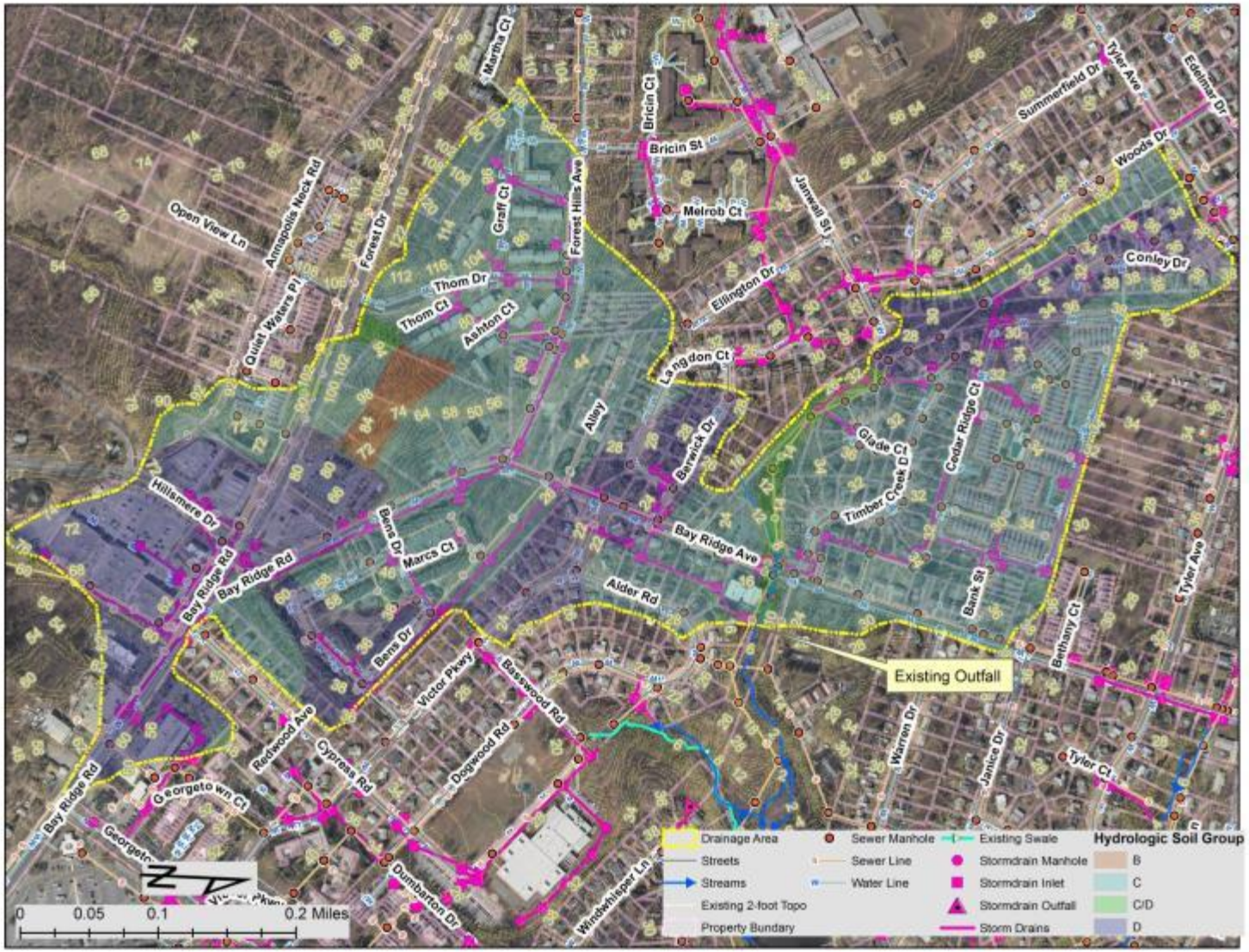


Figure 46: Existing Conditions and Drainage Area

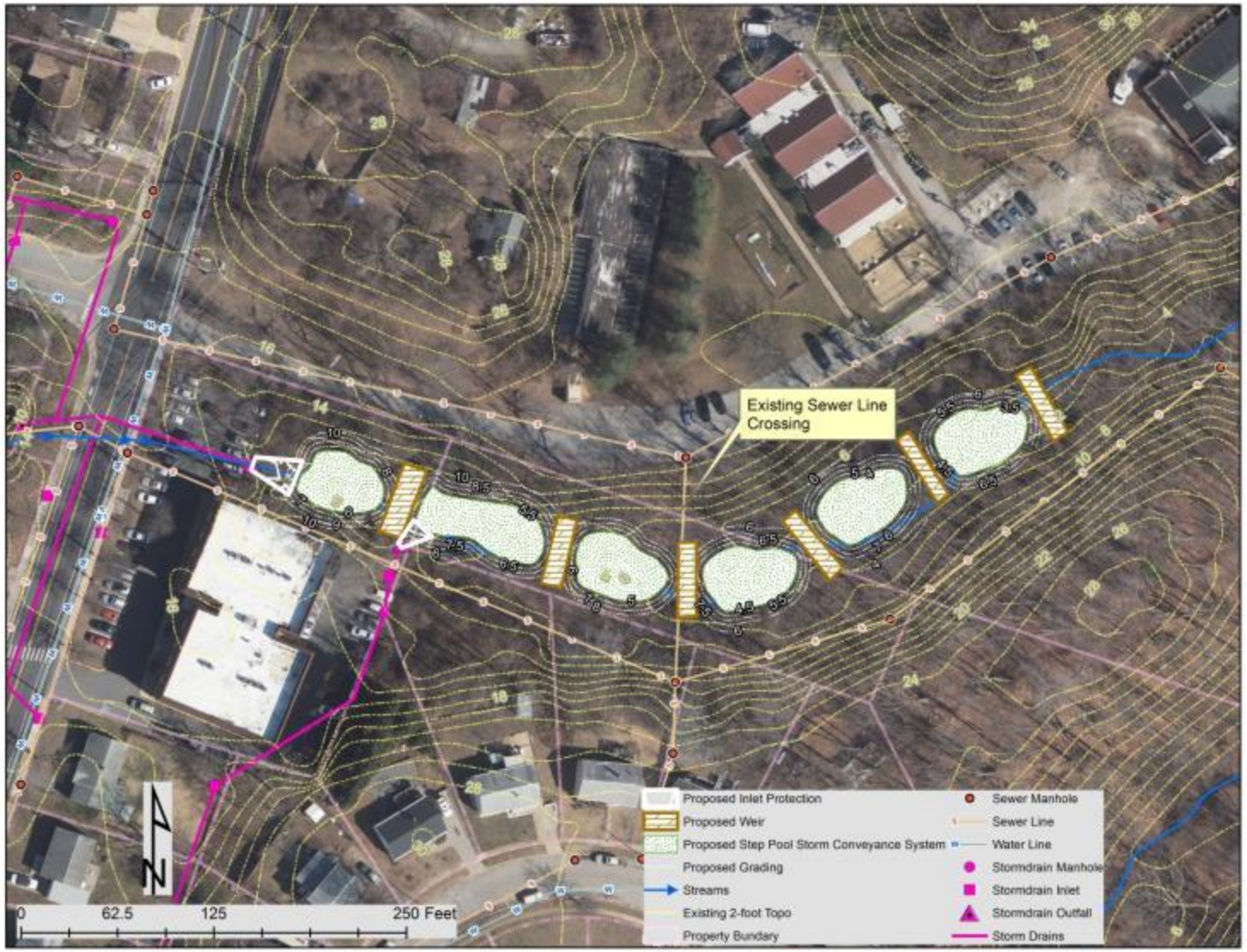


Figure 47: Proposed Retrofit Concept Design

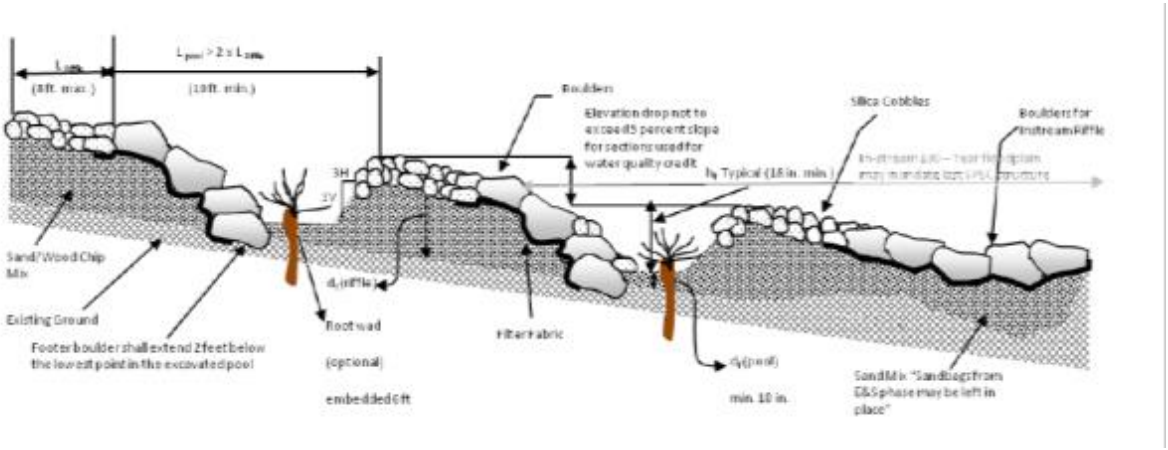


Figure 48: Typical Profile of SPSC (Anne Arundel County's *Regenerative Step Pool Storm Conveyance Design Guidelines* (Revised December 2012)

Site Photographs

Existing 72-inch RCP Outfalls Crossing Bay Ridge Avenue

Downstream of Outfall 04

Project ID: Out_07

Total Treated Drainage Area: 55.0 acres
Total Treated Impervious Area: 30.2 acres
Total Water Quality Volume (WQv):
~108,704 cubic feet; 2.50 acre-feet
Annual Nutrient Removal:

- TN: 367.1 lbs
- TP: 24.7 lbs
- TSS: 6.9 tons

Existing Site Description

The existing outfall is a 48-inch RCP located northeast of the intersection of Windwhisper Lane and Georgetown Road. Stormwater runoff from commercial, high-density residential and medium-density residential areas along Georgetown Road, Fairhope Court, Dorchester Drive, Silverwood Circle, and Bay Forest Court is discharged from the outfall. There is also a 15-inch RCP next to the 48-inch RCP that captures stormwater runoff from a small portion of Georgetown Road east of the outfall area. There are no existing stormwater management facilities within this drainage area. The stormwater from the pipe flows approximately 550 feet north of the outfall and flows into an existing swale west of the outfall before entering Back Creek. Currently, gabion baskets are placed along the edges of the stream, with additional gabion baskets placed across the stream functioning like a weir. A scour pool has developed downstream of the outfall area. The outfall is approximately 500 feet from the existing FEMA 100-year floodplain. There are several trees along the stream banks. Although the stream is wide near the outfall, it is not identified as perennial stream in the National Hydrography Dataset. An existing sewer line was identified across the stream in the outfall area. The soils in the drainage area and downstream of the outfall area are hydrologic soil groups C and D. The outfall area is located on a privately owned parcel. Figure 49 shows the existing conditions map with drainage area.

Proposed Project Description

The proposed project involves converting the existing outfall to a SPSC. The SPSC would be designed using the Anne Arundel County *Regenerative Step Pool Storm Conveyance Design Guidelines* (Revised December 2012) and MDE's *Stormwater Design Manual*. According to the design guidance, the existing slope of 2 percent is suitable to implement the SPSC system. A SPSC of approximately 350 feet is recommended. Approximately five pools with a sand filter surface area of approximately 6,000 square feet will be required to capture and treat the entire water quality volume from the drainage area. The pools would have a maximum depth of 3 feet with 3 to 1 side slopes.

Implementation of the SPSC would reduce pollutants such as TN, TP, and TSS. Implementation of the SPSC would also mitigate existing erosion issues downstream of the outfall as these

systems are designed to manage stormwater runoff quantity along with quality. This project will help the City of Annapolis achieve approximately 30.2 acres of impervious area credits toward its upcoming NPDES MS4 requirements. Figure 50 provides the schematic of the proposed SPSC system, and Figure 51 provides a typical profile.

Feasibility Assessment

Property Ownership	The property is privately owned; the City would need to coordinate with the property owner to obtain permission to implement this project.
Construction Access	The site can be access from Windwhisper Lane. Open area is available to stage construction activities. Existing slopes are navigable by construction equipment.
Utility Conflicts	An existing sewer line runs across the stream in the project area. A detailed survey needs to be performed to identify the exact location of the sewer line when the project proceeds to design. There are no water lines in the project area. Though there were no indicators of underground electric utilities at the project site (i.e., no light poles or utility boxes), confirmation should be obtained during final design.
Environmental Impacts	Potential tree impacts are anticipated to be a challenge for this project. Several mature trees along the banks would be affected during project implementation.
Design/Construction	Geotechnical investigation will be required to determine the infiltration rates of the soils in the project area during final design.

Plans and Permits

The following plans and permits may be required for the implementation of this project:

- Site/Schematic Development Application
- Stormwater Management Plan
- Natural Resources and Forest Stand Delineation
- Forest Conservation Plan/Buffer Management Plan
- Grading and Erosion Sediment Control Plan
- Temporary Traffic Control Plan
- MDSPGP for activities in US waters
- General Permit for Stormwater Discharge Associated with Construction Activity (if the area disturbed is greater than 1 acre)

Cost Estimate

Table 31: Cost Estimate for Outfall 07 Retrofit

Item	Quantity	Units	Unit Cost	Total
Clear and Grub	4200	SY	$2.00	$8,400.00
Excavation and Hauling	3150	CY	$50.00	$157,500.00
Grading	3150	SY	$3.50	$11,025.00
Sand	1150	CY	$70.00	$80,500.00
Filter Fabric	90	SY	$4.00	$360.00
Tree Removal	50	EA	$800.00	$40,000.00
Plantings	2000	SY	$10.00	$20,000.00
Sand Stone Boulders	60	CY	$240.00	$14,400.00
Cobble Weir	30	CY	$90.00	$2,700.00
Wood Chips	350	CY	$25.00	$8,750.00
Rip-Rap	200	CY	$130.00	$26,000.00
Clear Water Diversion Pipe	350	LF	$30.00	$10,500.00
Stabilized Construction Entrance	2	EA	$2,000	$2,000.00
CY - Cubic Yards SY - Square Yards EA - Each LF - Linear Feet			Initial Project Costs	$382,135
		Contingency	20%	$76,427
		Erosion and Sediment Control	15%	$57,320
		Base Construction Costs		$515,882
		Mobilization	10%	$51,588
		Total Construction Cost[31]		**$567,470**
		20 Years Life Cycle Maintenance Cost[32] (Average Annual Maintenance Cost of $891)		$17,820

[31]Additional cost of approximately $100,000 for design, environmental services, geotechnical investigation, survey, and permitting is assumed.
[32] University of Maryland. October 2011. Cost of Stormwater Management Practices in Maryland Counties.

Computations

Table 32: Water Quality Volume (WQv) Calculations

Design Parameters	**Site Value**
Treated Drainage Area (ac), A	55
Percent Impervious Cover, I	54.9
Rainfall Depth (inches), P	1
Volumetric Runoff Coefficient, R_v	0.54
Water Quality Volume (acre-feet), WQ_v	**2.50**
Water Quality Volume (cubic-feet), WQ_v	**108,704**

Figure 49: Existing Conditions and Drainage Area

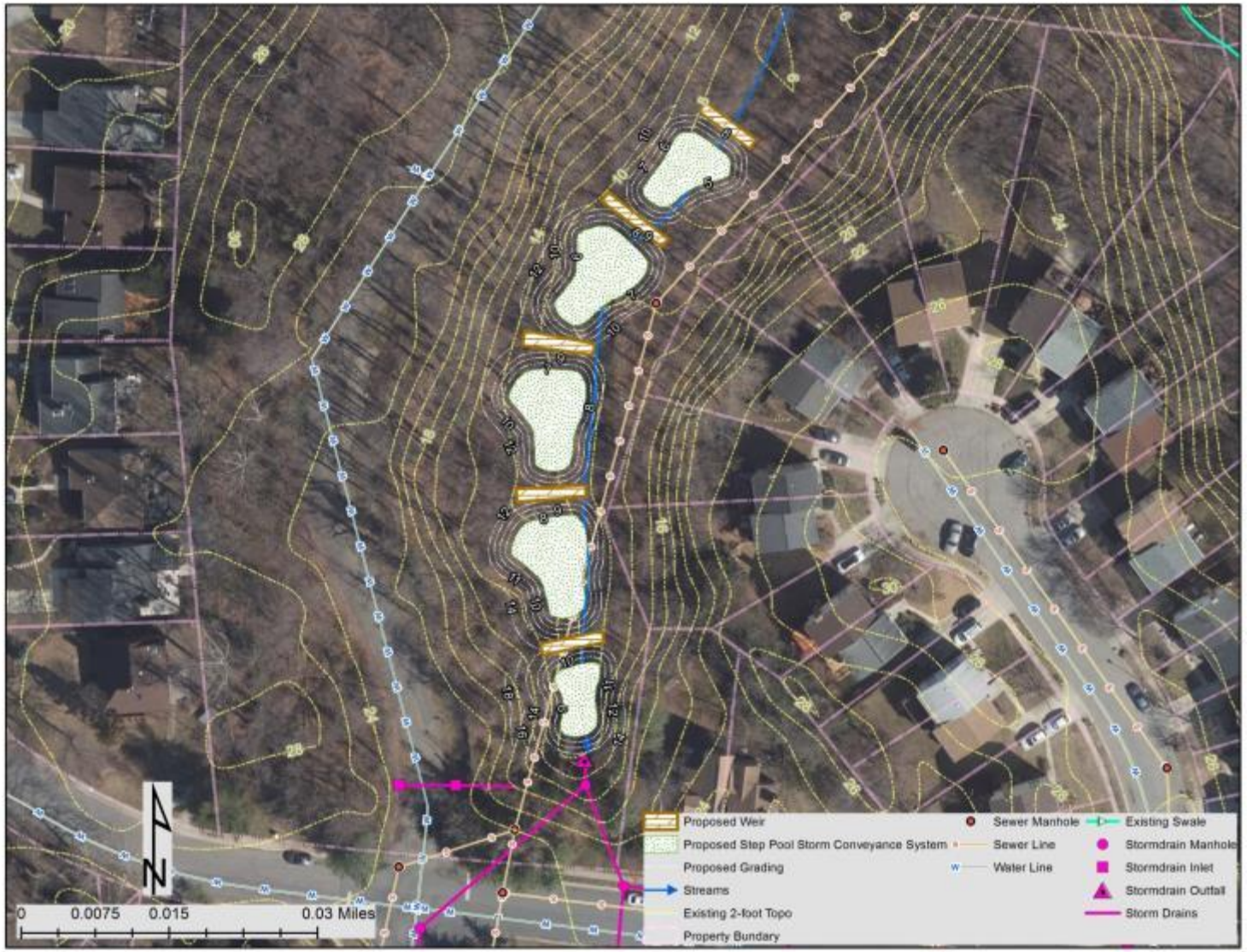


Figure 50: Proposed Retrofit Concept Design

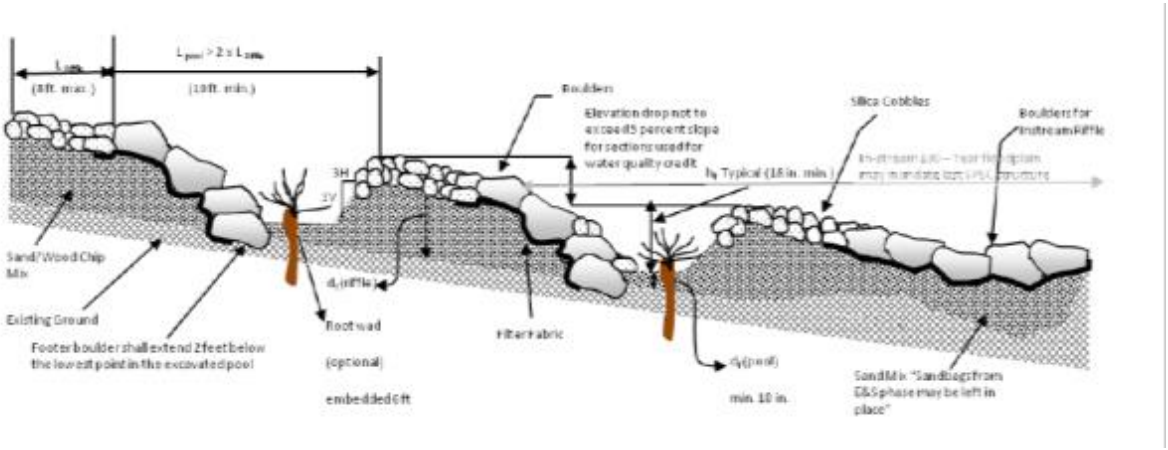


Figure 51: Typical Profile of SPSC (Anne Arundel County's *Regenerative Step Pool Storm Conveyance Design Guidelines* (Revised December 2012)

Site Photographs

Existing Outfall 07

Downstream of Outfall 07

Appendix E

Scoring Criteria for Prioritizing Concept Designs

Scoring Criteria for the Development of High Priority Project Priority Ranking Matrix

AECOM prepared conceptual designs as part of Task 5 for 16 high priority projects selected by the City. The concept designs included detailed information for each project (e.g., detailed drainage areas, nutrient removal estimates, and cost estimates). This ranking criteria was developed to rank the proposed conceptual design projects as part of Task 6.

Prioritization criteria were developed to provide a framework to select storm water management projects to include in the City Capital Improvement Program (CIP). The scoring criteria are summarized in the table below. A maximum of 100 points is possible. A high score represents a good storm water management opportunity or Best Management Practice (BMP), while a low score represents a less favorable opportunity. The maximum points possible for each category can be updated based on recommendations by the City.

Storm Water Management Prioritization Criteria

	Criterion	**Max Possible Score**
A.	Impervious Acres Treated	10
B.	Total Nitrogen Removal	5
C.	Total Phosphorous Removal	5
D.	Total Suspended Solids Removal	5
E.	Site Ownership	10
F.	Site Access	5
G.	Utility Conflicts	10
H.	Environmental Impacts of Proposed Solution	10
I.	Regulatory Approval	10
J.	Flooding and Erosion Concerns	10
K.	Anticipated Project Cost per Acre Treated	10
L.	Public Visibility	5
M.	Anticipated 20 Year Maintenance Cost per Acre Treated	5
A.	Impervious Acres Treated	10
B.	Total Nitrogen Removal	5
C.	Total Phosphorous Removal	5
D.	Total Suspended Solids Removal	5
E.	Site Ownership	10
F.	Site Access	5
G.	Utility Conflicts	10
H.	Environmental Impacts of Proposed Solution	10
I.	Regulatory Approval	10
J.	Flooding and Erosion Concerns	10
K.	Anticipated Project Cost per Acre Treated	10
L.	Public Visibility	5
M.	Anticipated 20 Year Maintenance Cost per Acre Treated	5
TOTAL		**100**

This scoring criteria builds on the preliminary criteria developed for the 52 potential facilities identified from the field reconnaissance (Task 3) in the Interim Submittal provided to the City on September 10, 2015. Detailed estimates for cost and pollutant removal included as part of the concept design packages allow for a more detailed comparison than could be completed for the interim submittal.

The details of each criterion are discussed in Sections A to M below, and an overall summary table is provided in Section N.

A. Impervious Acres Treated 10

This criterion is based on the number of impervious acres treated by each proposed facility. The Maryland Department of the Environment (MDE) Phase II National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permits require a 20-percent reductions in untreated impervious acres. The impervious cover was estimated for all other proposed BMPs using geographic information system (GIS) data and field estimates.

Impervious Area Treated	Points
Less than 5 Acres	0
Between 5 and 10 Acres	5
Greater than 10 Acres	10

B. Total Nitrogen Removal 5

Total nitrogen is one of the three water quality impairments covered in the Chesapeake Bay Total Maximum Daily Load (TMDL). The nitrogen removal for each proposed concept design was calculated based on MDE removal efficiencies to estimate progress toward meeting the Chesapeake Bay TMDL requirements.

Total Nitrogen Removal	Points
Less than 50 pounds removed	0
Between 50 and 100 pounds removed	2.5
Greater 100 pounds removed	5

C. Total Phosphorous Removal 5

Total phosphorous is one of the three water quality impairments covered in the Chesapeake Bay TMDL. The phosphorous removal for each proposed concept design was calculated based on MDE removal efficiencies to estimate progress toward meeting the Chesapeake Bay TMDL requirements.

Total Phosphorous Removal	Points
Less than 5 pounds removed	0
Between 5 and 10 pounds removed	2.5
Greater 10 pounds removed	5

D. Total Suspended Solids Removal 5

Total suspended solids is one of the three water quality impairments covered in the Chesapeake Bay TMDL. The total suspended solids removal for each proposed concept design was calculated based on MDE removal efficiencies to estimate progress toward meeting the Chesapeake Bay TMDL requirements.

Total Suspended Solids Removal	Points
Less than 2 tons removed	0
Between 2 and 4 tons removed	2.5
Greater 4 tons removed	5

E. Site Ownership 10

This criterion evaluates the impact of property ownership for the proposed project site. Public sites are owned by the City of Annapolis and are typically easier to implement projects when compared to privately owned sites. For sites on private property, county property, or state highway property, it may not be feasible or cost effective to acquire the necessary property or obtain required easements to construct the BMP. Agreements between the City and private sites owned by Home Owners Associations or Institutions (e.g., Colleges) are considered more feasible than other private sites.

Property Description	Points
Private/County/Maryland State Highway	0
Home Owners Association or Institution	5
City	10

F. Site Access 5

Site access was scored for each project based on whether poor, fair, or good construction access was available. Sites requiring demolition of structures, road construction, easements on private property, or clearing and grubbing of trees were considered less desirable. Sites that are relatively easy to access with equipment, but have limited space for staging without compromising existing land use (e.g., parking), are considered to have fair construction access.

Access	Points
Poor	0
Fair	2.5
Good	5

G. Utility Conflicts 10

Utility impacts were estimated from field visits, desktop analysis, and design plans. The scoring is based on the typical impacts existing utilities may cause during construction. Major impacts include relocating utilities, and minor impacts include raising manhole rims. Unknown impacts are for sites with the potential for utility conflicts but available data is insufficient to determine the nature of the conflict, if any.

Utility Impacts	Points
Major	0
Minor or Unknown	5
None	10

H. Environmental Impacts of Proposed Solution 10

Potential proposed impacts to trees, streams and wetlands were assigned a ranking as described in the table below. Trees, natural streams, and natural wetlands provide environmental benefits that are difficult to reproduce once impacted. A lower score was assigned to projects that would impact trees, wetland, and trees.

Types of Environmental Impacts	Points
Construction in wetlands or streams, or involves removal of more than 10 trees	0
Construction on edge of wetlands or streams, or removal of 1 to 9 trees	5
No impact to wetlands or trees	10

I. Regulatory Approval 10

Potential regulatory approval was assigned in the table below. In addition to environmental impacts, regulatory approvals for wetland, critical area, 378 Pond, and floodplain impacts can be time consuming and expensive. A lower score was assigned to projects that would impact wetlands, floodplains, or dam safety.

Utility Impacts	Points
Regulatory approvals required	0
Regulatory approvals are not required	10

J. Flooding and Erosion Concerns 10

Flooding and erosion concerns was scored for each project based on whether there was evidence of flooding or erosion at each site. The City identified several locations with existing flooding concerns, and AECOM looked for evidence of flooding and erosion at field sites.

Utility Impacts	Points
No flooding or erosion concerns at site	0
Evidence of erosion at site	5
Flooding concerns at site	10

K. Anticipated Project Cost per Acre Treated 10

The evaluation of cost was a quantitative comparison of costs for a new or retrofit project based on the costs developed as part of the concept design packages (Task 5). This criterion was calculated by dividing the estimated project cost by the impervious acres treated. The anticipated project cost per impervious acre treated was scored for each project based on whether costs were expected to be greater than $60,000 per impervious acre treated, between $30,000 and $60,000 per impervious acre treated, or less than $30,000 per impervious acre treated.

Stormwater management practices that treat large drainage areas are generally more expensive than those that treat less; however, the anticipated cost per impervious acre treated may decrease for practices that treat large drainage areas.

Anticipated Projects Cost / Impervious Acres Treated	Points
Greater than $60,000	0
$30,000 to $60,000	5
Less than $30,000	10

L. Public Visibility 5

Public acceptance of storm water treatment practices is often related to whether practices are aesthetically pleasing. Practices that will be aesthetically pleasing when implemented in public areas are given a high score (e.g., rain gardens, step pool storm conveyance systems, and bioretentions), while those that are in public areas and would not be aesthetically pleasing (e.g., sand filters and infiltration basins) are given a low score. Practices that are aesthetically acceptable (e.g., ponds, swales, porous pavement, and infiltration trenches) or practices that are not aesthetically pleasing but are out of public view are given medium scores.

Utility Impacts	Points
In public view and not aesthetically acceptable	0
Aesthetically acceptable and/or not in public view	2.5
Aesthetically pleasing	5

M. Anticipated 20 Year Maintenance Cost per Acre Treated 5

The evaluation of 20 year life cycle maintenance cost was a quantitative comparison of costs for a new or retrofit project based on the costs developed as part of the concept design packages (Task 5). This criterion was calculated by dividing the estimated 20 year life cycle maintenance cost by the impervious acres treated. The anticipated 20 year life cycle maintenance cost per impervious acres treated was scored for each project based on whether costs are expected to be greater than $4,000 per impervious acre treated, between $2,000 and $4,000 per impervious acre treated, or less than $2,000 per impervious acre treated.

Anticipated Annual Maintenance Cost / Impervious Acres Treated	Points
Greater than $4,000	0
$2,000 to $4,000	5
Less than $2,000	10

N. Ranking Criteria Summary Table 100

A table summarizing the ranking criteria is provided below.

Prioritization Category	*Max Score*	*Description*	*Score*
Impervious Area Treated	10	Less than 5 Acres	0
		Between 5 and 10 Acres	12.5
		Greater than 10 Acres	25
Total Nitrogen Removal	5	Less than 50 pounds removed	0
		Between 50 and 100 pounds removed	2.5
		Greater 100 pounds removed	5
Total Phosphorous Removal	5	Less than 5 pounds removed	0
		Between 5 and 10 pounds removed	2.5
		Greater 10 pounds removed	5
Total Suspended Solids Removal	5	Less than 2 tons removed	0
		Between 2 and 4 tons removed	2.5
		Greater 4 tons removed	5
Site Ownership	10	Private/County/Maryland State Highway	0
		Home Owners Association or Institution	5
		City	10
Site Access	5	Poor	0
		Fair	2.5
		Good	5
Utility Conflicts	10	Major	0
		Minor or Unknown	5
		None	10
Environmental Impact of Proposed Solution	10	Construction in wetlands or streams, or involves removal of more than 10 trees	0
		Construction on edge of wetlands or streams, or removal of 1 to 9 trees	5
		No impact to wetlands or trees	10
Regulatory Approval	10	Regulatory approvals required	0
		Regulatory approvals are not required	10
Flooding Concerns	10	No flooding or erosion concerns at site	0
		Evidence of erosion at site	5
		Flooding concerns at site	10
Anticipated Project Cost / Impervious Acre Treated	10	Greater than $60,000	0
		$30,000 to $60,000	5
		Less than $30,000	10
Public Visibility[1]	5	In public view and not aesthetically acceptable	0
		Aesthetically acceptable and/or not in public view	2.5
		Aesthetically pleasing	5
Anticipated 20 Year Life Cycle Maintenance Cost Per Impervious Acre Treated	5	Greater than $4,000	0
		$2,000 to $4,000	2.5
		Less than $2,000	5

Appendix F

Concept Design Prioritization Matrix

Table E-1: City of Annapolis High Priority Project Ranking Table

Project ID	Location	Project Type	Impervious Drainage Area (0-10)	Total Nitrogen Removal (0-5)	Total Phosphorous Removal (0-5)	Total Suspended Solids Removal (0-5)	Ownership (0-10)	Access (0-5)	Utility Impacts (0-10)	Environmental Impact of Proposed Solution (0-10)	Regulatory Approval (0-10)	Flooding and Erosion Concerns (0-10)	Anticipated Project Cost / Impervious Acre (0-10)	Public Visibility (0-5)	Maintenance Burden (0-5)	Total Score (0-100)	Rank
BMP_15	Southwest of the intersection of Child's Point Road and Woods Road	Wet Pond Retrofit	10	5	5	5	5	5	10	10	10	0	10	2.5	5	82.5	***1***
Out_01	North of Edgewood Road (Osprey Nature Center)	Step Pool Conveyance System	10	5	5	5	10	5	10	0	0	5	10	5	5	75	***2***
BMP_14	Northwest of the intersection of Harness Creek View Court and Harness Creek View Drive	Wet Pond Retrofit	5	2.5	2.5	2.5	5	5	10	5	10	10	5	2.5	2.5	67.5	***3***
CtyRqst_01	Northwest of the intersection of Ridgewood Street and Woodlawn Avenue	Step Pool Conveyance System	10	5	5	5	5	0	10	0	0	5	10	2.5	5	62.5	***4***
BMP_20	North of Moreland Parkway	Wet Pond Retrofit	10	5	5	5	0	2.5	10	5	0	0	10	2.5	5	60	***5***
Out_04	Southeast of the intersection of Timber Creek Drive and Bay Ridge Avenue	Step Pool Conveyance System	10	5	5	5	0	2.5	0	0	0	10	10	5	5	57.5	***6***
BMP_21	Northwest of the intersection of Langdon Court and Berwick Drive	Wet Pond Retrofit	10	5	5	5	0	5	10	0	0	0	10	2.5	5	57.5	***7***
Out_07	Northeast of the intersection of Windwhisper Lane and Georgetown Road	Step Pool Conveyance System	10	5	5	5	0	2.5	5	0	0	5	10	2.5	5	55	***8***

Project ID	Location	Project Type	Impervious Drainage Area (0-10)	Total Nitrogen Removal (0-5)	Total Phosphorous Removal (0-5)	Total Suspended Solids Removal (0-5)	Ownership (0-10)	Access (0-5)	Utility Impacts (0-10)	Environmental Impact of Proposed Solution (0-10)	Regulatory Approval (0-10)	Flooding and Erosion Concerns (0-10)	Anticipated Project Cost / Impervious Acre (0-10)	Public Visibility (0-5)	Maintenance Burden (0-5)	Total Score (0-100)	Rank
BMP_07	Southeast of the intersection of Coybay Drive and Annapolitan Lane (Annapolis Walk)	Wet Pond Retrofit	5	2.5	2.5	2.5	5	5	10	5	0	0	10	2.5	5	55	***9***
City_06	Northwest of the Hunt Meadow Drive pool parking lot	Step Pool Conveyance System	5	5	5	5	10	2.5	10	0	0	5	0	5	2.5	55	***10***
City_01	Between Tyler Avenue, Hunt Meadow Drive, and Ironstone Court	Wet Pond	5	2.5	2.5	2.5	10	0	10	0	10	0	5	2.5	2.5	52.5	***11***
BMP_08	5 Cherry Grove Avenue (The Village Greens)	Wet Pond Retrofit	5	0	0	0	5	2.5	10	5	10	0	5	2.5	2.5	47.5	***12***
BMP_05	Northeast of the intersection of Juliana Circle East and Newtowne Drive (Riders Glen)	Dry Pond Retrofit to Sand Filter	0	0	0	0	5	5	10	10	10	0	5	0	0	45	***13***
BMP_22	Between Bloomsbury Square and Rowe Boulevard	Grass Swale to Bio Swale Retrofit	0	0	0	0	10	5	5	10	10	0	0	5	0	45	***14***
BMP_09	7101 Bay Front Drive (BayWoods of Annapolis)	Wet Pond Retrofit	0	0	0	0	5	2.5	10	10	0	0	5	2.5	0	35	***15***
BMP_17	914 Bay Ridge Road (Georgetown Plaza)	Bioretention Retrofit	0	0	0	0	0	5	10	5	10	0	0	5	0	35	***16***